The Second State of 3Rs in Asia and the Pacific

– Advancing Circular Economy in Asia and the Pacific Towards Achieving the Sustainable Development Goals (SDGs)

United Nations Centre for Regional Development

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List of Abbreviations

AIT	Asian Institute of Technology
BCSIR	Bangladesh Council of Science and Industry Research
BMA	Bangkok Metropolitan Administration
CPCB	Central Pollution Control Board
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
ILO	International Labor Organization
IPLA	International Partnership for Expanding Waste Management Services of Local Authorities
IRP	International Resource Panel
ISWA	International Solid Waste Association
JICA	Japan International Cooperation Agency
J-PRISM	Japanese Technical Cooperation Project for Promotion of Regional Initiative on Solid Waste Management in Pacific Island Countries
MOEJ	Ministry of Environment Japan
NEA	National Environment Agency
OECD	Organisation for Economic Co-operation and Development
PICTs	Pacific Island Countries and Territories
PROs	Producer Responsibility Organisations
ROAP	Regional Office for Asia and the Pacific
SIDS	Small Island Developing States
SPREP	Secretariat of the Pacific Regional Environment Programme
UNCRD	United Nations Centre for Regional Development
UNEA	United nations Environment Assembly
UNEP	United Nations Environment Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNFCCC	United Nations Framework Convention on Climate Change
WHO	World Health Organization

Preface

Asia-Pacific has been the most dynamic region globally, and rapid urbanization and industrial transformation have triggered the most growth in resource use. The policy and scientific community in Asia and the Pacific have recognized the large challenges of resource supply security, increasing waste and pollution, climate change, and increasing frequency and magnitude of natural disasters as critical constraints to future growth and rising material living standards region. The region's unsustainable consumption and production patterns are the root causes of the three-fold global crises of climate change, biodiversity loss, and pollution. Such crises, and the resulting environmental degradation, threaten human well-being and the achievement of the SDGs.

3R and circular economy provides not only an important basis for achieving SDG 12 (sustainable consumption and production) but also meaningful synergies in combinedly achieving the other SDGs such as SDG 6 (clean water and sanitation), SDG 13 (combat climate change), SDG 11 (safe, resilient, sustainable cities and communities), and SDG 14 (life below water), among others.

The Regional 3R and Circular Economy Forum in Asia and Pacific, organized by the United Nations Centre for Regional Development (UNCRD) and supported by the Ministry of Environment of Japan (MOEJ), brings both the policy and scientific community to convene on an annual basis to strengthen the science-policy interface in addressing 3R and resource efficiency as the basis for economic growth, pollution prevention and strengthening resilience of cities and communities, and after all, to achieve these international agendas and agreements.

Starting from the 6th Regional 3R and Circular Economy Forum in Maldives (2015), circular economy approach has been mainstreamed in the policy discussions among the member countries. In the 7th Regional 3R and Circular Economy Forum in November 2016, the member countries adopted the Adelaide 3R Declaration towards the Promotion of Circular Economy in Achieving Resource Efficient Societies in Asia and the Pacific under the 2030 Agenda for Sustainable Development. At the 8th Regional 3R and Circular Economy Forum in April 2018, the participating Mayors and local authorities signed the Indore 3R Declaration of Asian Mayors on Achieving Clean Water, Clean Land, and Clean Air in Cities. In the 9th Regional 3R and Circular Economy Forum in March 2019, the member countries agreed on the Bangkok 3R Declaration Towards Prevention of Plastic Waste Pollution through 3R and Circular Economy. The 10th Regional 3R and Circular Economy Forum recognized eco-town's important role in advancing 3R and circular economy. The most recent 11th Regional 3R and Circular Economy Forum investigated integrating circular economy in major development sectors towards achieving zero waste societies and the SDGs. Information presented at all these annual Regional 3R and Circular Economy Forums shows that several member countries are already undertaking 3R policy implementation and activities under the Hanoi 3R Goals (2013-2023) that support the global agendas and agreement.

To assist with the discussions leading to the formulation of the successor of the Hanoi 3R Declaration, which ends in 2023, it is necessary to measure the progress made by the member countries toward achieving the 33 goals as measured by the relevant indicators. This publication provides a synthesis and assessment report on the current 3R and circular economy policy implementation status. It provides the member countries with science-based advice on existing and future challenges and opportunities, including those on business, socio-economic and socio-cultural aspects of the 3R in advancing resource circulation and circular economy in the region.

Executive Summary

The Asia-Pacific is seen as the most dynamic region globally, and rapid urbanization and industrial transformation have triggered the most growth in resource use. The region has identified major challenges such as resource supply security, increasing waste and pollution, climate change, and increasing frequency and magnitude of natural disasters as critical constraints to future growth. Globally, the UN member countries are concurrently implementing several international agendas and agreements, such as the 2030 Agenda for Sustainable Development and the underlined SDGs, the Paris Agreement on Climate Change, the New Urban Agenda, the Addis Ababa Action Agenda, the Nairobi Mandate, the Sendai Framework for Disaster Risk Reduction, the UN Decade on Ecosystem Restoration, among others.

The 2030 Agenda for Sustainable Development and the SDGs call for equitable economic growth and provide an important political and implementation framework to implement 3R and resource efficiency to achieve circular economic development. UNCRD's 3R and circular economy initiative brings both the policy and scientific community to convene on an annual basis the Regional 3R and Circular Economy Forum in Asia-Pacific to strengthen the science-policy interface in addressing 3R and resource efficiency as the basis for economic growth, pollution prevention and strengthening resilience of cities and communities, and after all, to achieve these international agendas and agreements.

The Ha Noi Declaration, Sustainable 3R Goals for Asia and the Pacific for 2013-2023, was adopted in the 4th Regional 3R Forum in Asia and the Pacific held in Ha Noi, Viet Nam in March 2013 including 33 goals and their indicators, Sustainable 3R Goals for Asia and the Pacific for 2013-2023 (Ha Noi 3R Goals), to assess national level 3R progress. The first report, "State of the 3Rs in Asia and the Pacific," is an experts' assessment of the regional 3R progress since 2013. The report was officially launched at the 8th Regional 3R Forum in Asia and the Pacific in 2018, reviewing the status of 3R policy implementation in the region based on country inputs to the Regional 3R and Circular Economy Forum about specific Ha Noi 3R Goals (2013-2023).

The overall objective of the 'Second State of 3Rs in Asia and the Pacific" is to assist the member countries of the Regional 3R and Circular Economy Forum in Asia and the Pacific for improved decision-making towards effective implementation of 3Rs and resource circulation, and circular economy approaches at the local and national level, including the promotion of 3Rs as an economic industry, by improving data, information, and indicators availability in all waste sectors (municipal, industrial, hazardous, e-waste, agricultural and biological, etc.). To achieve a low carbon and resource efficiency society, it also aims to contribute towards the 2030 Agenda for Sustainable Development and the SDGs. The report also provides an opportunity to assess progress on relevant SDGs by tracking applicable SDG Tier 1 and Tier 2 Indicators. The report is also expected to serve as a precursor to the discussions leading to the formulation of the successor of the Hanoi 3R Declaration, which ends in 2023. The following observations were noted:

- The 3R's concept evolved into resource efficiency and circular economy to increase competitiveness and secure the supply of raw materials and energy while reducing environmental pressures (environmental concerns). Therefore, a linkage between material resource efficiency and waste policy was created to combine environmental benefits (for

example, by avoiding final disposal of waste) with economic gains (by avoiding the purchase of virgin materials and reducing disposal costs) It signaled a new level of ambition in applying the logic of the waste hierarchy, including additional goals on waste prevention and using waste as a resource.

- Most countries have specific 3R policies, programs and projects addressing the reduction in the quantity of MSW (Ha Noi Goal 1). The policies have been translated into specific regulations of municipal solid waste, which have been institutionalized at the national level to be implemented at the provincial and local levels. Though at the local level, the level of participation of households in "source" segregation is low, trends indicate that more countries are approaching the "average to high" level. The recycling rate of different items like paper, plastics, metal, construction waste, E-waste, and other waste streams show marked variation from "Poor" to "Very High" (Ha Noi Goal 3).

- Plastic consumption in Asia and the Pacific region is increasing every year. Plastic consumption ranges from 0.13 percent to 0.75 percent of material consumption in Asia and the Pacific region, an indicator of variation in resource usage. The plastic waste generation in the region is expected to reach 140 million tonnes by 2030. The national reporting of plastic waste recycling varies from country to country considering differences in the definition of recycling rate. The low segregation rate of mixed plastic waste further adds to the region's treatment and disposal complexity. The national governments in Asia and the Pacific region have initiated policy and regulatory responses at the national and regional levels The majority of these responses are targeted at single-use plastics considering their short life cycle and the scale of their impacts. The two main mechanisms national governments employ are bans or restrictions on the supply and distribution of single-use plastics. Most countries have opted for partial bans or restrictions in thickness requirements and material composition. Some countries have introduced market-based instruments, particularly national legislation on plastic bags, while others have packaging laws or regulations which govern plastic bags. Other approaches include the implementation of extended producer responsibility (EPR), fines related to plastic bag legislation, and city-level regulation of plastic bags.

- Asia and the Pacific region generated nearly 50 percent of the global E-waste quantities in 2019, amounting to 24.9 million tonnes. The availability and reliability of data on E-waste generation is very limited in many countries as they have not developed proper inventories. E-waste is predominantly handled by the informal E-waste recycling sector that utilizes poor recycling methods to extract valuable metals while disposing of the toxic compounds in the open environment. Recycling is one of the most popular options for managing E-waste. Among Asia and Pacific nations, direct E-waste regulations vary significantly. Only a few countries in the region have fully implemented E-waste regulations, while others have limited implementation of E-waste regulations or are developing ones. The transboundary movement of E-waste from industrialized nations to emerging and developing economies has caused significant challenges to many nations in Asia and the Pacific due to a lack of infrastructure and financial resources to deal with the issue. The major environmental and health impacts occur when the informal sector is involved in the last stage of the E-waste recycling chain. Advanced processesandtechniques are necessary to extract valuable components such as metals. Tackling emerging and problematic E-waste streams (e.g., Li-ion batteries, solar panels) will be a major challenge in the region.

Recent years have seen an exponential growth of solar photovoltaic panels (solar PV panels) in Asia and the Pacific region.

- Several Asia and Pacific countries have developed hazardous waste classification systems or catalogues to achieve sound hazardous waste management. Data constraints are reported for hazardous waste generation in Asia and the Pacific region. According to the market forecast, hazardous waste generation in Asia and the Pacific region is expected to reach 66.18 million tonnes in 2027. Hazardous waste generation in the region exhibited an overall rise from 2011 to 2023. Most nations are still struggling to develop a sustainable hazardous waste management system. Though Ha Noi 3R Goals related to this waste stream are widely reported by countries in Asia and the Pacific region, SDG Goals are not reported covering this waste stream.

- Disasters such as earthquakes, tsunamis, floods, and cyclones frequently occur in Asia and the Pacific, generating a large amount of waste due to their strong destructive force. In Asia and the Pacific, construction and demolition waste (including disaster waste) or CDW regulations vary significantly. from full implementation to limited and none. to none. The barriers to proper utilization of CDW include increased energy and transport costs, lack of knowledge on recycled products, limited technologies for waste recovery, low quality and reduced performance, lack of market availability of the products, and limitations caused by specifications, standards, and permits.

- Agricultural biomass waste in the region originates from several sources, major crops, and the respective residues, as well as livestock and livestock waste. Most national legislation, policies, plans, and strategies for agricultural biomass waste are related to renewable energy generation in Asian and Pacific countries. This legislation provides sustainable sources of electricity and income for rural inhabitants and reduce GHG emissions. The common theme between policies, plans, and regulations of Asia and the Pacific countries are (i) clearly stating the share of renewable energy sources in national electricity generation by a certain year: (ii) special focus on using renewable energy sources for electricity and power in rural areas to make rural areas self-sustaining and improve the socio-economic situation of villages: (iii) incorporation and implementation of the feed-in-tariff scheme: (iv) Blending of biofuel and biodiesel by a certain year. Most countries with specific regulations, plans, and strategies on biofuel and biodiesel blending state the use of agricultural waste as the feedstock and (v) the inclusion and implementation of bio-gasification for power and energy. The availability of data for using agricultural biomass waste is missing in most Asia and Pacific countries. The resource circulation of agricultural biomass waste through 3R (reuse, recycle, recover) depends on the type of agricultural biomass waste and other characteristics such as moisture content, energy content, etc.

- Food loss and waste represent lost opportunities for sustainable consumption and production, food security, and proper nutrition, and they happen in every stage of the food supply chain. Globally, 13.8 percent of food is lost along the supply chain, and 17 percent is wasted. The causes of food loss and waste in Asia and the Pacific region vary and may be influenced by several factors, from culture and consumer behavior to economic capacity. Policy approaches for food loss in the region are closely tied to the focus on food security in Asia and the Pacific nations as a response to the growing food demand and the need to reduce food losses along the food supply chain. Overall, the policy priorities in the region aim to increase the productivity and efficiency of food systems through various measures like improving agricultural knowledge and research, strengthening technological and personnel capability, and providing financial assistance. Food rescuing and redistribution of surplus foods are the main programs to curb food waste in the region. Technological innovation and behavioral change initiatives are developed to combat increasing food loss and waste in the region. Most of the technological initiatives present in the region are food recycling, composting, and conversion of waste to energy and other useful resources. To stimulate behavioral changes, education and awareness campaigns are the most common initiatives done by Asia and Pacific nations.

- The global medical waste management market was estimated to grow from $13.5 billion in 2019 to 14.9 billion in 2020 at a compound annual growth rate (CAGR) of 10.6 percent. The remarkable growth is mainly due to the COVID-19 outbreak and the measures to contain it. The market is then expected to stabilize and reach $16.62 billion in 2023 at a CAGR of 3.8 percent. Many Asian resource-constrained countries have only fundamental laws and limited regulatory bodies to enforce healthcare waste management. Mishandling and ignorance have created various environmental problems, especially in densely populated countries. Some countries in the Asian region have formulated a broad range of regulations for healthcare waste management by the respective legislations and regulatory authorities.

- Water security is one of the major challenges in Asia and the Pacific region, which needs urgent attention. The majority of the population experience water scarcity for at least one month per year. Industries are competing for water due to the economic expansion in the region. Irrigation for agricultural practices consumes the highest share of water in the region, accounting for 60-90 percent of annual wastewater withdrawals. Despite the achievements in Asia and the Pacific (home to 60 percent of the world's population), 1.5 billion people living in rural areas and 0.6 billion in urban areas still lack adequate water supply and sanitation facilities. The on-site sanitation systems have resulted in low treatment efficiencies of around 30-60 percent, lower than centralized sewerage systems using aeration. Although centralized sewerage systems are adequate solutions in densely populated areas, they are not widely used in many countries of Asia and Pacific countries mainly due to the large investment cost required for the construction. It could be observed that most of the countries in Asia and the Pacific region have developed national water and sanitation policies. However, these policies do not adequately deal with all the issues associated with sanitation practices. In some Asia and Pacific countries, there is no proper coordination between the various sectors involved with the wastewater sector, which needs further strengthening while formulating these policies. Around 90 percent of the wastewater is discharged untreated. Several improvements are required to develop the wastewater sector in Asia and the Pacific region, particularly on public perception, policy, legislative and institutional reform, infrastructure and technology, research and development, and alternate financing.

- There is a significant increase in the waste generated from new and emerging waste streams. Quantifying them is difficult, as several studies globally, as well as Hanoi 3R indicators reporting, indicate that due to informal sector operation, comprehensive data on waste generation, segregation, reuse, repurposing, treatment, and disposal are not available. Further, data related to littering or illegal movement at local, national and global levels is scattered. Therefore, the real magnitude of the problem remains unclear, though the impacts of informal treatment in some countries are unquestionably significant.

- The extensive use of batteries, from storing energy to operating various types of equipment, results in millions of tonnes of batteries in operation in all countries. Primary (single-use or "disposable") batteries are used once and discarded. The development in automobile, aviation and aerospace, marine hybrid propulsion, defense, telecommunication, micro-grid, etc. predicts higher battery market growth. Higher operational costs in the recycling of batteries are the major constraint in the growth of battery recycling. Other constraints are: (i) Large quantities and range of strategic minerals needed to power renewable energy transition and digital tech, including demand for battery metals (nickel, cobalt, copper, lithium): (ii) Needed only in small quantities, cannot be easily recycled using conventional technologies. (iii) About 3 percent of rare-earth materials are recycled worldwide. Crude recycling targets mean that most valuable materials are not reclaimed in recycling processes. The automotive battery recycling market in Asia and the Pacific region is predicted to have the fastest growth rate of 8.5 percent CAGR in the current decade (2021-2030).

- To work towards the Paris Agreement, countries in the Asia Pacific region are implementing carbon neutral technologies that include (i) Technologies for renewable energy, solar energy, wind energy, ocean energy, bioenergy, hydrogen energy, nuclear energy, geothermal energy, and energy storage; (ii) Technologies for enhanced carbon sink in global ecosystems that include carbon sink in terrestrial ecosystems, carbon sink in marine ecosystems, zero waste biochar as a carbon-neutral tool ; (iii) carbon neutrality based on satellite observation and Digital Earth. Renewable energy, such as hydropower, solar, wind, and ocean energy, is regarded as the most important and efficient means to achieve carbon neutrality as other sources like nuclear and H_2 energy.

- Rapid waste generation leads to littered waste due to area overflowing waste bins in densely populated areas. The application of IoT and artificial intelligence (AI) in waste management systems in an urban area has a high potential to revolutionize the waste management system. It makes the system more efficient and results in clean cities. IoT-powered systems equip waste collection in real time and inform the stakeholders of waste overflows. Combining IoT waste data analytics with modern IoT solutions helps identify and improve challenges. To save money from the operational inefficiencies of traditional methods of trash collection and disposal procedures, IoT-driven solutions are required. More cities across Asia and the Pacific are implementing smart waste management solutions to more efficient and clean waste management systems to save money and reduce the environmental impact. It includes smart bins with RFID readers, Smart Waste Management Platform, Intelligent Routing and Route Optimization, Container Tracking, Pneumatic waste pipes, and Smart recycling. Other existing smart waste management systems are (i) Solar-Powered Trash Compactors; (ii) Garbage Truck Weighing Mechanisms; (iii) E-Waste Kiosks (iv) Recycling Apps.

A comprehensive overview of the progress achieved by countries on the Ha Noi 3R Goals (2013-2023) has been carried out at national and regional levels, which finds expression in existing and emerging waste management systems. Following are some key observations under the 33 Goals:

- Most countries have reported subscriptions to policies, programs, projects, and regulations related to 22 of the 33 Ha Noi 3R goals. Goals 1, 2, and 3 related to solid (municipal and other) waste, its sub-streams, for example, paper, metal, organic, etc., and their recycling aspects are widely reported in the region. Recycling activities are happening both in the formal and informal sectors. Many countries have specific 3R policies, programs and projects in place. The policies have been translated into specific regulations of municipal solid waste, which have been institutionalized at the national level to be implemented at the provincial and local levels. The facilities for recycling construction waste are poor in many countries. Institutional and financial challenges are reported to be significant, followed by policy and technical.

- Most countries in the region, which have vibrant industrial sectors, have reported initiatives as per Goals 6, 7, and 8. Inventories of hazardous waste (Goal 9) exist, although they are not updated on the Basel Convention website. Many countries have not defined the amount of agricultural biomass and livestock waste grossly generated annually, although they make composts and fertilizers from agricultural biomass waste.

- Regarding emerging waste issues, E-waste management has been prioritized, and several countries have started to apply EPR-based policies for E-waste management (Goals 13 and 15). While marine and coastal plastic waste has been given increasing regional attention, concrete actions taken by national governments are limited in most countries (Goals 12 and 15). Goal 15 is evolving across the region. Some countries that have enacted EPR-based legislation have provided a list of products and product groups targeted by EPR nationally for 2018-2021.

- Most reporting countries have introduced specific policies and guidelines for product standards (towards quality and durability, environment and eco-friendliness, and labour standards) (Goal 17). The countries have introduced specific energy efficiency schemes for the production, manufacturing, and service sectors. Countries in Asia and the Pacific region have addressed climate mitigation in waste management policies, plans, and programs as part of national communication to UNFCCC (Hanoi Goal 18).

- The low response by countries has been observed for Ha Noi Goals 6, 8, 20, 22, 24, 26, 29, 30, 31, 32, and 33. It indicates the priority areas for future attendance at the regional level. The country-wide status of the three different types of models has been described. Model 1: Linear and Simple Waste Management System, Model 2: Resource Efficiency and 3R Waste Management System and Model 3: Integrated Resource Efficiency, 3R Waste Management and Circular Economy. Island countries in the Pacific Region face difficulties implementing ideal waste management systems in Asia. These countries face policy, institutional, and financial challenges in addition to logistics and availability of land and space constraints.

- An analysis of the internalization and evolution of Ha Noi 3R goals has been carried out considering “Circularity” and “Sustainability” in Asia and the Pacific region. The Ha Noi 3R declaration has significantly triggered a transformation from a “Linear" to a “Circular” economy. As a result, the major economies are adopting policies and regulations, programs, plans, and projects related to "Circularity," thereby pulling their economies towards material recycling and resource productivity, pushing for resource efficiency and sustainability.

Within the scope of the Regional 3R and Circular Economy Forum in Asia and Pacific, the following interventions are recommended under four major categories:

(a) Strengthening Institutional foundation, legislation, policies, strategies, and standards
One of the biggest challenges is to develop a waste management ecosystem that can promote policies, legislation, and standards. Even in the most developed system in the region, there are inefficiencies due to a lack of coordination among different ministries and agencies. At the same time, new and emerging waste streams load already existing ecosystems. Resource efficiency, productivity, and waste reduction measures must be accelerated. This directly influences effective service delivery, clarifying roles and responsibilities among different stakeholders and setting clear objectives, priorities, and built-in mechanisms for implementation, monitoring, feedback, and improvement. The waste management system should be flexible enough to accommodate new waste streams in the ecosystem, e.g., waste from solar panels and EV batteries.

(b) Securing Finance and Promotion of Private Sector Investment
There is a need to reform the existing public sector funding of waste management systems. In addition to public sector funding, there is a need to intensify private sector funding to support waste management systems. This could be through public-private partnerships and "Polluter Pay Principles" as per EPR regulations. The producers should be made accountable for the cost of pollution from their products. Public sector financing should also cover volume-based fee systems, solid waste collection and treatment charges to cover investment costs, and financial incentives such as subsidies and soft loans for tax benefits for sound recycling technologies can be introduced.

(c) Closing Implementation Gaps between Rural and Urban Areas
There is a huge urban and rural divide in the sound waste management systems in Asia and the Pacific region. The rural waste management system should synergize with the urban one. For example, a "hub and spoke" model has the potential to extend the boundary of the 3R waste management ecosystem while also diffusing the principles of circularity and sustainability across the population. For example, "Swachh Bharat – Rural" launched with the "Swachh Bharat – Urban" mission provides a synergistic program of garbage-free India nationally.

(d) Promoting Capacity Development for Emerging Ecosystem, Operation and Maintenance
As the system is evolving due to the internalization of circularity, sustainability and environmental and social governance, there is an urgent need for "Reskilling" and capacity development. Further, the rapid intervention of technology in every aspect of the waste value chain has accelerated it and needs to be considered a high priority. Therefore, capacities for data management and evidence-based policymaking need to be enhanced for continued progress on the 3Rs.

Policy Brief for Decision Makers

Introduction

The Asia-Pacific is seen as the most dynamic region globally, and rapid urbanization and industrial transformation have triggered the most growth in resource use. The region has identified major challenges such as resource supply security, increasing waste and pollution, climate change, and increasing frequency and magnitude of natural disasters as critical constraints to future growth. Globally, the UN member countries are concurrently implementing several international agendas and agreements, such as the 2030 Agenda for Sustainable Development and the underlined SDGs, the Paris Agreement on Climate Change, the New Urban Agenda, the Addis Ababa Action Agenda, the Nairobi Mandate, the Sendai Framework for Disaster Risk Reduction, the UN Decade on Ecosystem Restoration, among others.

The 2030 Agenda for Sustainable Development and the SDGs call for equitable economic growth and provide an important political and implementation framework to implement 3R and resource efficiency to achieve circular economic development. UNCRD's 3R and circular economy initiative brings both the policy and scientific community to convene on an annual basis the Regional 3R and Circular Economy Forum in Asia-Pacific to strengthen the science-policy interface in addressing 3R and resource efficiency as the basis for economic growth, pollution prevention and strengthening resilience of cities and communities, and after all, to achieve these international agendas and agreements.

The Ha Noi Declaration, Sustainable 3R Goals for Asia and the Pacific for 2013-2023, was adopted in the 4th Regional 3R Forum in Asia and the Pacific held in Ha Noi, Viet Nam in March 2013 including 33 goals and their indicators, Sustainable 3R Goals for Asia and the Pacific for 2013-2023 (Ha Noi 3R Goals), to assess national level 3R progress. The first report, "State of the 3Rs in Asia and the Pacific," is an experts' assessment of the regional 3R progress since 2013. The report was officially launched at the 8th Regional 3R Forum in Asia and the Pacific in 2018, reviewing the status of 3R policy implementation in the region based on country inputs to the Regional 3R and Circular Economy Forum about specific Ha Noi 3R Goals (2013-2023).

The overall objective of the 'Second State of 3Rs in Asia and the Pacific" is to assist the member countries of the Regional 3R and Circular Economy Forum in Asia and the Pacific for improved decision-making towards effective implementation of 3Rs and resource circulation, and circular economy approaches at the local and national level, including the promotion of 3Rs as an economic industry, by improving data, information, and indicators availability in all waste sectors (municipal, industrial, hazardous, e-waste, agricultural and biological, etc.). This policy brief is also expected to guide policymakers to achieve a low carbon and resource efficiency society; it also aims to contribute towards the 2030 Agenda for Sustainable Development and the SDGs.

Need and Benefits of Implementing 3Rs and Circular Economy

The region is experiencing high resource intensity, particularly material intensity, increasing deforestation, and higher carbon dioxide, nitrous oxide, and methane emissions. The waste generation trend is expected to grow rapidly till 2030 and will stabilize beyond 2050. This trend also strongly correlates with the region's material intensity trends and GHG emissions. The projected climate change in Asia and the Pacific could lead to a shortage of water resources, widespread land degradation, and increased desertification. As a result, the net cumulative effect can strain the finite pool of natural resources and may exceed the threshold rate at which these resources could be replenished.

The trends predict that recycling will gradually become more competitive than mineral mining due to projected technological developments and changes in the relative prices of production inputs. This leads to growth in the recycling sector, outpacing growth in mining, lowering emissions and carbon neutrality, and GDP growth. Further, the demographic transition to urban dwellers and environmental links with urbanization will largely determine the sustainable development pathways of the region during the next 25 years and beyond. This calls for: Conserving resources and increasing resource efficiency; Greening, Improving Environmental Conditions and Carbon Neutrality; Improvement in solid waste management due to increasing public pressure for healthy living; Climate Change Mitigation; Promoting Green Jobs, Green Economy and More Prosperous Living. This can be achieved by establishing 3R and circular economy in a step-wise approach to achieve self-sufficiency and SDGs.

3R and Circular Economy Policy Considerations

Plastic Waste

Plastic consumption in Asia and the Pacific region is increasing every year. Plastic consumption ranges from 0.13 percent to 0.75 percent of material consumption in Asia and the Pacific region, an indicator of variation in resource usage. The plastic waste generation in the region is expected to reach 140 million tonnes by 2030. The national reporting of plastic waste recycling varies from country to country, considering differences in the definition of recycling rate. The low segregation rate of mixed plastic waste further adds to the region's treatment and disposal complexity. The national governments in Asia and the Pacific region have initiated policy and regulatory responses at the national and regional levels. Most of these responses are targeted at single-use plastics, considering their short life cycle and the scale of their impacts. The two main mechanisms national governments employ are bans or restrictions on the supply and distribution of single-use plastics. Most countries have opted for partial bans or restrictions on thickness requirements and material composition. Some countries have introduced market-based instruments, particularly national legislation on plastic bags, while others have packaging laws or regulations that govern plastic bags. Other approaches include the implementation of extended producer responsibility (EPR), fines related to plastic bag legislation, and city-level regulation of plastic bags.

Key guidance for policy design

Plastic waste management is challenged by several barriers related to regulatory, economic, technological, data, and information on plastic waste reduction. To overcome these barriers, several interventions can be developed broadly under (1) Regulatory, (2) Economic instruments, (3) Technology, (4) Data and information, and (5) Voluntary measures by industries. To implement these interventions, there is an urgent need to develop a stable interface between science, policy, and business. The governments are essential in setting up effective collection infrastructure, facilitating the establishment of related self-sustaining funding mechanisms, and providing an enabling regulatory and policy landscape. Businesses have a responsibility beyond the design and use of their packaging, which includes contributing towards it being collected and reused, recycled, or composted in practice. Academia has a major role in research and development towards a new plastic economy. The implementation of the policies and regulations, as well as the creation of waste plastic management infrastructure coupled with capacity building through regional knowledgebase (database, experts, indicator monitoring, information sharing, and awareness), are the major policy instruments that could lead to sustainable management and reduction of plastic waste.

E-waste

Asia and the Pacific region generated nearly 50 percent of the global E-waste quantities in 2022, amounting to 30 million tonnes. The availability and reliability of data on E-waste generation is very limited in many countries as they have not developed proper inventories. E-waste is predominantly handled by the informal E-waste recycling sector, which utilizes poor recycling methods to extract valuable metals while disposing of toxic compounds in the open environment. Recycling is one of the most popular options for managing E-waste. Among Asia and Pacific nations, direct E-waste regulations vary significantly. Only a few countries in the region have fully implemented E-waste regulations, while others have limited implementation of E-waste regulations or are developing ones. The transboundary movement of E-waste from industrialized nations to emerging and developing economies has caused significant challenges for many Asian and Pacific countries due to a lack of infrastructure and financial resources to deal with the issue. The major environmental and health impacts occur when the informal sector is involved in the last stage of the E-waste recycling chain. Advanced processes and techniques are necessary to extract valuable components such as metals. Tackling emerging and problematic E-waste streams (e.g., Li-ion batteries, solar panels) will be a major challenge in the region. In recent years, there has been exponential growth in solar photovoltaic panels (solar PV panels) in Asia and the Pacific region.

Key guidance for policy design

Asia and the Pacific countries must develop well-defined national E-waste management strategies closely aligned to the SDGs. Such an approach should look at solving the existing environmental and health impacts of E-waste and reducing E-waste through circular economy principles. The strategy should also create enabling conditions for the private sector to develop business and economic opportunities to recover materials from E-waste. The strategy should consider the country's financial, institutional, political, and social aspects, focusing on synergizing the informal E-waste recycling sector with the formal sector. Some of the key policy instruments could include the following:

- Elimination of hazardous substances during the production of electrical and electronic equipment (EEE) and the dismantling and processing of E-waste
- Formalisation of the informal E-waste recycling sector to create decent working conditions and environmentally sound management of E-waste
- Recognition of the informal E-waste sector and integration into a formal waste management system, thereby protecting their labour rights
- Establishment of proper institutional infrastructures for collection, storage, transportation, recovery, treatment, and disposal of E-waste
- Eliminate open dumping and open burning of E-waste and use of poor chemical processes to separate valuable materials in E-waste
- Design EEE with circularity in mind to prevent E-waste generation at the end-of-life and implement Extended Producer Responsibility (EPR) systems to achieve recycling of E-waste

Chemical and Hazardous Waste

Chemical and hazardous waste is mainly generated by manufacturing and service sectors. Several Asia and Pacific countries have developed hazardous waste classification systems or catalogues to achieve sound hazardous waste management. Data constraints are reported for hazardous waste generation in the region. According to the market forecast, hazardous waste generation in the region is expected to reach 66.18 million tonnes in 2027. Hazardous waste generation in the region exhibited an overall rise from 2011 to 2023. Most nations are still struggling to develop a sustainable hazardous waste management system.

Key guidance for policy design

Asia and the Pacific countries need to develop a more functioning mechanism for recycling and disposing of hazardous wastes. Hazardous wastes shall be supervised strictly before they are adequately treated since severe environmental and health problems might be induced by illegal disposal. Both researchers and government officers shall stipulate specifications for disposing of hazardous wastes. Policymakers shall synthesize the informal sector with the formal sector when constructing the mechanism. Besides, publicizing data and information on the generation, collecting, disposal, and movement of hazardous waste is necessary for assessing the implementation of global conventions and for researchers to give policy advice.

Construction and Demolition Waste

Disasters such as earthquakes, tsunamis, floods, and cyclones frequently occur in Asia and the Pacific, generating a large amount of waste due to their strong destructive force. In Asia and the Pacific, construction and demolition waste (including disaster waste) or CDW regulations vary significantly from full implementation to limited and none. The barriers to proper utilization of CDW include increased energy and transport costs, lack of knowledge on recycled products, limited technologies for waste recovery, low quality and reduced performance, lack of market availability of the products, and limitations caused by specifications, standards, and permits. Most countries have limited up-to-date and publicly accessible data on CDW quantity and composition, making it challenging to understand CDW management trends over time. Due to the development of urbanization and climate change, the CDW has a significant influence on the environment, which needs proper planning and management. Governments and authorities in urban areas have attempted to meet the demand for housing and services through increased construction. However, a lack of awareness of resource-efficient construction practices has resulted in the excessive use of natural resources and the generation of large amounts of construction waste that is rarely recycled.

Key guidance for policy design

The key regional policies to address CDW issues should incorporate circular economy concepts. In all Asia and the Pacific countries, designing with long life and ease of maintenance will be important in future construction. Improving resource productivity is also essential. Reuse and recycling of CDW can be enhanced by sharing international experiences in policy and technology. The decarbonization of housing is attracting attention as a transition toward a decarbonization society. As new materials and construction methods are developed, it is necessary to pay close attention to trends in CDW, and at the same time, from the perspective of circular economy, it is essential to emphasize the importance of design with post-use management in mind

Agriculture Biomass Waste and Livestock Waste

Agricultural biomass waste in the region originates from several sources, major crops, and the respective residues, as well as livestock and livestock waste. Most national legislation, policies, plans, and strategies for agricultural biomass waste are related to renewable energy generation in Asian and Pacific countries. This legislation provides sustainable sources of electricity and income for rural inhabitants and reduce GHG emissions. The common theme between policies, plans, and regulations of Asia and the Pacific countries are (i) clearly stating the share of renewable energy sources in national electricity generation by a certain year: (ii) special focus on using renewable energy sources for electricity and power in rural areas to make rural areas self-sufficient and improve the socio-economic situation of villages: (iii) incorporation and implementation of the feed-in-tariff scheme: (iv) Blending of biofuel and biodiesel by a certain year. Most countries with specific regulations, plans, and strategies on biofuel and biodiesel blending state the use of agricultural waste as the feedstock and (v) the inclusion and implementation of bio-gasification for power and energy. The availability of data for using agricultural biomass waste is missing in most Asia and Pacific countries. The resource circulation of agricultural biomass waste through 3R (reuse, recycle, recover) depends on the type of agricultural biomass waste and other characteristics such as moisture content, energy content, etc.

Key guidance for policy design

The utilization of agricultural biomass waste is expected to continue increasing in coming years, but several challenges must be overcome to achieve a circular economy in agricultural biomass waste management. Most national legislations and plans are focused on renewable energy, and under this big umbrella of renewable energy, several renewable sources have to compete with each other. Perhaps that is why hydro or solar energy (in addition to its mature technology and other positives) capacity and projects are greater in number than agricultural biomass waste-related capacity and projects. Thus, a holistic approach is required by the renewable energy sector to achieve the common goal. Efforts from all stakeholders are required to realize the maturation of technologies for maximum extraction of resources from agricultural biomass waste. Similar attempts must be made to increase the capacity of new technologies, advancing from laboratory scale to pilot scale to commercialization. There is an urgent requirement for dedicated legislation to manage agricultural biomass waste. Only developed countries of Asia and the Pacific have specific waste laws for agricultural biomass waste. Lack of regulations hinders the sustainable utilization of agricultural biomass waste. Currently, having only energy-related policies and laws in developing countries of Asia and Pacific countries does not translate into resource circulation of agricultural biomass waste, as tapping into this renewable energy source is not mandatory. Several clear goals or targets could be set related to agriculture biomass waste, including data collection, quantitative targets of utilization, quantitative targets of increase in installed capacity for bioenergy, quantitative targets of reducing GHG emissions, and encouraging technology sharing.

Food Waste

Food loss and waste represent lost opportunities for sustainable consumption and production, food security, and proper nutrition, and they occur in every stage of the food supply chain. Globally, 13.8 percent of food is lost along the supply chain, and 17 percent is wasted. The causes of food loss and waste in Asia and the Pacific region vary and may be influenced by several factors, from culture and consumer behavior to economic capacity. Policy approaches for food loss in the region are closely tied to the focus on food security in Asia and the Pacific nations as a response to the growing food demand and the need to reduce food losses along the food supply chain. Overall, the policy priorities in the region aim to increase the productivity and efficiency of food systems through various measures like improving agricultural knowledge and research, strengthening technological and personnel capability, and providing financial assistance. Food rescuing and redistribution of surplus foods are the main programs to curb food waste in the region. Technological innovation and behavioral change initiatives are developed to combat increasing food loss and waste in the region. Most of the technological initiatives present in the region are food recycling, composting, and conversion of waste to energy and other useful resources. To stimulate behavioral changes, education, and awareness campaigns are the most common initiatives done by Asia and Pacific nations. The causes of food loss and waste in Asia and the Pacific region vary and may be influenced by several factors, from culture and consumer behavior to economic capacity. Food losses and waste in developing nations can be attributed to financial, technological, and managerial inefficiencies.

Key guidance for policy design

Food produced has consumed valuable resources and may have contributed to environmental impacts related to the different phases of the food system. There is a need to develop practical, sustainable, and inclusive strategies and programs, particularly in food loss reduction (production and storage sector), and encourage all actors in the food supply chain to actively participate in crafting solutions against food loss and waste. Working towards reducing food loss through the development of rural communities will also be particularly beneficial to many of the countries where food loss is among the highest. Rural development needs to be reinvigorated by investing in rural infrastructure, education, training, technology, and knowledge transfer, specifically focusing on reducing food loss. Roads, telecommunication facilities, irrigation systems, water supply infrastructure, and other services that enable local production need to be developed to improve the position of the rural stakeholders and enhance the processes during the pre-retail stage. Adequate data collection, management, and analysis must also be encouraged since this will provide a clear picture of the problem and effectively inform policymaking and program development. Such data will also be helpful to track the progress of implemented measures on food loss and waste. Efforts must be developed throughout the region to address food waste management needs. The development of master plans, strategies, and frameworks should be the primary focus of the Asia and Pacific nations to ensure food supply and security. Food rescuing and redistribution of surplus foods are the main programs that can be done to curb food waste in the region. Technological innovation and behavioral change initiatives must be developed to combat increasing food loss and waste in the area. Addressing the challenges of food loss and food waste can benefit from cooperation between public and private entities, and north-south and south-south collaboration.

Healthcare and Medical Waste

The global medical waste management market was estimated to grow from $13.5 billion in 2019 to 14.9 billion in 2020 at a compound annual growth rate (CAGR) of 10.6 percent. The remarkable growth is mainly due to the COVID-19 outbreak and the measures to contain it. The market is expected to stabilize and reach $16.62 billion in 2023 at a CAGR of 3.8 percent. Many Asian resource-constrained countries have only fundamental laws and limited regulatory bodies to enforce healthcare waste management. Mishandling and ignorance have created various environmental problems, especially in densely populated countries. Some countries in the Asian region have formulated a broad range of regulations for healthcare waste management based on the respective legislations and regulatory authorities. Effective healthcare waste management (HWM) has become a significant environmental and green healthcare issue that needs government attention. Despite the severe nature of this issue, little attention has been given to waste management strategies, robust policy regulations and legislation, appropriate knowledge and awareness, allocating sufficient funds, and, most importantly, their implementation. Sorting at source, health care waste storage, transportation, and disposal are the main bottlenecks in many countries.

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Key guidance for policy design

A national model should be developed for managing healthcare waste, incorporating new technologies that can help reduce management costs with minimum labor requirements and mitigate risk. Recent technological advances in artificial intelligence, the Internet of Things, and blockchain technology could significantly contribute to solving environmental challenges posed by HCW. Such applications may be applied to waste generation, waste separation and packaging, waste storage containers, waste collection, temporary waste storage area, waste treatment, off-site and on-site transport of waste, waste disposal, hospital staff training, waste management regulations, hospital sewage system, energy, and waste recycling and reuse for establishing system and ease in implementation. A dedicated budget is needed at the national and local levels of the governments to tackle the situation. The Extend Producer Responsibility (EPR) must be applied to healthcare waste management at the national level, while the transboundary movement of the waste needs to be controlled. The illegal use of healthcare waste is a vulnerable area that laws and their implementation must prevent. Research should conduct more in-depth studies on healthcare waste management practice in regions where it is not given much attention. Behavioural and socioeconomic studies should be conducted to provide a solution for system improvement and to find loopholes in the current rules and policies that do not fit in circumstances of developing countries owing to the scarcity of resources. Data management is another issue which should be looked into to know the present condition for taking appropriate actions. More data should be generated with the help of scientific studies to pave the way for future researchers to develop environmentally sustainable healthcare waste management methods

Wastewater Management

Water security is one of the major challenges in Asia and the Pacific region, and urgent attention is needed. Most of the population experience water scarcity for at least one month per year. Industries are competing for water due to the economic expansion in the region. Irrigation for agricultural practices consumes the highest share of water in the region, accounting for 60-90 percent of annual wastewater withdrawals. Despite the achievements in Asia and the Pacific (home to 60 percent of the world's population), 1.5 billion people living in rural areas and 0.6 billion in urban areas still lack adequate water supply and sanitation facilities. The on-site sanitation systems have resulted in low treatment efficiencies of around 30-60 percent, lower than centralized sewerage systems using aeration. Although centralized sewerage systems are adequate solutions in densely populated areas, they are not widely used in many countries of Asia and Pacific countries mainly due to the significant investment cost required for the construction. It could be observed that most of the countries in Asia and the Pacific region have developed national water and sanitation policies. However, these policies do not adequately address all the issues associated with sanitation practices. In some Asia and Pacific countries, there is no proper coordination between the various sectors involved with the wastewater sector, which needs further strengthening while formulating these policies. Around 90 percent of the wastewater is discharged untreated. Several improvements are required to develop the wastewater sector in Asia and the Pacific region, particularly on public perception, policy, legislative and institutional reform, infrastructure and technology, research and development, and alternate financing.

Key guidance for policy design

The policy instruments to deal with the wastewater and sanitation sector can be broadly categorized into a) Public perception, b) Policy, legislative, and institutional reform, c) Infrastructure and technology, d) Research and Development, and e) Alternate Financing. Proper assessment of the public perception of the reuse of treated wastewater is highly important for successfully implementing these projects. In countries where knowledge of wastewater treatment is lacking, people are reluctant to reuse treated wastewater. Therefore, public perception is essential for initiating and operating these projects in the long term. Policies must be developed to support innovative processes for resource recovery from wastewater. Incentives should also be introduced to initiate these projects. Infrastructure and technology development are required to implement wastewater treatment technologies in Asia and the Pacific successfully. Research and development for the latest technologies is essential for improving the region's safe water and treated sludge reuse. Transferring technology and other regional resources is one of the best options to overcome wastewater management challenges. Public-private participation (PPP) projects within the region are significant in the wastewater sector. Blended finance schemes to provide additional finance for wastewater projects in developing countries are of high importance.

Recommendations for an effective waste management system

The essential policy directions for an effective waste management system can be categorised into four broad areas:

(i) Strengthening institutional foundation – legislations, policies, strategies, and standards

One of the biggest challenges is to develop a waste management ecosystem that can promote policies, legislation, and standards on the new and emerging waste streams. Resource efficiency, resource productivity, and waste reduction measures must be accelerated in the region. This directly influences effective service delivery, clarifying roles and responsibilities among different stakeholders and setting clear objectives, priorities, and built-in mechanisms for implementation, monitoring, feedback, and improvement. The efficient and effective waste management system should be flexible enough to accommodate new waste streams, such as waste from solar panels and electric vehicle batteries. A strict combination of policy instruments, such as banning and prohibition, should be applied prudently for effective management and to make the environment cleaner and safer. The involvement of stakeholder engagement and consensus-building-based policy must be addressed.

(ii) Securing finance and promotion of private sector investment

There is a need to reform the existing public sector funding in waste management systems. In addition to public sector funding, there is a need to intensify the involvement of the private sector to support the waste management system. This could be through public-private partnerships and “Polluter Pay Principles.” The brands should be more accountable for the cost of pollution from their products. The public sector financing should cover a volume-based fee system, solid waste collection and treatment charges to cover investment costs, and financial incentives such as subsidies and soft loans for tax benefits for sound recycling technologies can be introduced. Other mechanisms to mitigate pollution from a product should internalize costs incurred during its life cycle. Furthermore, the gaps between institutional and financial requirements should be bridged.

(iii) Filling implementation gaps between rural and urban areas

There is a huge gap between urban and rural areas in the sound waste management systems in the region. The rural waste management system should synergize with the urban one. For example, a hub-and-spoke model has the potential to extend the boundaries of 3R and waste management systems while diffusing the principles of circularity and sustainability across the population.

(iv) Promoting capacity development for emerging ecosystems, operation, and maintenance

As the system evolves with the internalization of circularity, sustainability, and environmental and social governance, the region urgently needs re-skilling and capacity development. The quick intervention of technologies in every new and emerging waste value chain has further accelerated and needs to be done as a top priority in the region. The capacity for data management and evidence-based policymaking must be enhanced for the region's continued progress of the 3R and circular economy.

The following key recommendations are proposed across the upstream, downstream, and the entire value chain in the region to achieve an effective waste management system:

No.	Interventions
Policy and Regulatory	
1.	Mandate requirement for recycled content to create demand.
2.	Ban or reduce contaminants, including hazardous contaminants and additives.
3.	Mandate labeling for biodegradable items and improve associated standards.
4.	Internalise the externalities associated with primary plastics through taxes or trading mechanisms. This will support the price of recycled plastics.
5.	Ban plastics from landfills to drive the supply of material, increase economies of scale, reduce costs, and increase resilience.
6.	Use Extended Producer Responsibility (EPR) regulation to drive the supply of material, increase economies of scale, reduce costs, and increase resilience.
7.	Ensure regulation is proportionate and clarify end-of-waste requirements.
8.	Develop effective voluntary standards for the recycling sector to limit the need for regulation.
9.	Industry-led initiatives to prevent waste crime, including transboundary movement.
10.	Regulation and enforcement to ensure consistent environmental standards in global markets.
11.	Mandate sellers to establish and audit end destinations for environmental standards.
Technology	
1.	Develop alternatives to problematic and hazardous additives and designs for the environment, including the effects of problematic additives in recycled waste.
2.	Support the development of domestic reprocessing capacity to reduce reliance on global markets.
3.	Support the development of better and more cost-effective technologies, including digital and smart, for collecting, transporting, and sorting waste.
4.	Businesses must promote design for the environment, agree to use recycled materials, and ensure that their raw material extractions are sustainable and socially responsible.
Institutional	
1.	Use public sector procurement policies to create demand for recycled content.
2.	Provide information and training to designers and manufacturers to encourage the use of recycled content.
3.	Provide information to consumers to encourage the purchase of products using recycled content and drive demand.
4.	Encourage openness about standards and provide information on end-destinations.
5.	Work with the supply chain to encourage the use of recycled content.
6.	Standardise waste collection systems to increase economies of scale and reduce costs.
7.	Introduce mandatory data reporting mechanisms for plastics recycling.
8.	Enforcement action is needed to reduce illegal dumping, particularly in low and middle income countries where it is commonplace.
9.	Enforcement action to reduce illegal waste trafficking.
10.	Charge waste producers for the collection and disposal of non-recyclable waste.
11.	Raise public awareness to create demand for recycled products and to reduce littering and dumping.
12.	Share best practices on all aspects of the collection, segregation, and reprocessing supply chain.
13.	Industry-led initiative to ensure consistent environmental standards in global markets.
14.	A plan needs to be in place for consumers to use products responsibly and reduce the amount of waste created during the use phase

15.	Circularity needs to be introduced with materials.
Financial	
1.	Set statutory targets for recycling to drive the supply of material, increase economies of scale, reduce costs, and improve the supply chain's resilience.
2.	Mobilise investment for developing the collection, sorting, and processing systems, particularly in low-income countries, including Island Nations.
3.	Direct or indirect government support for recycled products.
4.	Incentivize recycling over energy from waste by introducing a tax to reflect the relative environmental burden and benefit.
5.	Support developing and demonstrating commercially viable technologies for mixed and or low-value waste.
6.	Use financial market mechanisms to increase the resilience of the market to fluctuations in prices (e.g. futures markets).
7.	Businesses need to invest in technologies and innovation that make it possible to avoid materials that are unrecyclable because of their toxicity.

Conclusions

The extraction and processing of resources causes half of global greenhouse gas emissions and much of biodiversity loss and water stress. It is proved that the “take-make-use-discard” model is enormously inefficient. It depletes the planet’s limited resources, creates waste, pollution, and health issues, and substantially contributes to greenhouse gas emissions. Circular economy presents many opportunities for businesses in the waste management sector. To achieve a circular economy, it’s critical that the right policies and incentives should be in place in the region. The policies that incentivize intelligent design for circularity extend product life and establish infrastructure for waste management and recycling must be institutionalized in the region in the future. Furthermore, the new technologies will enhance the effective and efficient waste management system in the region. The future digitalization for networking and collaboration, innovation, and education will increase the adoption and impact of sustainable lifestyles and lead to clean and safe recycling. Initiatives must be taken for decontamination, neutralizing dangerous substances, toxic-free manufacturing, and safer production for people and the planet in the future.

Municipal solid waste could be effectively managed through a waste hierarchy approach that puts efforts to reduce consumption and increase reuse ahead of efforts focused on waste collection, recovery, and disposal. This approach focuses on the concrete actions, efforts, and initiatives to protect development gains from climate, disaster, and material depletion risks. Furthermore, this approach works hand in hand with the various global agendas, the 2030 Agenda for Sustainable Development, Sendai Framework, Basel, Rotterdam, and Stockholm conventions, the Paris Agreement on Climate Change, The Addis Ababa Action Agenda on Financing for Development, the New Urban Agenda. The momentum generated by the region for the facilitation of 3R policy dialogues and consolidation of 3R policies, strategies, programs, and projects need to be sustained in the future to achieve circularity and sustainability in the region and to converge towards sustainability and other UN conventions and global agendas.

Chapter 1: Background and Scope of Work

1.1 About the State of 3Rs in Asia and the Pacific Project

The State of 3Rs in Asia and the Pacific is a synthesis and status report to assess current status of 3Rs policy implementation in the region based on the country report submitted during the annual Reginal 3R and Circular Economy Forum in Asia and the Pacific, which is convened by UNCRD with the support of Ministry of the Environment, Government of Japan and other partners.

The State of the 3Rs in Asia and the Pacific Report was initiated and formulated in the 6th Regional 3R Forum in Maldives in 2015 as a joint and collaborative initiative with United Nations Centre for Regional Development (UNCRD) as the Secretariat of Regional 3R and Circular Economy Forum in Asia and the Pacific, with the funding support of the Ministry of the Environment of Japan (MOEJ). The project has aimed to assessing the progress of 3R related efforts in the region based on the country report on Ha Noi 3R Declaration – Sustainable 3R Goals for Asia and the Pacific for 2013-2023 (3RGs) and policy relevant data gathering on 3R and waste management.

The overall objective of State of the 3Rs in Asia and the Pacific is to assist participated countries of the Regional 3R and Circular Economy Forum in Asia and the Pacific on improved decision making towards effective implementation of 3Rs and environmentally sound waste management system at local, regional and national level.

The Regional 3R and Circular Economy Forum associated with the State of the 3Rs assessment and reporting in Asia and the Pacific are complementary to each other with an objective to maximize contributions towards the SDGs. While the Forum (policy process) flags emerging issues for policy and technological interventions, the State of 3R report (a scientific assessment process) aims to address and analyze them in a more detailed way in support of the monitoring needs of both the local and national governments for continuous improvement.

The specific objectives of this project are:

a) To develop synthesis and assessment report on current status of 3R policy implementation in the region based on country reports submitted to the Regional 3R and Circular Economy Forum in Asia and Pacific,
b) To compile data-relevant aimed at monitoring the progress of 3R policy implementation in the region in relation to the Hanoi 3R Declaration (2013-2023), and
c) To contribute to the Regional 3R and Circular Economy Forum in Asia and the Pacific by providing science-based advice on existing and future challenges and opportunities, including those on business, socioeconomic and sociocultural aspects of the 3R in advancing resource circulation and circular economy in the region.

Towards this end, this second series of work is based on the various thematic chapters: Plastic waste, E-waste, Chemical and Hazardous waste, Construction and Demolition waste (including Disaster waste), Agricultural biomass and livestock waste, Food waste, Healthcare and medical waste, Wastewater management, among others. This series also introduces the conventional and frontier technologies in advancing 3Rs and circular economy opportunities, followed by the experts' assessment of policy readiness for related Ha Noi 3R Goals and progress.

Sustainable development can be applied to corporate policy in the business world as it encompasses three key areas: economic, environmental, and social. Sustainable development requires that a country must contribute to economic growth, social progress and promote environmental sustainability. The three key areas of sustainable development can be ranked in the following order of importance, environmental conservation, economic development, and social sustainability. Achieving sustainable development involves a vigorous and urgent debate on different dimensions (Khajuria et al., 2009). Sustainability is a complex issue because it emerges as the result of the interplay of a whole range of different dimensions such as economic, environmental and social dimensions.

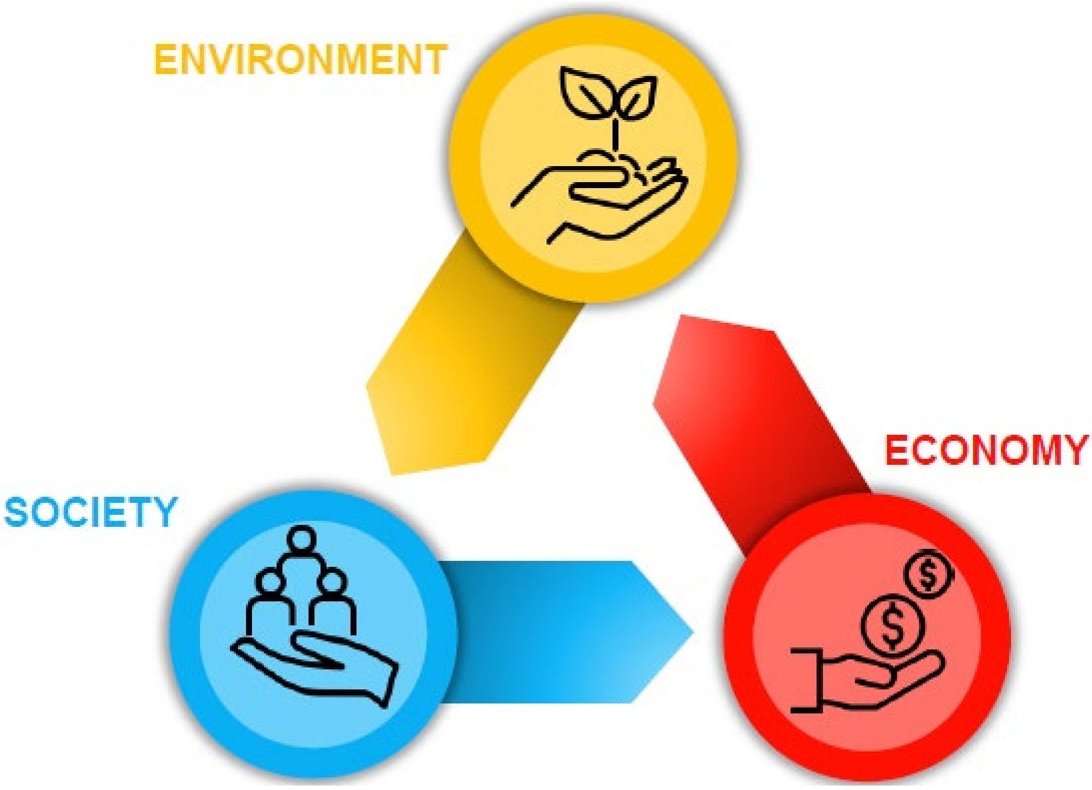

Figure 1.1-1: Three important dimensions to achieve Sustainable Development

Economic dimension
The Asia and the Pacific region has GDP above US$ 40 trillion (nominal) with US$ 8922 per capita (IMF, 2022). During the past 50 years the region has experienced rapid economic growth, higher incomes, reduced poverty reduction emerging rapidly expanding middle class. The two thirds of the regional economies, account for 80 percent of the region's GDP (UN ESCAP, 2018) as shown in **Figure 1.1-2**.

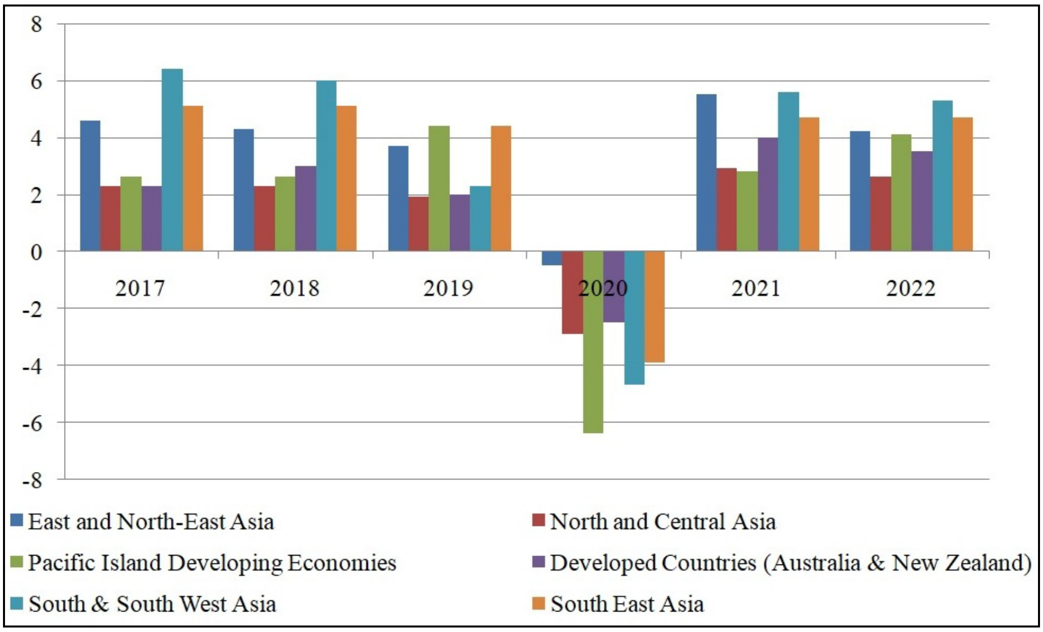

Figure 1.1-2: Sub-Regional GDP Growth Rates. Source: (UN ESCAP, 2018, 2021)

The region experienced major economic disruption in 2020 with the outbreak of COVID – 19 pandemics. There was a major economic contraction leading to widespread socio-economic and environmental implications. The economic performance in developing countries of Asia and the Pacific in 2020 was at its worst in history (UN ESCAP, 2018). Although Asia and the Pacific remained the most economically robust region in the world during the COVID – 19 pandemics in 2020 it is poised to lead the global economic recovery in 2021 **(Figure 1.1-2)**. As economic activities gradually normalize worldwide, pre-pandemic development challenges, existing vulnerabilities and downward economic pressures may re-emerge. It is evident that long-term economic growth momentum has been disrupted. For example developing countries in the region are characterized by a large degree of social and economic inequality (UNDP, 2014). The economic indicators show that within the region pre-pandemic status sets to return, domestic private consumption would be the major economic growth driver in recent years leading to waste generation and other environmental issues.

Environmental dimension

The unsustainable and inefficient utilization of natural resources along with population growth, industrialization and urbanization are resulting in pollution, declining biodiversity and natural resource depletion (UNEP, 2015). The trends indicate that there is a shift in economic activity from very resource-efficient economies to less resource efficient economies and having a negative impact on the environment.

In the region, the material productivity is double the world average. The region is expected to account for more than half of global production by 2050 (ADB, 2018b). The domestic material consumption per person increased from 2.9 tonnes in 1970 to 11.9 tonnes in 2015, with a high growth rate at 5.2 percent per annum. It has now surpassed the global average of 11.2 tonnes (ADB, 2018a). However, the energy generation continues to rely on fossil fuels and the share of renewable energy remains small despite that the use of renewable energy is very significant particularly solar and wind (UNEP, 2016).

In the past years, the region experienced four types of shocks: financial crises; negative terms-of-trade shocks; natural disasters; and epidemics and pandemics. The first two are “economic” shocks and the last two are “non-economic” shocks (UN ESCAP, 2021a). **Figure 1.1-3** shows that non-economic shocks have been significant since 2000because of the natural disasters and pandemics. However, the growth rates have significantly increased during the past twenty years and region shows their resilience.

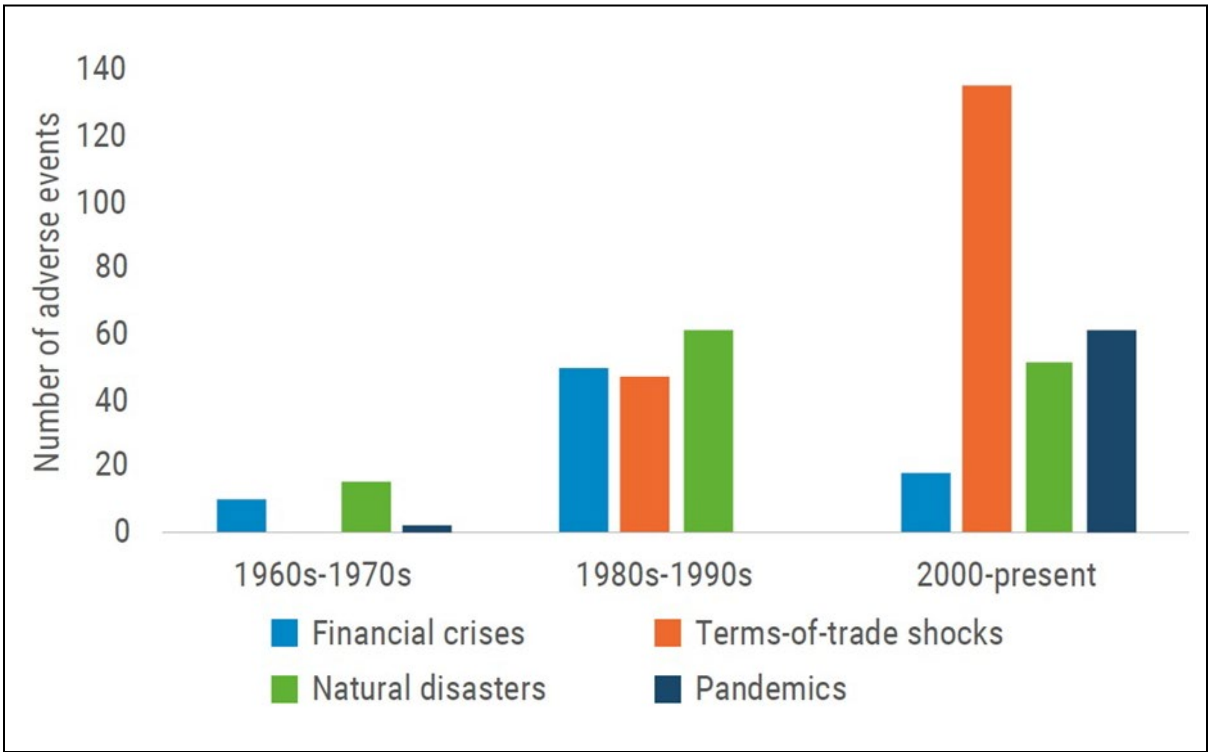

Figure 1.1-3: Shocks and Crises in Asia and the Pacific. Source: (UN ESCAP, 2021a)

The recent trends of waste generation is an important component in environmental dimension that indicates the total global waste generation is around 7–10 billion tonnes per year, of which total municipal solid waste (MSW) is around 2 billion tones (UNEP and ISWA, 2015). MSW generation in Asia and the Pacific is projected to increase until 2030, and is expected to reach 1.6 kilograms per person per day or around 1.4 billion tonnes a year (UNEP et al., 2017). The waste collection rates are moderate at 40–80 percent in developing countries in the region but reach almost 100 percent in more developed economies such as Japan, Australia, Republic of Korea and Singapore. During COVID – 19 pandemic higher waste generation abruptly strained waste management chains which were weak to begin with, and nearly caused them to collapse in some cities in the region (UN ESCAP, 2021a). The increasing frequency of pandemics such as COVID – 19 has been linked to unsustainable human activities and increasing pressures on ecosystems. It has been predicted that future pandemics will emerge more often, spread more rapidly, do more damage to the world economy and affect more people than COVID-19 (UN ESCAP, 2021a).

Social dimension

The rate of economic expansion and its capacity to be sustained is influenced by social development. Asia and the Pacific have the highest growth rate and are making significant strides in social and economic development (UN ESCAP, 2017). Rapid economic development has resulted in the creation of employment and has helped pull millions of people out of extreme poverty (UN ESCAP, 2017). Countries in the Asia-Pacific region have been at the forefront of the fight against global poverty. Despite leading the world in decreasing poverty, the Asia-Pacific region still has a significant number of people living in poverty. According to estimates, there were 400 million people living in extreme poverty in this region in 2013 (UN ESCAP, 2017).

Despite great economic development and poverty reduction in Asia-Pacific, health care, education, and other basic services remain uneven. The Asia-Pacific region missed the millennium development objective of decreasing the number of people without basic sanitation. Half a billion people, mostly in rural regions, lack access to better sanitation in the Asia-Pacific region (UN ESCAP, 2017). The likelihood of achieving the SDG sanitation objective by 2030 is low unless the rate of advancement increases (UN ESCAP, 2017).

A healthy, safe, and productive workforce is crucial to the region's success in reaching the SDGs. Asia and the Pacific have 3.2 billion working-age people and 2.1 billion employed. Asia-Pacific workers are unhealthy, unsafe, and unproductive (UN ESCAP, 2022). Despite modest progress towards the SDG since 2015, none of the objectives relating to a healthy, protected, and productive workforce is projected to be met by 2030 if the present momentum continues (UN ESCAP, 2022). Women and teenagers are disproportionately unemployed, with two in three employees lacking adequate jobs (Goal 8). Over half of the region's population lacks social protection (Goal 1), and over 20% face catastrophic out-of-pocket health costs (Goal 3) (UN ESCAP, 2022).

In addition, social security for all people in the Asia-Pacific region is essential to its growth and stability. Half of the region has no kind of social security. There are very few countries that have comprehensive social safety nets. Social security, but not health care, receives less than 2% of GDP in several countries in the region (UN ESCAP, 2021). The global average for investment is 11%, which is quite a little lower. Following the COVID-19 pandemic, efforts in Asia and the Pacific should focus on building a universal social protection floor to achieve SDGs 1, 3, 5, and 10. (UN ESCAP, 2021).

1.2 Relevance of 3R, Circular Economy, Ha Noi 3R Declaration and its connectivity with SDGs and its targets

UNCRD has been convening annual Regional 3R Forum in Asia and the Pacific since 2009 (renamed Regional 3R and Circular Economy Forum in Asia and the Pacific since 2019, during the 9th Regional 3R and Circular Economy Forum in Asia and the Pacific) with the objective view of providing strategic policy advice to national governmental authorities in mainstreaming the 3R in overall policy, planning and development. The Forum seeks to address policies, programme, measures, tools and technologies on sustainable production and consumption, integrated solid waste management in the context of promoting resource efficiency and as a means towards achieving zero waste society and step ahead towards the UN the 2030 Agenda for Sustainable Development. A chronology of Regional 3R and Circular Economy Forum with specific themes is given in **Table 1.2-1**.

Table 1.2-1: Chronology of Emergence of Regional 3R and Circular Economy Forum

Forum and Year	Venue and Date
1st Regional 3R Forum in Asia (2019)	Tokyo, Japan and November 11-12, 2009
2nd Regional 3R Forum in Asia (2010)	Kuala Lumpur, Malaysia and October 4-6, 2010
3rd Regional 3R Forum in Asia (2011)	Singapore and October 5-7, 2011
4th Regional 3R Forum in Asia (2013)	Ha Noi, Vietnam and March 18 – 20, 2013

Forum and Year	Venue and Date
5th Regional 3R Forum in Asia and the Pacific (2014)	Surabaya, Indonesia and February 25-27, 2014
6th Regional 3R Forum in Asia and the Pacific (2015)	Male, Maldives and August 16 - 19, 2015
7th Regional 3R Forum in Asia and the Pacific (2016)	Adelaide, South Australia, Australia and Nov 2 - 4, 2016
8th Regional 3R Forum in Asia and the Pacific (2018)	Brilliant Convention Centre, Indore, Madhya Pradesh, India and April 10-12, 2018
9th Regional 3R and Circular Economy Forum in Asia and the Pacific (2019)	Bangkok, Thailand and March 4- 6, 2019
10th Regional 3R and Circular Economy Forum in Asia and the Pacific (2020)	Webinar and Series of Webinars [Webinar I: 24 November 2020, Webinar II: 1 December 2020, Webinar III: 8 December 2020, Webinar IV: 14 December 2020, Webinar V:17 December 2020 and Webinar VI: 22 December 2020]
11th Regional 3R and Circular Economy Forum in Asia and the Pacific (2023)	Siem Reap, Cambodia and February 8-10, 2023

In order to demonstrate the participated countries achievements related to 3R efforts and renewed commitment to realizing a promising decade of the Ha Noi 3R Declaration (2013-2023) helps to take necessary actions and measures for achieving resource efficient society and a green economy in the Asia and the Pacific region. The Ha Noi 3R Declaration Sustainable 3R Goals for Asia and the Pacific for 2013-23 was emerged with 33 Sustainable Goals and adopted at the Fourth Regional 3R Forum in Asia and the Pacific (2013) **(Appendix 1)**.

Furthermore, the participated countries adopted the new declaration, particular on the concept of Circular Economy named Adelaide 3R Declaration towards the Promotion of Circular Economy in Achieving the Resource Efficient Societies in Asia and the Pacific under the 2030 Agenda for Sustainable Development adopted during the 7th Regional 3R and Circular Economy Forum in Asia and the Pacific (2016) This declaration provides a platform to integrating the 3R and resource efficiency plans, programs and policies in the overall policy, planning and development practices at local, provincial and national level with an aim of circularity while keeping the 2030 Agenda for Sustainable Development with 17 Sustainable Goals at its core in the context of waste. Continuously, the Regional 3R and Circular Economy Forum evolved by mainstreaming circular economy, SDGs (sustainability) and self-sufficiency in the region.

On 25 September 2015, the Heads of State and Government and High-Level Representatives of 193 Member States of the United Nations adopted the 2030 Development Agenda titled "Transforming our world: the 2030 Agenda for Sustainable Development". This Agenda outlines 17 Sustainable Development Goals (SDGs) and the associated 169 targets. It is structured around five pillars– people, prosperity, planet, peace and justice, and partnership.

While the Asia-Pacific countries are progressively addressing and adopting 3R policies and programs, including technological interventions, the region still faces a number of challenges in achieving sustainable consumption and production (SDG 12), among others. The relevant SDGs and their targets to the 3R related efforts have been summarized in **Table 1.2-2.**

Table 1.2-2: SDGs and their Targets

Goal 1 – end poverty in all its forms everywhere	• By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance.
Goal 6 – ensure availability and sustainable management of water and sanitation for all	• By 2030, the proportion of untreated wastewater should be halved
Goal 7 - Ensure access to affordable, reliable, sustainable and modern energy for all	• By 2030, ensure universal access to affordable, reliable and modern energy services. • By 2030, increase substantially the share of renewable energy in the global energy mix
Goal 8 – promote sustained, inclusive and sustainable economic growth and productive employment and decent work for all	• Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services
Goal 9 – build resilient infrastructure, promote inclusive and sustainable industrialization and foster Innovation	• Increase the access of small-scale industrial and other enterprises, in particular in developing countries, to financial services, including affordable credit, and their integration into value chains and markets • By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities
Goal 11 – make cities and human settlements inclusive, safe, resilient and sustainable	• By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management
Goal 12 – ensure sustainable consumption and production patterns	• Implement the 10-year framework of programmes on sustainable consumption and production, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries • By 2030, achieve the sustainable management and efficient use of natural resources • By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment • By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse • Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products
Goal 13 - Take urgent action to combat climate change and its impacts	• Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries. • Integrate climate change measures into national policies, strategies and planning
Goal 14 – conserve and sustainably use the oceans, seas and marine resources for sustainable Development	• By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land based activities, including marine debris and nutrient pollution • By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans • By 2030, increase the economic benefits to Small Island developing States and

	least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism • Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular small island developing States and least developed countries • Enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in UNCLOS, which provides the legal framework for the conservation and sustainable use of oceans and their resources, as recalled in paragraph 158 of The Future We Want
Goal 15 – protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	• Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species

1.3 Scope and Structure of the Report

"The Second State of the 3Rs in Asia and the Pacific – Advancing Circular Economy in Asia and the Pacific towards achieving the Sustainable Development Goals (SDGs)" is expected to be officially launched in FY 2024 when the Ha Noi 3R Declaration (2013-23) will complete its timeframe.

This report presents an experts' assessment of the regional 3R progress in using the indicators of the Ha Noi 3R Declaration – Sustainable 3R Goals for Asia and the Pacific (2013-2023) by implementing the State of the 3Rs in Asia and the Pacific project. In the next chapter, the report will discuss the urgent needs and multiple benefits of implementing 3R and Circular Economy approach in the region. The third chapter entitled 'Trends of 3Rs and Circular Economy in Asia and the Pacific' introduces the various thematic chapters such as plastic waste, e-waste, chemical and hazardous waste, food waste, agricultural biomass and livestock waste, healthcare and medical waste, wastewater and among others. In the fourth chapter, the report indicates the experts' assessment of policy readiness for related to Ha Noi 3R Declaration- Sustainable 3R Goals by each country. In last chapter, we provide major recommendations based on the analysis of policies and technologies along with the way forward section with circular solutions.

1.4 Key Messages: Chapter-1

Achieving sustainable development involves a vigorous and urgent debate on different dimensions. Sustainability is a complex issue because it emerges as the result of the interplay of a whole range of different dimensions such as economic, environmental and social dimensions.

The region has experienced rapid economic growth, leading to higher incomes, poverty reduction and the emergence of a rapidly expanding middle class. The region experienced major economic disruption in 2020 with the outbreak of COVID 19 pandemic. There was major economic contraction leading to widespread socio-economic and environmental implications. The economic performance in developing countries of Asia and the Pacific in 2020 was at its worst in history The economic indicators show that within the region pre-pandemic status sets to return, domestic private consumption would be the major economic growth driver in recent years leading to waste generation and other environmental issues.

The population growth, industrialization and urbanization had led to a sharp increase in natural resource use in the region, which is both unsustainable and inefficient, and results in pollution, declining biodiversity, and natural resource depletion. Key environmental issues facing the region include air pollution, water pollution and stress, marine litter at sea and along shorelines and coastal areas, inadequate waste management, deforestation, land degradation, and biodiversity loss.

As a regional response to these environmental issues, UNCRD has been convening annual Regional 3R Forum in Asia and the Pacific since 2009 under the project of Promotion of 3R in Asia and the Pacific, supported by the Ministry of the Environment, Japan. The 3R forum emerged by institutionalizing 3Rs from conceptual stage to functional stage in the fourth 3R Forum at Hanoi. In order to demonstrate their renewed commitment to realizing a promising decade (2013-2023) of sustainable actions and measures for achieving resource efficient society and a green economy in the Asia and the Pacific region through the implementation of the 3Rs, the countries in Asia and the Pacific resolved to voluntarily develop, introduce and implement policy options, programmes and projects towards realizing the 33 sustainable 3R goals in the region. The 3R goals while promoting circularity and self-sufficiency are integrated into the 2030 Agenda for Sustainable Development with 17 Sustainable Goals at its core.

The overall objective of the report in Asia and the Pacific is to assist the member countries of the Regional 3R and Circular Economy Forum in Asia and the Pacific for improved decision making towards effective implementation of 3Rs and resource circulation and circular economy approaches at local and national level, including promotion of 3Rs as an economic industry, by improving data, information, and indicators availability in all waste sectors (municipal, industrial, hazardous, WEEE, agricultural and biological, etc.). With an objective to achieve a low carbon and resource efficiency society, it also aims to contribute towards the 2030 Agenda for Sustainable Development and the Sustainable Development Goals (SDGs).

As an outcome of the implementation of 3R goals, it is time to assess their status at the end of 2023. Therefore, a report on the state of 3Rs has been planned. The report is also expected to serve as a precursor to the discussions leading to the formulation of the successor of the Hanoi 3R Declaration which comes to an end in 2023.

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Chapter 2: Urgent Needs and Multiple Benefits of Implementing 3Rs and Circular Economy Approach in Asia and the Pacific

2.1 3R and Resource efficiency as the heart of circular economy

The concept of 3R (Reduce, Reuse and Recycle) came into existence in 1990, which was adopted as an effective approach to waste management. Conceptually, it is organized into the waste hierarchy which prioritizes practices that prevent the generation of waste, followed by the reduce, reuse and recycle and treatment before its final disposal. The highest priority goes to “Reduce”, and then “Reuse” and lastly, “Recycle”. Reducing means choosing to use things to reduce the amount of waste generated. Reusing involves the repeated use of items or parts of items which still have usable aspects. Recycling implies recovering and using waste itself as a resource. **Figure 2.1** illustrates the circulation flow of resources, production and disposal to explain the principle of “3R plus”. The 3R concept evolved into resource efficiency and circular economy to increase competitiveness and to secure the supply of raw materials and energy as well as to reduce dependence on imports called economic interests, and the need to reduce pressures on the environment concerns.

As part of 3R and circular economy initiative, the goal of allowing the economy to create more with less, delivering greater value with less input, using resources in a sustainable way and minimizing their impacts on the environment well-emphasized. Further, this framework supports the shift towards a resource-efficient and low-carbon economy for policymakers and aimed to boost economic performance while reducing resource use, identify and create new opportunities for economic growth and greater innovation, and ensure security of supply of essential resources and limit the environmental impacts of resource use and fight against climate change. A linkage between material resource efficiency with waste policy and programme by avoiding final disposal of waste and by avoiding the purchase of virgin materials and reducing disposal costs helps to get environmental benefits) and economic gains.

Further evolution into circular economy represents a fundamental alternative to the linear take-make-consume-dispose economic model that currently predominates. The Ellen MacArthur Foundation defines a circular economy as one that is restorative, and one which aims to maintain the utility of products, components and materials and retain their value. It aims to minimize the need for new inputs of materials and energy, while reducing environmental pressures linked to resource extraction, emissions and waste. It provides opportunities to create well-being, growth and jobs, while reducing environmental pressures.

Circular economy can be further simplified that 3R is a system of closing, slowing and narrowing resources flows and loops. **Figure 2.1-1** clearly demonstrates the evolution of 3R into resource efficiency and circular economy. Therefore, 3R has a central role in enhancing resource efficiency and creating a circular economy that enables society to maximize the economic return on scarce resources.

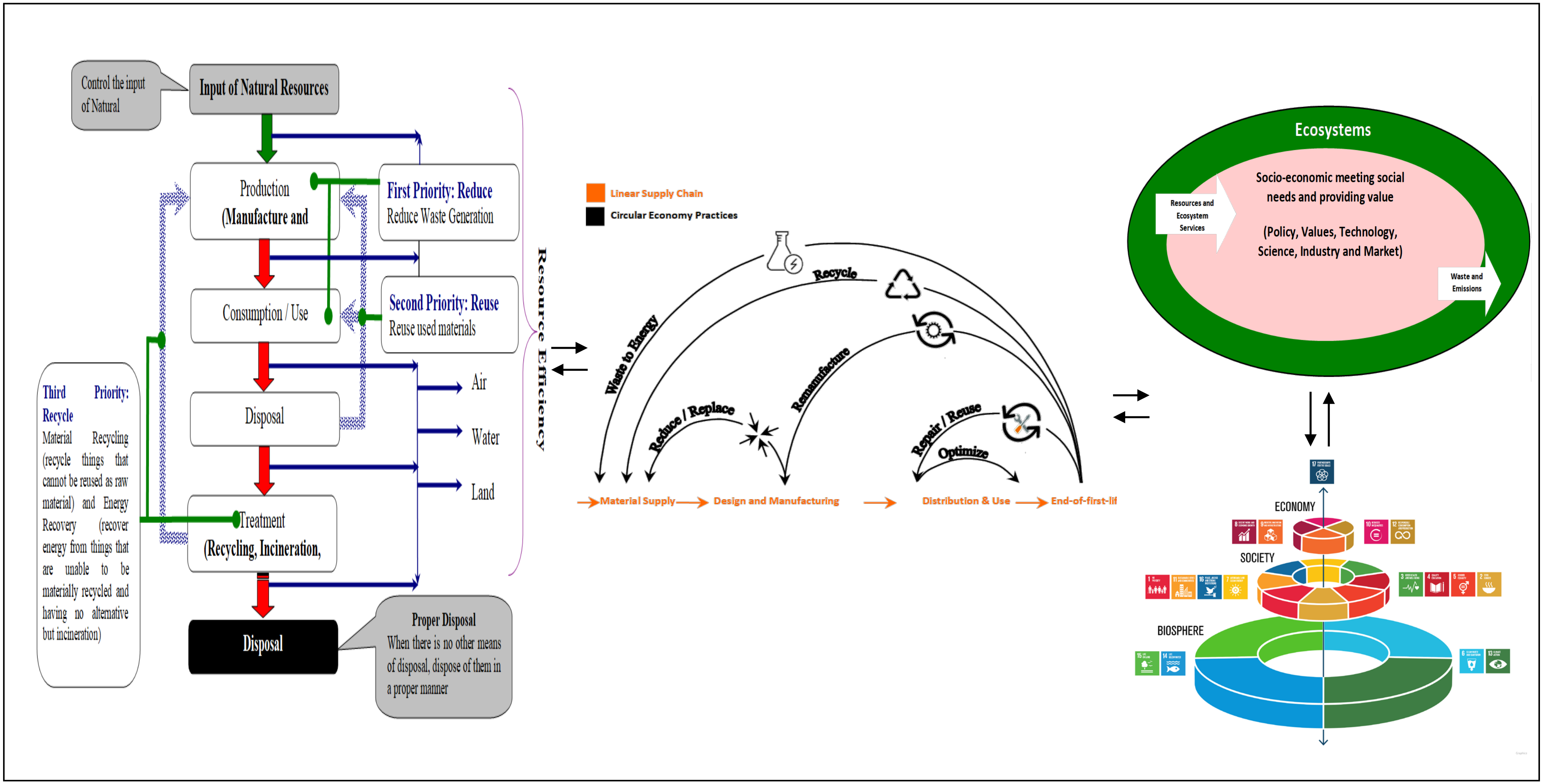


Figure 2.1-1: Concept of 3Rs, Resource Efficiency and Circular Economy. Source: (UNCRD, 2019a; UNCRD et al., 2018c)

2.2 *Key factors for promoting circular economy in Asia and the Pacific*

2.2.1 Circular Economy towards Sufficiency Economy

Sufficiency economy philosophy has several implications in achieving the SDGs. In a society specific societal function such as energy food need to be delivered using different means. There is a need to link 3R for narrowing, slowing and closing loops. Sufficiency economy philosophy is a thinking process and progress with a right mix of moderation, reasonableness and resiliency. Increasing the connection between circular economy and climate change is a need of the hour. Circular economy is an enabler for climate policy. A right mix of these factors has an impact on sustainability through balancing 4 dimensions of life vis-à-vis economy, society, environment and culture. For realizing the potential of 3R through sufficiency economy, there is a need for systemic approach mainly through regulation of economic drivers: jobs, security of supply and action plan at an international level that would initiate ground action.

2.2.2 Saving Resources and Energy and Increasing Resources Energy Efficiency

Asia and the Pacific region are a net importer of fossil fuels, where electricity generated from combustible fuels dominates and **(Figure 2.2.2-1)** GDP per unit use of energy is increasing since 2010 **(Figure 2.2.2-2)** (ADB, 2021a).

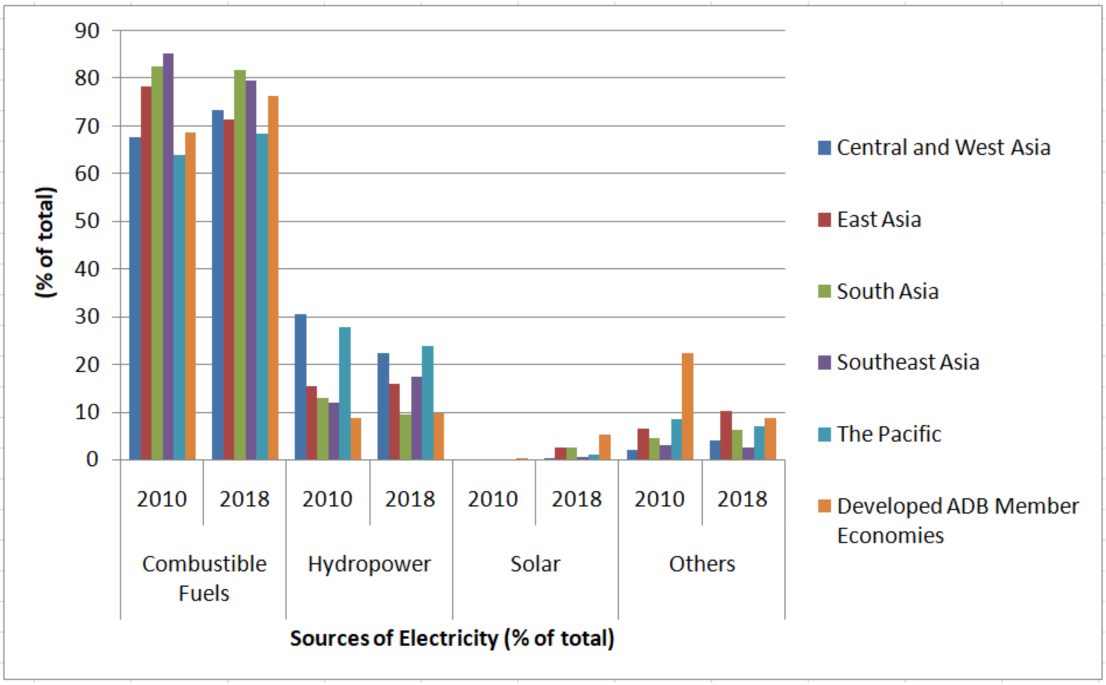


Figure 2.2.2-1: Electricity Production and Sources. Source: (ADB, 2021a)

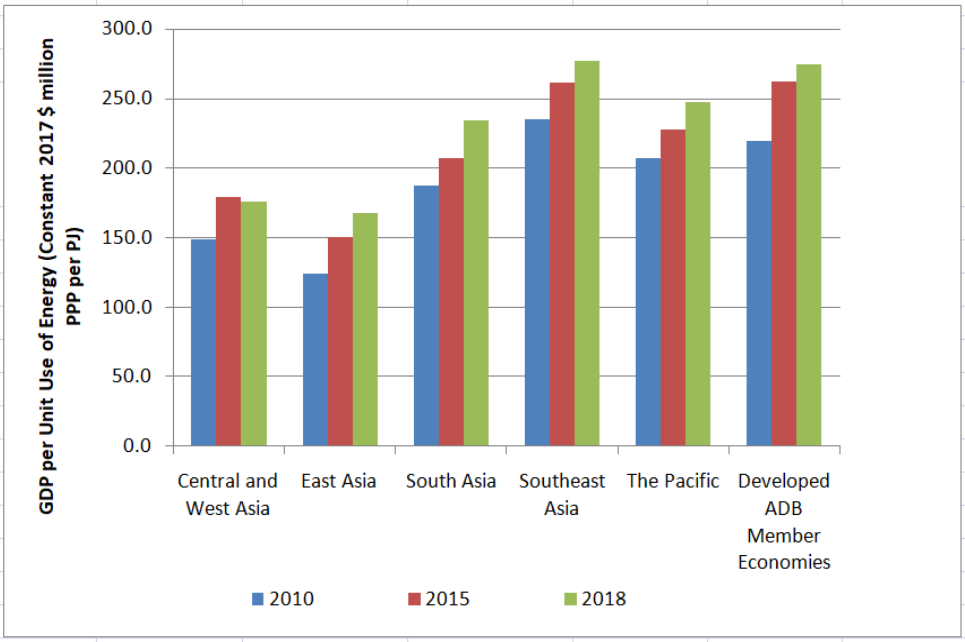


Figure 2.2.2-2: GDP Per Unit Use of Energy. Source: (ADB, 2021a)

The regional material consumption has increased sharply over the past four decades, accounting for more than 50 percent of world consumption while material productivity has not increased and is double the world average and four times the rest of the world's average. The net change in material footprint **(Figure 2.2.2-3)** indicates that it increased by 124 percent as compared to 29 percent for the rest of the world (UN ESCAP, 2020b).

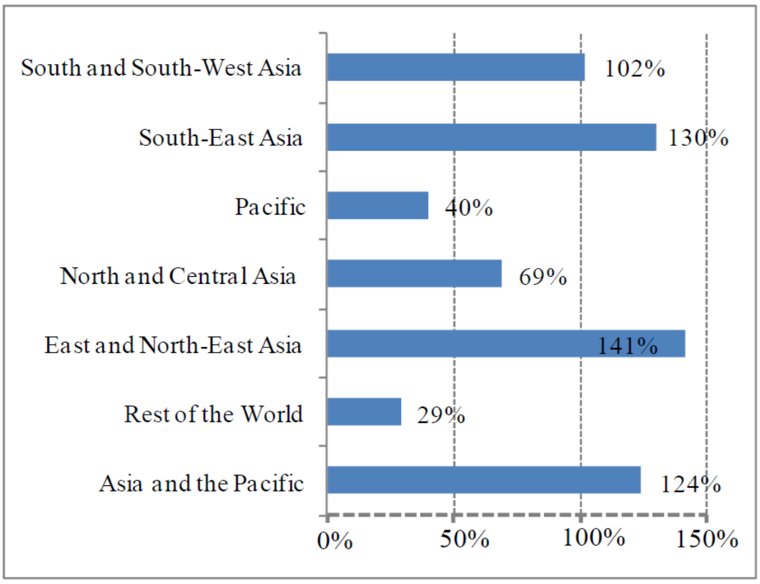


Figure 2.2.2-3: Net Change in Material Footprint, 2000-2017. Source: (UN ESCAP, 2020b).

In terms of material resource use comprising of fossil fuels, biomass, metals and non-metallic minerals, the region is the most resource-intensive both in terms of domestic material consumption and material footprint and has approximately 2 Kg per US$ domestic material consumption per dollar of economic output in comparison to 1.2 Kg per US$ of world's average (ADB, 2018a). **Figure 2.2.2-4** and **Figure 2.2.2-5** indicate variation in the level of resource-use intensity within sub regions. Apart from the Pacific, all sub regions have a higher resource intensity than the world average (UN ESCAP, 2018b).

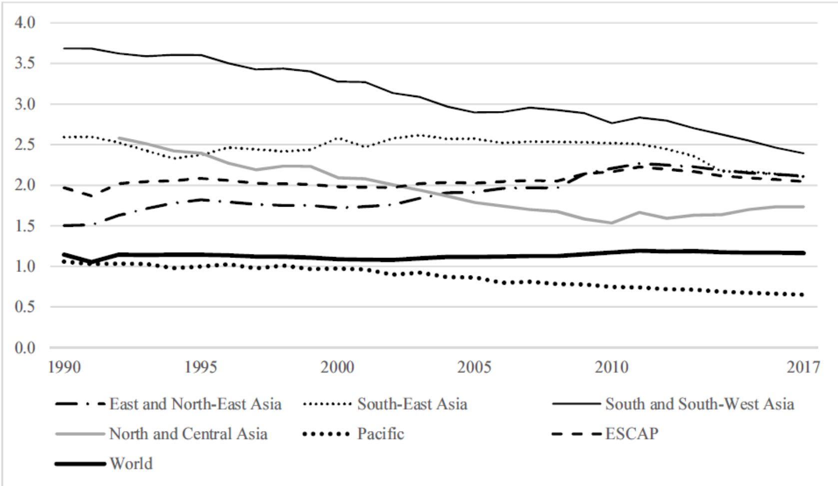


Figure 2.2.2-4: Trends in resource intensity: domestic material consumption, 1990–2017 (Kilograms per United States dollar). Source: (UN ESCAP, 2018b)

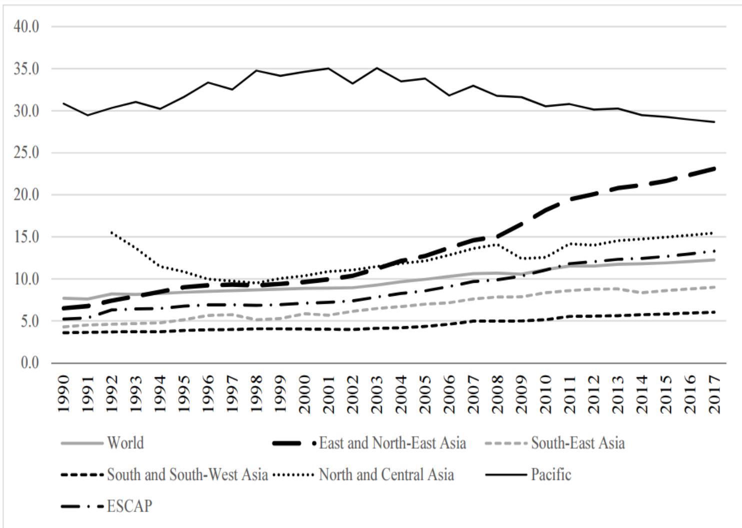


Figure 2.2.2-5: Trends in domestic material consumption, 1990–2017 (Tons per capita). Source: (UN ESCAP, 2018b)**.**

Economic development has positive correlations with resource intensity in the region. It indicates that if countries are developed then they may have higher per capita resource consumption. However, if developing countries are in a high growth trajectory then their per capita resource consumption may accelerate in future. As a result, net cumulative effect can strain the finite pool of natural resources and may exceed the threshold rate at which these resources could be replenished (UN ESCAP, 2020b). Non-metallic minerals such as construction materials are projected to grow rapidly because of needs and a lack of high-value recycling. The rapid increase in both primary and secondary recycled metals for India, Indonesia, PR China, and other developing countries is predicted and calls for conserving resources as well as increasing resource efficiency in the region (OECD, 2019c). Future predicted trends in material use till 2060 are given below in Figure 2.2.2-6.

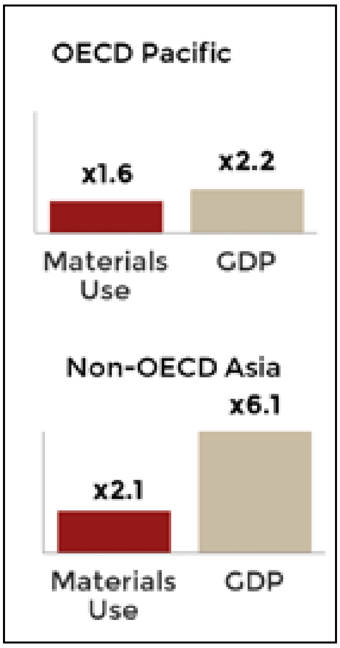
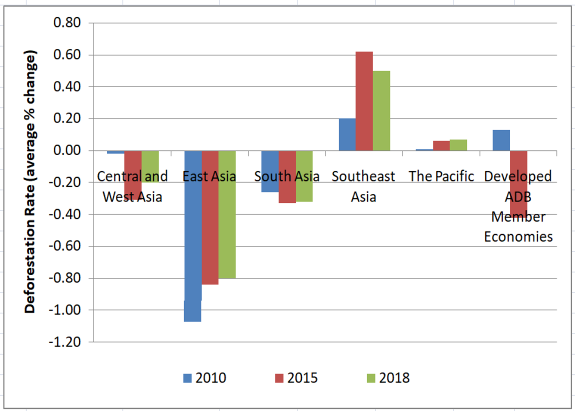
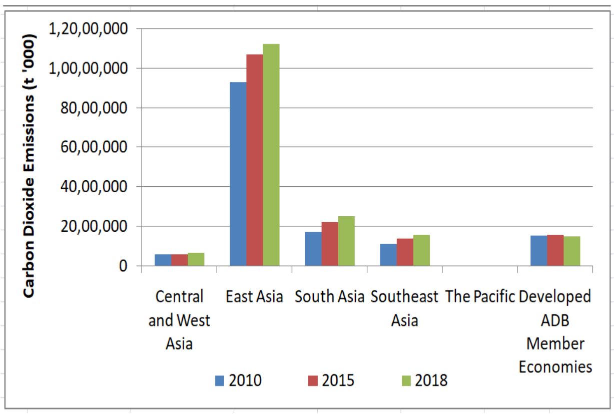


Figure 2.2.2-6: Growth of Materials Use and GDP, 2011 – 2060. Source: (OECD, 2019c)

2.2.3 Greening, Improving Environmental Conditions and Carbon Neutrality

The region is experiencing increasing deforestation, higher carbon dioxide, nitrous oxide and methane emissions (ADB, 2021a) as shown in Figure 2.2.3-1 Deforestation and land degradation throughout the region is caused by several factors that include demand for timber products and palm oil, intensive farming and urbanization. Forest and vegetation fires are major causes of air pollution in the region. However, there is some evidence of improving the environmental conditions by adopting practices related to carbon neutrality in the region.





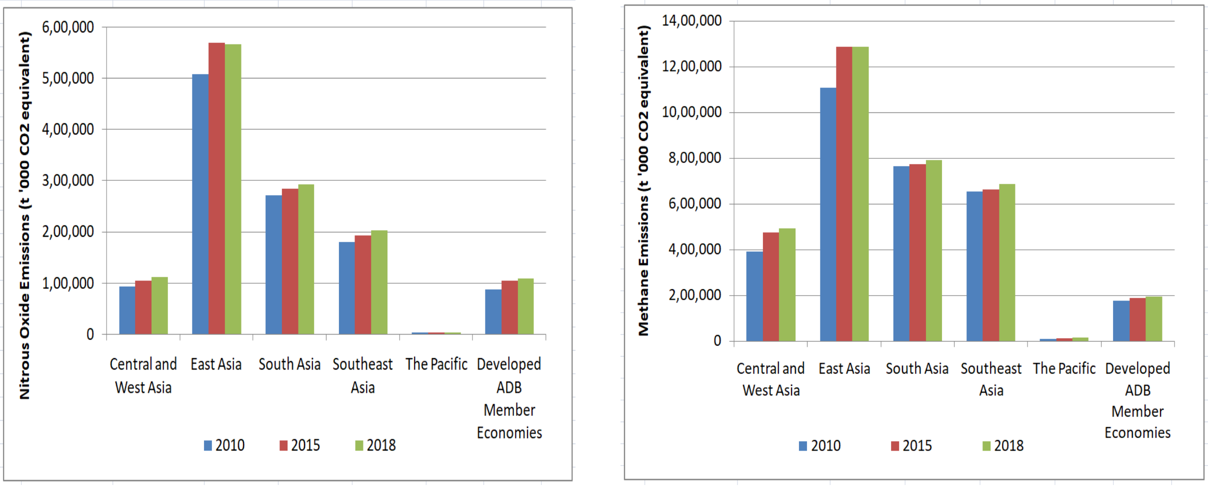


Figure 2.2.3-1: Deforestation and Pollution. Source: (ADB, 2021a).

2.2.4 Improving Proper Solid Waste management for Public Health and Environmental Protection

The waste generation trend is expected to grow rapidly till 2030 and will stabilize beyond 2050 (UNEP et al., 2017a). This trend also strongly correlates with material intensity trends for the region as shown in **Figure 2.2.4-1.** The improvement in solid waste management is must due to increasing public pressure for healthy conditions.

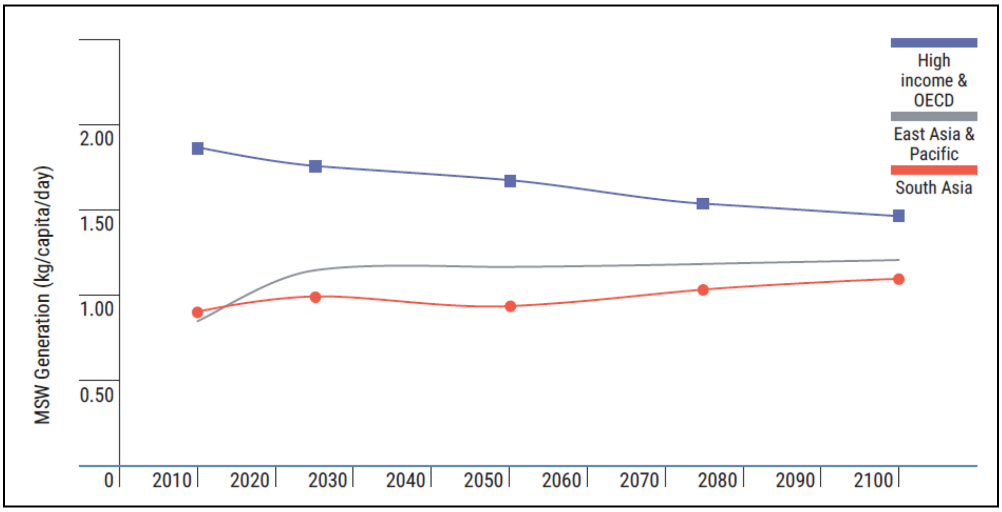


Figure 2.2.4-1: Forecasted MSW Generation Per Capita Across Different Regions, 2010–2100. Source: (UNEP et al., 2017a)

2.2.5 Climate Change Mitigation

The greenhouse gas emissions are forecasted to rise through 2050 with the current rate of domestic material consumption under business-as-usual scenario **(Figure 2.2.5-1).** The projected climate change in region could lead to a shortage of water resources, widespread land degradation and increased desertification (UN ESCAP, 2020a).

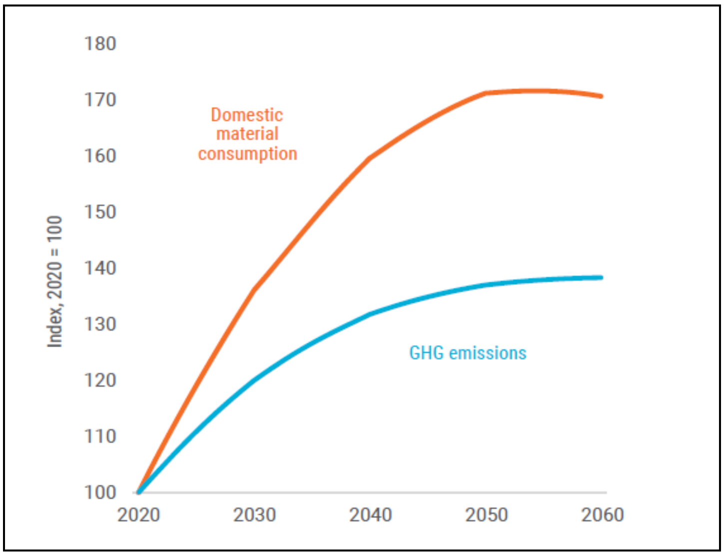


Figure 2.2.5-1: Domestic Material Consumption and GHG Emissions in 2020-2060 with 2020 Levels. Source: (UN ESCAP, 2020a)

2.2.6 Promoting Green Jobs, Green Economy, and More Prosperous Living

The 2030 Agenda for Sustainable Development Goals (SDGs) agreed on the notion of a Green Economy and underlined the current environmental, economic and social challenges such as increasing gap in poverty, hunger and education between different strata of society in the region is clearly visible.

Within this purview, recycling and reuse of wastes based on 3R policies and circular economy have the potential to create green job opportunities and at the same time promote the transition to a green economy. As recycling continues to grow, more workers will be needed to collect, sort and process recyclables. Reuse centres can also be used as means of creating green job opportunities. Furthermore, these processes have the potential to encourage more green investment opportunities in economic activities such as resource recovery, Waste-to-Energy, and the promotion of eco-industrial zones. These initiatives can significantly contribute to efforts aimed at encouraging healthier and more liveable cities, with increased quality of life. The increasing trends of transition into technology based circular economy offers tremendous potential to promote green jobs, green economy and more prosperous living.

2.3 Role of 3R and Circular Economy towards Achieving the SDGs

Establishing 3R and circular economy are the step wise approach achieving self-sufficiency which is represented by SDGs. Sound material accounting of material flows is very crucial to determine the circularity and self-sufficiency ecosystem. Further, the technology and unexpected exigencies like COVID-19 are externalities which impact the emerging ecosystem. The countries are distributing their risks while developing infrastructure through innovative financing such as Public-Private-Partnership (PPP).

The concept of 3Rs, which is central to circular economy ultimately converge to sufficiency economy and sustainability. **(Figure 2.1-1)** The principle of Sufficiency Economy looks at sustainability with a balanced perspective and refers to the balancing of four dimensions of life: economy, society, environment, culture. It shares ultimate common principles and objectives with SDG, seeking to eradicate poverty and reduce inequality as a means to achieve sustainable development, and towards the balance among three dimensions of sustainable development.

The Sustainable Development Goals (SDGs) were launched in 2015 and define a universal framework for measurement of sustainability across countries, regions, business entities etc. They are seventeen in number covering areas such as the eradication of extreme poverty and hunger, quality education for all, gender equality, protection of natural resources, addressing climate change, improving disaster resilience, attaining peace and security, achieving economic growth, and creating decent jobs. These indicators were developed to ensure that economies can track their collective progress toward 2030 targets and indictors for inclusive, safe, resilient, smart and sustainable development.

SDG 12 calls to ensure sustainable consumption and production patterns for example, material footprint and domestic materials consumption, food loss, recycling rates and hazardous waste production, sustainable public procurement actions. These indicators are directly affected by the implementation of circular economy and 3R policies. They aim at the introduction of a sustainable lifestyle, in which producers and consumers move away from the linear make-use-dispose model and introduce sharing, leasing, repair and remanufacturing concepts. Therefore, circular economy and 3R go beyond the efficient collection and recycling of waste.

SDG 7, affordable and clean energy that aims at energy efficiency, less polluting energy generation from clean conventional sources and renewable sources. SDG 9 aims to upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes. SDG 6, clean water and sanitation not only aims to reduce water pollution through treatment but also conserve it through reduce, reuse and recycle. It also aims to improve public health through provisions of adequate sanitation to every stratum of society. SDG 11 aims for sustainable cities and communities while SDG 13 aims for Climate action including decarbonization, carbon neutrality, adaptation, mitigation and governance.

In Asia and the Pacific region, where economies are integrated by the use and management of natural resources has economic, social and environmental consequences that often extend beyond the borders of single countries or regions that affect future generations. These consequences arise due to the rate of exploitation and the productivity of natural resource stocks. This creates the environmental pressures associated with the extraction, processing, use and disposal of materials. The costs of mitigating these pressures affect international trade and market prices of raw materials and other goods. As a result, the productivity and the competitiveness of the economy of the countries and region gets impacted (OECD, 2008).

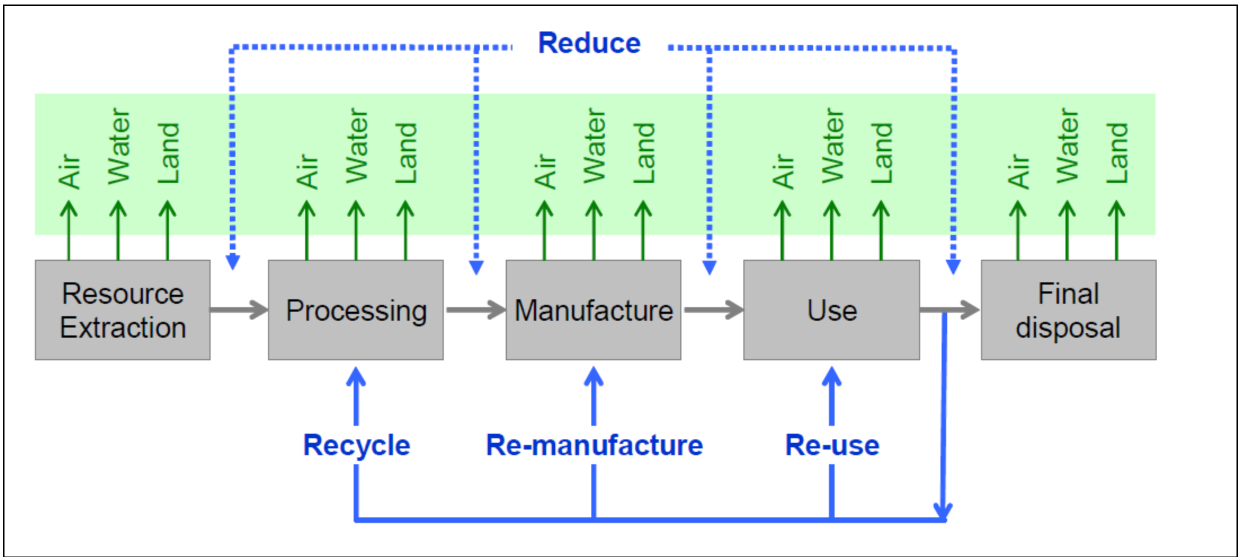
Therefore, using materials efficiently is important for environmental quality, economic growth and prosperity. Circular economy transitioning into sufficiency economy (SDG) requires sound material flow to achieve sustainable resource use and to ensure that the flows of materials are managed in an efficient way through the economic system. It is critical not only from an environmental perspective but also from an economic and trade perspective. It facilitates resource productivity, achieve efficiency gains and secure adequate supplies of material resources to the economy while limiting the adverse environmental impacts associated with their extraction, processing, use and disposal at the same time (OECD, 2008).

Many countries in the region address these issues in their national sustainable development strategies or environmental plans. They have launched initiatives to promote waste prevention, integrated product policies, 3R related policies, sustainable materials management, and circular economy approaches as depicted in **Table 2.3-1**.

Table 2.3-1: Laws on Circular Economy in Japan Source: (ABD, 2022a).

Economy	Law	Year	Major Content for Circular Economy
Japan	Law for Promotion of Sorted Collection and Recycling of Containers and Packaging (Container and Packaging Recycling Law)	2000	Applying EPR to glass containers, plastic packages and containers, and paper cartons and packages.
	Basic Act for Establishing a Sound Material-Cycle Society	2001	Basic act for promoting 3R (reduce, reuse, and recycle).
	Law for Promotion of Effective Utilization of Resources	2001	Labeling for recycling. Encourage voluntary initiative by industry.
	Law for the Recycling of Specified Kinds of Home Appliances (Home Appliance Recycling Law)	2001	Applying EPR to televisions, air-conditioners, refrigerators, and washing machines.
	Act on Promotion of Procurement of Eco-Friendly Goods and Services by the State and Other Entities (Act on Promoting Green Procurement)	2001	Require governments and incorporated administrative agencies to procure eco-friendly products including recycled goods.
	Law for Promotion of Recycling and Related Activities for Treatment of Cyclical Food Resources (Food Wastes Recycling Law)	2001	Big generators of food waste should make efforts to reduce and recycle food waste.
	Construction Materials Recycling Law	2002	Contractors are required to sort out and recycle waste generated in demolition work of buildings.
	Law for the Recycling of End-of-Life Vehicles (End-of-life Vehicles Recycling Law)	2005	Applying EPR to end-of-life vehicles.
	Act on Promotion of Recycling of Small Waste Electrical and Electronic Equipment (Small Home Appliance Recycling Law)	2012	Promote recycling of small waste electrical and electronic equipment, such as mobile phones, radios, digital cameras, personal computers, and printers.
	Plastic Resource Circulation Act	2022	To promote circulation of plastics in a comprehensive and planned way, basic policy includes: • Design for the Environment by manufacturers • Reduction of single-use plastics by retailers and service providers • Separation, collection and recycling of plastic waste by municipalities and private sectors

Material Flow Analysis is among the most useful tools which assists in determining SDG indicators and guide decision making. It provides an integrated view of physical resource flows through the economy while capturing flows that do not enter the economy, but that are relevant from an environmental point of view at the same time. It also shows how flows of materials shift among countries and within countries, and how this affects the economy and the environment within and beyond national borders (OECD, 2008).



Object of interest	**Substances** chemical elements or compounds	**Materials** raw materials, semi finished goods	**Products** (manufactured goods) batteries, cars, computers, textiles	**Businesses** establishments, enterprises	**Economic Activities** mining, construction, chemical industry, ironand steel industry	**Countries, Regions** total materials groups of materials, particular materials
Type of analysis	**Substance Flow Analysis**	**Material System Analysis**	**Life Cycle Assessment**	**Business level Material flow Analysis**	**Input-Output Analysis**	**Economy-wide Material flow Analysis**

Figure 2.3-1: Material flow through the commercial life cycle and their application. Source: (OECD, 2008).

The accounting of material flow analysis tracks both direct flows, physically entering the economy and indirect and unused flows. The mapping of different types of analysis and technique used is shown in **Figure 2.3-1**. Few countries in the region, 3R policies have been institutionalized at any level, substance, materials, products, sector, business or economic activity have experienced the benefits such accounting towards achieving sufficiency economy. In this regard, SDG reports by countries and business entities in the region provide adequate evidence of approaches, policies and programmes (UNEP et al., 2017a).

2.3.1 Technology as a Driver for clean Energy and Green Industry towards Sufficiency Economy

Today's multidimensional global challenges include addressal of triple planetary crisis of pollution, biodiversity loss and climate change along with poverty reduction. Technology development and application has been accelerated during the last two years due to pandemic. Accordingly, policies have to undergo significant changes in future. Policies designed to stimulate early-stage growth and technology development have led to clean energy technologies now being cost-competitive with conventional energy technologies. This has enabled some governments to pass ambitious laws to decarbonize their economies by fully relying on clean energy (Dahlke et al., 2021).

Further, cost factors are driving force for technology adoption and replication, such as falling of lithium battery prices, sectorial integration with solar storage, growth in green hydrogen is expected to drive the market. In addition, the heavy-duty electric vehicles have become a promising solution to reduce emissions (Jackson, 2021). Some emerging trends may drive clean energy and green industry towards sufficiency economy as given below.

- New energy-based generation output forecasting and operation monitoring.
- Key technologies of large-scale wind power dispatch: A grid-based forecasting technology for distributed wind power generation has been developed and applied in many parts of PR China.(Dahlke et al., 2021).
- Technologies for energy storage system operation: Technological breakthroughs have been made in promoting the application of intermittent access for energy storage systems.
- Green hydrogen is the renewable energy where technological options are crucial to accelerate decarbonization efforts, particularly for hard-to-abate sectors where electrification is not viable eg, for heavy industry, chemicals and transportation (Jackson, 2021).

Processes and products are becoming more resource efficient than their earlier versions due to various economic, environmental and societal compulsions. Research for cost effective and affordable alternate materials, which deliver the same functionality with less amount of pollution has accelerated their adoption such as alternate material to plastics. New recycling technologies, recycling of solar panels and wind turbine blades require scale up and commercialization.

Digitization and Artificial Intelligence is going to be an increasing demand to manage the complexity of operations. For smart and clean cities, more effective protection, control, automation and communication systems are required. This technology will enable greener operations in implementing predictive maintenance of clean energy, solar, wind and recycling industry of energy sources. This could support not only the smart management of supply chain and cost, but also the carbon profile of energy sources. For instance, in the summer of 2020, while the passenger aviation industry was collapsing due to the COVID-19 pandemic, e-business maintained a robust flow of cargo airplanes from products to consumer. It shows the promising attempts to use AI in simulating new catalysts for more efficient chemical processes and developing new nano materials for higher capacity batteries (IEA, 2021a).

Sustainability should be integrated into research in this field. Low-carbon industrial technologies, chemistry for low-carbon aviation fuel, and new approaches to nuclear energy will benefit from the systematic application of machine learning. The full power of digital tools to help the innovation process will drive the green industry to sufficiency economy (IEA, 2021a).

2.3.2 Importance of Public-Private-Partnership (PPP) for Advancing Circular Economy

Public-Private Partnerships (PPPs) provide an innovative way for driving economic development, environmental sustainability and social inclusiveness agenda of respective governments in the region. It is based on the premise that the private sector also has great potential to bring in innovation, efficiency, and financing to improve infrastructure and public services.

Conceptually, PPP financing options has different characteristics and relationships between the public and private sectors. These relationships are based on long-term contracts with the main aim of providing public services. In such contracts, the public partner is responsible for defining the standard of a public service that it can pay for, while the private partner is responsible for making this service available. The private partner bears significant risks relating to the financing, construction, operation, and maintenance of infrastructure, while the public partner bears the risks regarding regulatory issues and paying only for services received (Bogovac et al., 2021).

The implementation of many successful PPP projects is based on the concept of 3Rs and circular economy has been demonstrated. They have led to the number of reduced wastes and recover products and materials by 3R approach and circular economy. In Japan, municipal wastes of food and beverage and non-recycled paper and plastics which have high calorific value to generate power and thermal recycling for power generation has been successfully demonstrated under PPP (Hongo, 2014).

Case of Waste to Energy in Japan: Waste to energy is the generation of electricity by waste incineration, is very common in Japan due to narrow land. 387 waste incineration plants generate electricity with a total capacity of 2,079 MW. The annual generation amount in April 2020 to March 2021 was 10,153 GWh, which is equivalent to the amount of annual power consumption of about 2,380,000 homes. Out of 387 waste incineration facilities, 182 are operated and managed on PPP scheme. As a general principle, 3R+Renewable has higher priority while thermal recovery is considered as the last option in Japan (**Figure 2.3.4-1**).

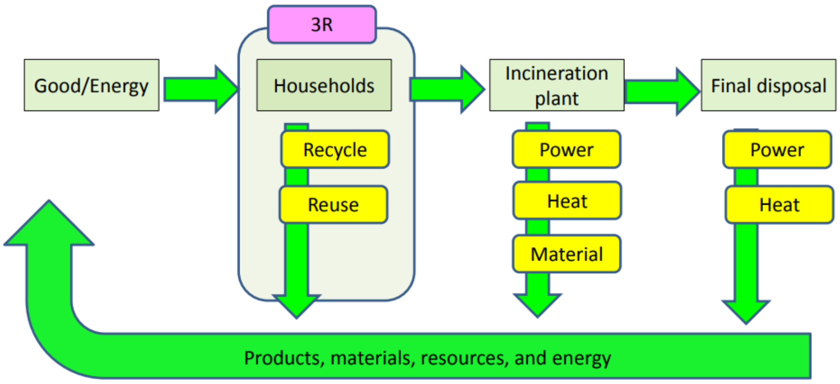


Figure 2.3.2-1: Concept of Material Flow. Source: (MOEJ, 2022b)

The onset of market shocks like COVID-19 and growing fiscal constraints will require the increasing use of alternative models which include greater private sector involvement through PPP (UNECE, 2021). COVID-19 has brought to light several critical social challenges and the infrastructure and public services needed to tackle them, which come at a high cost. Examples include access to healthcare, access to water supply and sanitation, access to waste management, and access to education. PPPs projects are needed urgently to help governments with limited resources to fill this gap (Bogovac et al., 2021). Therefore, the possibility of raising additional finance in an environment of budgetary restrictions, pandemic and the use of entrepreneurial operational efficiencies which aims to reduce costs and increase the quality and efficiency of public services with the rapid development of infrastructure are immense (UNECE, 2021).

2.3.3 3Rs and Circular Economy under COVID-19 Pandemic

Asia and the Pacific regional growth path were unlikely to remain linear, in normal or under pandemic crisis such as COVID-19 pandemic. Some higher-income countries, already encountering restricted labor supply, budget constraints associated with aging populations, impacts of international trade tensions, and significant financing needed to address climate-related disasters (ADB, 2021a). However, the COVID-19 pandemic has created enormous challenges for many economies attempting to achieve development targets, including the SDGs. It has magnified long-standing social and economic inequities experienced by millions living below or near the poverty line. It has hit hard on poorer segments of population particularly on health, education, work disruptions and livelihood (ADB, 2021a).

An inward turn in economic and environmental policy was already underway in the region before the arrival of the COVID-19 as reflected in **Table 2.3.3-1** but the global disruption caused by the pandemic has accelerated this shift. Some countries adopted circular economic policies, such as applying extended producer responsibility (EPR) since the 1990s, however, from 2000, most of the countries have gradually adopted circular economy policies **(Table 2.3.3-1)**.

Table 2.3.3-1: Circular Economy Related Regulations before COVID-19. Source: (ABD, 2022a)

Economy	Law	Year	Major Content for Circular Economy
PR China	Provisional Management Measures on Packaging Resources	1999	Identify recovery channels, principles for sorting, and requirements for treating packaging materials.
	Management Rules of End-of-Life Vehicles Take-Back	2001	Qualification of end-of-life vehicles recycling company. Prohibit reuse of five assemblies (engine, steering, transmission, front and rear axles, and frame).
	Interim Measures for Administration of Automotive Parts Remanufacturing	2008	Specify the model companies for remanufacturing.
	Circular Economy Promotion Law	2008	Basic law.
	Regulation on the Administration of Recovery and Disposal of Waste and Discarded Electrical and Electronic Products	2009	Collecting recycling fee from producers of electrical and electronic products, and distributing the funds to recycling companies to cover the cost of recycling.
Viet Nam	Prime Minister Decision on Recall and Treatment of Discarded Product	2015	Applying EPR to some e-wastes, tire, and batteries from July 2016, and vehicles from January 2018.
	Environmental Protection Law	Revised in 2020	EPR is applied to food and beverage, electrical goods, tires, batteries, lubricants, and vehicles sectors.
Singapore	Resource Sustainability Act	2019	Applying EPR to e-waste, packages, and containers.
	Zero Waste Master Plan	2019	Priority waste stream: food waste, e-waste, and packaging.
Indonesia	Regulation of the Minister of Environment and Forestry Regarding Road Map to Waste	2019	Require producers to make a plan and report to reduce packaging and containers.

Economy	Law	Year	Major Content for Circular Economy
	Reduction by Producers		

During COVID-19 pandemic, the two major countries, PR China and India has taken up urgent steps to increase circularity. In PR China, policymakers are discussing a "dual circulation" strategy that aims to foster resilience by emphasizing the "internal" circulation of the domestic economy over the "external" circulation of the global economy. In India, the government has launched a "self-reliance" movement designed to reduce perceived supply-chain vulnerabilities. Some of major regulatory steps taken by Indian government are summarized in **Table 2.3.3-2**.

Table 2.3.3-2: Circularity Based Waste Management Regulations in India. Source: (CPCB, 2022b)

Economy	Law	Year	Major Content for Circular Economy
India	Plastic Waste Management rules	2016	Guidelines for Recycling of Plastics
	1st Amendment (CPCB EPR Registration)	2018	Central Pollution Control Board (CPCB) introduce EPR registration
	2nd Amendment (Ban on SUPs)	2021	Ban on single use plastic (SUP)
	3rd Amendment (Use of Recycled Plastics)	2021	Use of recycled plastic
	4th Amendment (EPR Guidelines)	2022	Extended producer responsibility guidelines for Producers, Importers, Brand Owners, Central Pollution Control Board, State Pollution Control Board or Pollution Control Committees, recyclers, and waste processors
	E-waste (Management and Handling) Rules	2011	Implementing EPR for effective channelization of E-Waste to registered dismantlers and recyclers
	E-Waste (Management) Rules	2016	Applying EPR plan for achieving targets and details out the mechanism for collection and channelization of e-waste generated by the producer
	Amendment	2018	Change in the EPR collection target
	Draft Notification	2022	Applying the penalty on companies who are not meeting their annual targets and EPR recycling targets also given. Changing Collection targets to recycling targets

The collection targets under EPR based plastics and E-waste rules have changed into recycling targets. Innovative financial mechanisms like "tradable permits" have been introduced in the regulation. Anomalies in the taxation of input and output materials for E-waste recycling have been rectified. Further, provisions of heavy penalty have been made in the regulations. These regulations aim to create a circular economy within the country (ABD, 2022a).

2.4 Key Messages: Chapter 2

The region is experiencing high resource intensity particularly material intensity, increasing deforestation, higher carbon dioxide, nitrous oxide and methane emissions. The waste generation trend is expected to grow rapidly till 2030 and will stabilize beyond 2050. This trend also strongly correlates with material intensity trends and GHG emissions for the region. The projected climate change in Asia and the Pacific could lead to a shortage of water resources, widespread land degradation and increased desertification. As a result, net cumulative effect can strain the finite pool of natural resources and may exceed the threshold rate at which these resources could be replenished.

The trends predict that recycling will gradually become more competitive than mining of minerals due to projected technological developments and changes in relative prices of production inputs. This leads to growth in the recycling sector outpacing growth in mining, lowering of emissions and carbon neutrality as well as growth in GDP. Further, the demographic transition to urban dwellers and environmental links with urbanization will largely determine the sustainable development pathways of the region during the next 25 years and beyond.

This calls for: Conserving resources as well as increasing resource efficiency; Greening, Improving Environmental Conditions and Carbon Neutrality; Improvement in solid waste management due to increasing public pressure for healthy living; Climate Change Mitigation; Promoting Green Jobs, Green Economy and More Prosperous Living. This can be achieved by establishing 3R and circular economy in step wise approach to achieve self-sufficiency and SDG.

Technology is a driver for clean energy and green industry towards sufficiency economy. Alternate materials are becoming more available and affordable. Digitization and Artificial Intelligence (AI) is going to be increasing demand for digitization and AI solutions to manage the resource efficiency and waste management.

Sound material accounting of material flows is very crucial to determine the circularity and self-sufficiency ecosystem. Further, the technology and unexpected exigencies like COVID-19 are externalities which should be factored in the emerging ecosystem. Technology is the main driver for clean Energy and Green Industry towards achieving 3R circularity and sufficiency economy. Further, cost factors are driving technology adoption and replication. Various governments are distributing their risks while developing infrastructure through innovative financing like PPP.

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Chapter 3: Trends of 3Rs and Circular Economy in Asia and the Pacific

This section describes trends of 3R and circular economy in the region based on trends in 3R and waste management policies and responses, growing volume and diverse waste streams and conventional and frontier technologies to address them. Furthermore, updating of the First State of 3Rs in Asia and the Pacific in terms of nine goals selected from the Ha Noi 3R Declaration (2013-2023).

3.1 Progress of nine goals of the Ha Noi 3R Declaration (2013-2023)

3.1.1 Reduction in the Quantity of Municipal Solid Waste (MSW) (3RG 1)

This goal has been defined as significant reduction in the quantity of MSW generated, by instituting policies, programs, and projects at national and local levels, encouraging both producers and consumers to reduce the waste through greening production, greening lifestyle, and sustainable consumption. This goal is analyzed with the progress has been evaluated on the basis of following aspects in the region as mentioned in the country reporting guidelines **Appendix 2** such as:

i. Specific 3R policies, programs and projects are implemented to reduce the quantity of MSW.
ii. Level of participation of households in "source" segregation of municipal waste streams
iii. Total annual government expenditure per capita (US$ per capita) in MSW in 2014-2015
iv. Challenges (policy, institutional, technological, financial) faced in implementation.
v. Pilot projects, master plans and policies developed or under development.
vi. Important policies, programs, projects and government plans to undertake within next five years (2016~2021)
vii. Relevance

Appendix 3 analyzed the status of implementation of 3RG 1 in the region. It indicates that majority of countries have specific 3R policies, programs and projects in place addressing reduction in the quantity of MSW. The policies have been translated into specific regulations of MSW which have been institutionalized at national level to be implemented at provincial and local level. Though at local level, the level of participation of households in "source" segregation is low, trends indicate that more countries are approaching "average to high" level. "High to Very High" status has been reported by developed countries like Japan, Republic of Korea and Singapore. Among developing countries, Lao PDR and India have reported higher participation of households in segregation. In India the progress in implementation of "Clean India Mission" (Swachh Bharat Mission) since 2014 has significantly contributed to increasing the ranking from "Low" to "High". The majority of countries report annual government expenditure on MSW in lumpsum figure annually. It shows huge variation from US$1 to US$153 per capita due to the population covered as well as the level of collection, transportation, treatment and disposal in the respective countries. This expenditure also indicates rising trend for example in Japan, the expenditure has increased from US$143 to US$153 per capita from 2019 to 2021. Technological and financial challenges are reported to be significant followed by institutional, policy and projects. India, Bangladesh, The

Philippines, Tuvalu and Palau have also reported implementation of policy and regulation as the challenge. The majority of countries had planned to develop master plans, plans, or strategies for the year 2016 to 2021. Republic of Korea, Russian Federation and Singapore have had planned policy and regulatory intervention during this period. A vast majority of countries have demonstrated examples of master plans and plans and strategies and projects implementation in municipal solid waste management. All the countries acknowledge high relevance of 3RG 1 as their national priority.

3.1.2 Increasing Recycling Rate of Recyclables (3RG 3)

This goal has been defined to achieve significant increase in recycling rate of recyclables (e.g., plastic, paper, metal, etc.), by introducing policies and measures, and by setting up financial mechanisms and institutional frameworks involving relevant stakeholders (e.g., producers, consumers, recycling industry, users of recycled materials, etc.) and development of modern recycling industry. The progress to achieve this goal has been evaluated based on the following criteria with the data of country reporting as shown in **Appendix 2**.

i. Recycling rate of various recyclables.
ii. Specific policies at local and national level for prevention or reduction of waste streams
iii. Rate of resource recovery from waste streams.
iv. Level of existence of resource recovery facilities and infrastructures in cities.
v. Challenges (policy, institutional, technological and financial) faced in implementation:
vi. Examples of pilot projects, master plans and policies developed or under development
vii. Important policies, programs, projects and master plans the government plans to undertake within next five years (2016~2021)
viii. Relevance

The recycling rate of different items like paper, plastics, metal, construction waste, E-waste and other waste streams show marked variation from “Poor” to “Very High”.

Paper
Paper recycling exists in the majority of countries, however, does not exist in most SIDS countries such as Kiribati, Tuvalu, Tonga, Cook Island, and Solomon Island. Countries which have reported poor recycling rate of paper are Afghanistan, Cambodia, Federated State of Micronesia, Indonesia, Marshall Islands, and Mongolia. Countries which have poor recovery rate of paper are Cambodia, Federated States of Micronesia, Indonesia, Marshall Islands, Mongolia and Nepal. Singapore has reported that recovery rate of paper is poor though recycling rate is average. Bangladesh, Bhutan, Sri Lanka, Palau and Thailand have reported average recovery rate and recycling rate. Nepal has reported average recycling rate and poor recovery rate. Japan, Malaysia, Myanmar, Pakistan, The Philippines and Republic of Korea have reported high recycling and recovery rate of paper.

Plastic
Plastic recycling facilities do not exist in most of SIDS countries such as Kiribati, Marshall Island, Solomon Islands, Tonga and Tuvalu. Afghanistan, Federated States of Micronesia, Indonesia, Marshall Islands, Nauru and Russian Federation have reported both poor plastic recovery rate and recycling rate. Bhutan, Bangladesh, Lao PDR, Mongolia, Nepal, Pakistan and Sri Lanka have average recycling rate. Bhutan, India, Japan, Malaysia, Myanmar, Pakistan and Republic of Korea reported to have high recycling rate of plastics. Bangladesh has reported average recovery rate while Nepal has reported poor recovery rate.

Metal
Metal recycling and recovery facilities do not exist in Cook Island, and Kiribati. Metal recycling facilities are poor in Afghanistan, Indonesia, Marshall Island, Nauru, Solomon Island and Tuvalu. Similarly, recovery is reported to be poor in these countries except for Nauru and Nepal. Average recycling and recovery have been reported in India, Mongolia, Palau, Sri Lanka and Thailand. Bangladesh, Bhutan, Cambodia, Federated States of Micronesia, Japan, Lao PDR, Malaysia, Myanmar, Nepal, Pakistan, Palau, The Philippines, Republic of Korea, Russian Federation and Singapore metal recycling and recovery have been reported to be above average i.e. high and very high.

Construction Waste
The facilities for recycling of construction waste have not been reported in Afghanistan, Bangladesh, Cook Island, Federated States of Micronesia, Indonesia, Kiribati, Marshall Island, Nepal, Palau, Solomon Island and Tuvalu. The resource recovery from this waste stream has been reported absent in these countries except Federated States of Micronesia. The recycling rate has been reported as poor in Bhutan, India, Lao PDR, Malaysia, Mongolia, Myanmar, Nauru, Pakistan, Palau, Russian Federation, Sri Lanka and Thailand. The resource recovery has also been reported to be poor in these countries along with Republic of Korea. The recycling rate is reported average in Myanmar and Cambodia. Recycling rate and resource recovery of construction waste have been reported as high to very high in Japan, The Philippines, Republic of Korea and Singapore.

E-waste
E-waste recycling exists in the majority of countries though majority is in informal sector. It does not exist in Cook Island, Federated States of Micronesia, Kiribati, Malaysia, Marshall Island, Mongolia, Nepal, Solomon Island and Timor Leste. Countries, which have reported poor recycling rate of E-waste are Afghanistan, Bhutan, Lao PDR, Myanmar, Nauru, Pakistan, Palau, Russian Federation, Singapore, Thailand, Tonga and Tuvalu. Cambodia, India, Lao PDR, Marshall Islands, Nauru, Palau, Russian Federation, Solomon Island and Tonga have reported poor recovery rate. Countries like Bangladesh and Japan have high recycling rate and very high recovery. The Philippines has reported high recycling as wells as recovery rate for E-waste. However, in others category some countries like Federated States of Micronesia have very high recycling as well as recovery rate of Aluminum. In Kiribati Aluminum cans, car lead-acid batteries and PET bottles has very high recycling and recovery rate. While Japan has very high recycling and recovery rate of cars.

Institutional and financial challenges are reported to be significantly followed by policy and technical. However, Federated States of Micronesia and Malaysia faced only financial challenge and Marshal Island faced only institutional challenge. The majority of countries have demonstrated examples of pilot projects and programs for the year 2016-2021. While some countries had demonstrated example to develop master plans like Japan, Cook Islands, Mongolia, Nepal, Sri Lanka and Thailand. Most countries had planned to develop master plans, plans or strategies for the year 2016-2021. Some countries such as Lao PDR, Japan, Russian Federation etc. have planned policy and regulatory intervention during this period. Almost all the countries acknowledge the high relevance of 3RG 3 as their national priority.

3.1.3 Inventory of Hazardous Waste (3RG 9)

This goal has been defined as develop proper classification and inventory of hazardous waste as a prerequisite towards sound management of such waste. The progress to achieve this goal has been evaluated based on the following criteria as mentioned in country reporting guidelines and shown in **Appendix 2**.

i. Systematic classification of hazardous waste.
ii. Specific rules and regulations are introduced to separate, store, treat, transportation and disposal of hazardous waste
iii. Challenges (policy, institutional, technological and financial) faced in implementation:
iv. Examples of pilot projects, master plans and policies developed or under development
v. Important policies, programs, projects and the government plans to undertake within next five years (2016~2021)
vi. Relevance

Majority of the countries have systematic classification of hazardous waste. However, some countries like Kiribati, Marshall Island, Mongolia, Nauru, Palau, Solomon Island, Timor Leste and Tuvalu does not have the systematic classification of hazardous waste. Majority of the countries have specific rules and regulation introduced to separate, store, treat, transportation and disposal of hazardous waste. While, some countries like Nauru, Palau and Timor Leste don't have specific rules and regulation of hazardous waste. Institutional, financial and technical challenges are reported to be significant followed by policy. However, Marshall Island and Tonga faced only institutional challenge, Federated States of Micronesia faced only financial challenge and faced only technical challenge. The majority of countries have demonstrated examples of pilot project and master plan for the year 2016-2021. While some countries have demonstrated examples of policy or related aspects like Bangladesh, Bhutan, Mongolia, Pakistan, Singapore and Vietnam. Majority of the countries had planned to develop master plan, plans and strategy for the year 2016-2021. Some countries like Bhutan, Indonesia, Japan, Kiribati, Mongolia, Nauru, Pakistan, Singapore and Tuvalu have planned policy and regulatory intervention during this period. Almost all the countries acknowledge high relevance of 3RG 9 as their national priority.

3.1.4 Use of Agricultural Biomass Waste and Livestock Waste (3RG 11)

This goal has been defined as promote full scale use of agricultural biomass waste and livestock waste through reuse and recycle measures as appropriate, to achieve a number of co-benefits including GHG emission reduction, energy security, sustainable livelihoods in rural areas and poverty reduction, among others. The progress to achieve this goal has been evaluated based on the following criteria as mentioned in **Appendix 2** and the results shows in **Appendix 6**.

i. The amount of (a) agricultural biomass and (b) livestock wastes are grossly generated per annum.
ii. Quantity of agricultural biomass wastes utilized or treated.
iii. Specific policies, guidelines, and technologies are introduced for efficient utilization of agricultural biomass waste and livestock waste as a secondary material input towards full scale economic benefits.
iv. Challenges (policy, institutional, technological and financial) faced in implementation.
v. Examples of pilot projects, master plans and policies developed or under development – include websites where relevant.

vi. Important policies, programs, projects and master plans the government plans to undertake within next five years (2016~2021).
vii. Relevance

Majority of the countries have not defined the amount of agricultural biomass waste and livestock waste that was grossly generated per annum. However, countries like Bangladesh, Federated States of Micronesia, India, Indonesia, Japan, Lao PDR, Mongolia, Myanmar, Nauru, Pakistan, Russian Federation, Thailand and Vietnam. Majority of the countries make compost from the agricultural biomass waste. However, some countries like Indonesia, Japan, Myanmar, Pakistan, The Philippines and Tonga were using agricultural biomass waste as secondary raw material input like for paper, bio-plastic, furniture etc. Majority of the countries have stated specific plans or master plan that were introduced for efficient utilization of agricultural biomass waste and livestock waste as secondary material inputs towards full scale economic benefits. However, some countries like Cambodia, Lao PDR, Russian Federation and Vietnam have some specific programs introduced for efficient utilization of agricultural biomass waste. Institutional and financial challenges are reported to be significant followed by policy and technological. However, countries like Japan, Lao PDR, The Philippines, Russian Federation and Tonga faced only institutional challenge, while Marshall Islands was the only country facing financial challenge. The majority of countries have demonstrated examples of pilot projects. While some countries like, Bangladesh, Federated States of Micronesia, Japan and Malaysia have demonstrated example to develop master plan and policy for the year 2018-2021. The majority of the countries have planned to develop master plans, plans, strategy and policy and regulations for the year 2018-2021. However, some countries like Bhutan, Indonesia, Lao PDR, Nepal and Vietnam have planned some programs during this period. Almost all countries acknowledge High relevance of 3RG 11 as their national priority.

3.1.5 Eliminating Marine Plastics (3RG 12)

This goal has been defined as strengthen regional, national, and local efforts to address the issue of waste, in particular plastics in the marine and coastal environment. The progress to achieve this goal has been evaluated based on the following criteria as mentioned in Country reporting guidelines in Appendix 2 and the result shows in **Appendix 7**.

i. Specific policies and regulations are in place to address the issue of plastic wastes in coastal and marine environment.
ii. Extent to which the issue of plastic waste is considered in integrated coastal zone management (ICZM).
iii. A list of center of excellences or dedicated scientific and research programs established to address the impacts of micro-plastic participles (<5mm) on coastal and marine species.
iv. Challenges (policy, institutional, technological and financial) faced in implementation.
v. Examples of pilot projects, master plans and policies developed or under development
vi. Important policies, programs, projects and the government plans to undertake within next five years (2016~2021).
vii. Relevance

The majority of countries like India, Indonesia and Tuvalu have policies and master plan and strategy to address the issue of plastic waste in coastal and marine environment. Some countries like Bhutan, Cambodia, Federated States of Micronesia, Japan, Malaysia, The

Philippines, Thailand and Tuvalu have reported as highly relevant the issue of plastic waste in integrated coastal zone management. The majority of countries have not provided the list of center of excellence of dedicated scientific and research program to address the impacts of microplastic particles. Policy and institutional challenge are reported to be significant followed by technical and financial. While some countries like Malaysia and Marshall Islands faced only institutional challenge, Nepal has faced only technical challenge. The majority of countries have demonstrated examples of pilot projects. While, some countries have demonstrated examples of policies, countries like Bangladesh, Russian Federation, Thailand and Tuvalu have demonstrated examples of master Plan. The majority of countries have planned to develop their policies and master plan and plan or strategy for the year 2018-2021. While some countries like Japan and Thailand have planned some projects for the year 2018-2021, almost all the countries acknowledge "high" relevance of 3RG 12 as their national priority.

3.1.6 E-Waste Management (3RG 13)

This goal has been defined as ensure environmentally-sound management of e-waste at all stages, including collection, storage, transportation, recovery, recycling, treatment, and disposal with appropriate consideration for working conditions, including health and safety aspects of those involved. The progress to achieve this goal has been evaluated based on the following criteria based on the country reporting guidelines in Appendix 2 and the result shows in **Appendix 8**.

i. People usually recycle their e-waste (waste electrical and electronic equipment).
ii. Specific policies and regulations are in place to ensure health and safety aspects of those involved in e-waste management (handling, sorting, resource recovery and recycling).
iii. Amount of e-waste is generated and recycled per year.
iv. Challenges (policy, institutional, technological and financial) faced in implementation.
v. Examples of pilot projects, master plans and policies developed or under development – include websites where relevant.
vi. Important policies, programs, projects and master plans, the government plans to undertake within next five years (2016~2021).
vii. Relevance

The majority of people in the countries usually recycle their E-waste by taking to recycling center, taking to landfill and taking to the retailer. The majority of countries have specific policies and regulations in place to ensure health and safety aspects of those involved in E-waste management (handling, sorting, resource recovery and recycling). However, countries like Cook Islands, Malaysia, Russian Federation and Vietnam have only regulations to ensure health and safety aspects of those involved in E-waste management. Some countries like Federated States of Micronesia, Japan, Malaysia, Mongolia, Republic of Korea, Russian Federation, Singapore, Sri Lanka, Thailand, Tuvalu and Vietnam have stated the amount of E-waste generated and recycled per year. Policy, institutional and financial challenges are reported to be significant followed by technical. Countries like Indonesia, Malaysia and Philippines faced only policy challenge. The majority of countries have demonstrated the policies and pilot projects from the period of 2018-2021. While countries like Lao PDR, Myanmar, Nauru, Pakistan, Singapore and Tuvalu have planned to develop master plans, plans and strategy as well. Almost all the countries acknowledge high relevance of 3RG 13 as their national priority.

3.1.7 Implementation of Extended Producer Responsibility (EPR) (3RG 15)

This goal has been defined as progressive implementation of "extended producer responsibility (EPR)" by encouraging producers, importers, and retailers and other relevant stakeholders to fulfill their responsibilities for collecting, recycling, and disposal of new and emerging waste streams, in particular e-waste. The progress to achieve this goal has been evaluated based on the following criteria followed by country reporting guidelines in **Appendix 2** and the result shows in **Appendix 9**.

i. Specific Extended Product Responsibility (EPR) policies are enacted or introduced.
ii. A list of products and product groups targeted by EPR nationally.
iii. Challenges (policy, institutional, technological and financial) faced in implementation.
iv. Examples of pilot projects, master plans and policies developed or under development
v. Important policies, programs, projects and master plans the government plans to undertake within next five years (2016~2021).
vi. Relevance

The countries which have reported specific Extended Producer Responsibility (EPR) policies that were enacted or introduced for the period of 2018 – 2021. These countries have provided a list of products and product groups targeted by EPR nationally for the period of 2018-2021. Institutional, financial and policy challenges are reported significant followed by technical. While countries like Kiribati, The Philippines and Thailand faced only policy as challenge. The majority of countries have demonstrated examples of policies and master plan or strategy for the period 2018-2021. While countries like Mongolia and Tuvalu have demonstrated the examples of pilot projects, majority of countries have planned to develop policies and master plans, plans and strategy for the year 2018-2021. While, come countries like Bhutan, Malaysia and Palau have planned some projects for the period 2018-2021, almost all the countries acknowledge high relevance of 3RG 15 as their national priority.

3.1.8 Improving Resource Efficiency and Resource Productivity (3RG 17)

This goal has been defined as improve resource efficiency and resource productivity by greening jobs nation- wide in all economic and development sectors. Progress to achieve this goal has been evaluated based on following criteria followed by the country reporting guidelines as **Appendix 2** and the results as shown in **Appendix 10**.

i. Specific policies and guidelines are introduced for product standard (towards quality, durability, environment, eco-friendliness, labour standard)
ii. Specific energy efficiency schemes are introduced for production, manufacturing and service sector.
iii. Specific policies are introduced to create green jobs in product and waste sector.
iv. Challenges (policy, institutional, technological and financial) faced in implementation.
v. Examples of pilot projects, master plans and policies developed or under development
vi. Important policies, programs, projects and master plans the government plans to undertake within next five years (2016~2021).
vii. Relevance

The majority of reporting countries have introduced specific policies and guidelines for product standard (towards quality, durability, environment or eco-friendliness, labour standards). While Cambodia is the only country which has introduced a master plans, plans or strategy for product standard for year 2018-2021. The countries have introduced specific energy efficiency schemes for production, manufacturing and service sector. However, some countries like Bangladesh, Cambodia, Japan, Lao PDR, Mongolia, Myanmar, The Philippines, Russian Federation, Sri Lanka and Thailand have introduced specific policies to create green jobs in product and waste sector. Policy and institutional challenges are reported to be significant followed by technical and financial challenges. While countries like The Philippines faced only policy as challenge, Thailand faced only financial challenge. Countries like Cook Islands, Myanmar and Pakistan have demonstrated example of master plan as well for the period 2018-2021, the majority of countries have planned to develop policies and master plans, plans or strategy for the period of 2018-2021. While countries like Bhutan, Cambodia, Lao PDR and The Philippines have planned some programs for the period 2018-2021, almost all the countries acknowledge high relevance of 3RG 17 as their national priority.

3.1.9 Co-benefits from Waste Management Technologies (3RG 18)

This goal has been defined to maximize co-benefits from waste management technologies for local air, water, oceans, and soil pollution and global climate change. The progress to achieve this goal has been evaluated based on the following criteria followed by the Country reporting guidelines as **Appendix 2** and the result shows in **Appendix 11**.

i. Climate mitigation is addressed in waste management policies and programs for co-benefits.
ii. Challenges (policy, institutional, technological and financial) faced in implementation.
iii. Examples of pilot projects, master plans and policies developed or under development
iv. Important policies, programs, projects and master plan the government plans to undertake within next five years (2016~2021).
v. Relevance

The majority of reporting countries have addressed climate mitigation in waste management policies and programs for co-benefits. Policy and institutional challenges are reported to be significant followed by financial and technical. While countries like Malaysia, Cook Islands and Tonga faced only financial challenge, the majority of countries have demonstrated the examples of pilot projects and master plans or plans. Countries like Mongolia, Sri Lanka and Tuvalu have demonstrated examples of some programs. The majority of countries are planning to develop master plans, plans or strategy for the period of 2018-2021. However, countries like Malaysia, Mongolia, Myanmar, Nauru, Pakistan, The Philippines, and Sri Lanka have planned to develop policies as well for the period 2018-2021. Almost all the countries acknowledge high relevance of 3RG 18 as their national priority.

3.2 Growing Volume and Diversification of Waste Streams with Presence of New Emerging Waste Streams

3.2.1 Plastic Waste

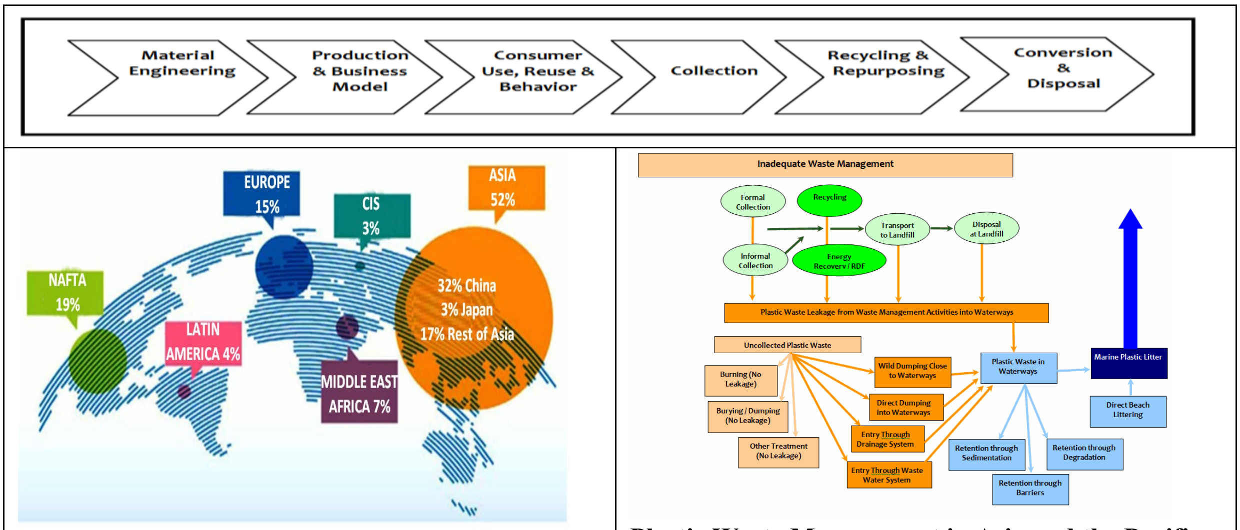
3.2.1.1 Introduction

Plastic waste is one of the emerging waste streams, which has significant potential to pollute our ecosystem. It has been estimated that the total MSW is around 2 billion tones (UNEP and ISWA, 2015b). With an average generation rate of 1.4 kilograms per person per day, the annual total MSW per year for the region has been estimated at around 870 million tonnes in

2014, accounting for 43 percent of the world's total. It is projected to increase until 2030, when it could be 1.6 kilograms per person per day or around 1.4 billion tonnes a year (UNEP et al., 2017b). The broad composition of MSW comprises of the organic share (50–70 percent) in low-income countries than (20–40 percent) in high-income ones (UNEP et al., 2017b). The proportion of plastic in MSW is around 8–12 percent across all the countries (UNEP et al., 2017b). About 1.15 and 2.41 million tonnes of plastic currently flows from the global riverine system into the oceans every year (Lebreton et al., 2017). About 15 from the top 20 polluting rivers are located in Asia (UNEP, 2017b). These 20 rivers accounted for more than two thirds (67 percent) of the global annual input while covering 2.2 percent of the continental surface area and representing 21 percent of the global population (UNEP, 2017b). Estimates indicate that 1.7 to 4.6 percent of the total plastic waste generated on land enters the ocean and ultimately becomes marine litter. Considering this hypothesis, the amount of plastic waste entering the ocean from region ranges from 2.3 to 6.4 million tonnes in 2030. In this context, it is pertinent to study the plastic value chain including plastic consumption and waste generation patterns in the region.

3.2.1.2 Conceptual Plastic Value Chain and Consumption Pattern

A conceptual plastic value chain in the context of the region has been described in **Figure 3.2.1-1**. It starts from material engineering for plastic and leads to its production followed by its consumption, collection, recycling and repurposing and finally its conversion and disposal. The figure also describes activities at each stage of plastic value chain.



Distribution of Global Plastic Production (2020)

Plastic Waste Management in Asia and the Pacific

Figure 3.2.1-1: Conceptual Plastic Value Chain in Asia and the Pacific. Source: (GIZ, 2018; OECD, 2018; Plastics Europe, 2021; UNEP, 2017b)

Figure 3.2.1-2 indicates trends in major plastic consuming countries in the region from 2015 to 2019. It indicates that Republic of Korea ranks first in per capita plastic consumption followed by Malaysia, Japan, Thailand, PR China, Australia, Vietnam, Indonesia, India and Pakistan. It is expected that per capita plastic consumption of PR China, Japan and Thailand is expected to converge by 2019 (GIZ, 2018; OECD, 2018; Plastics Europe, 2021; UNEP, 2017b).

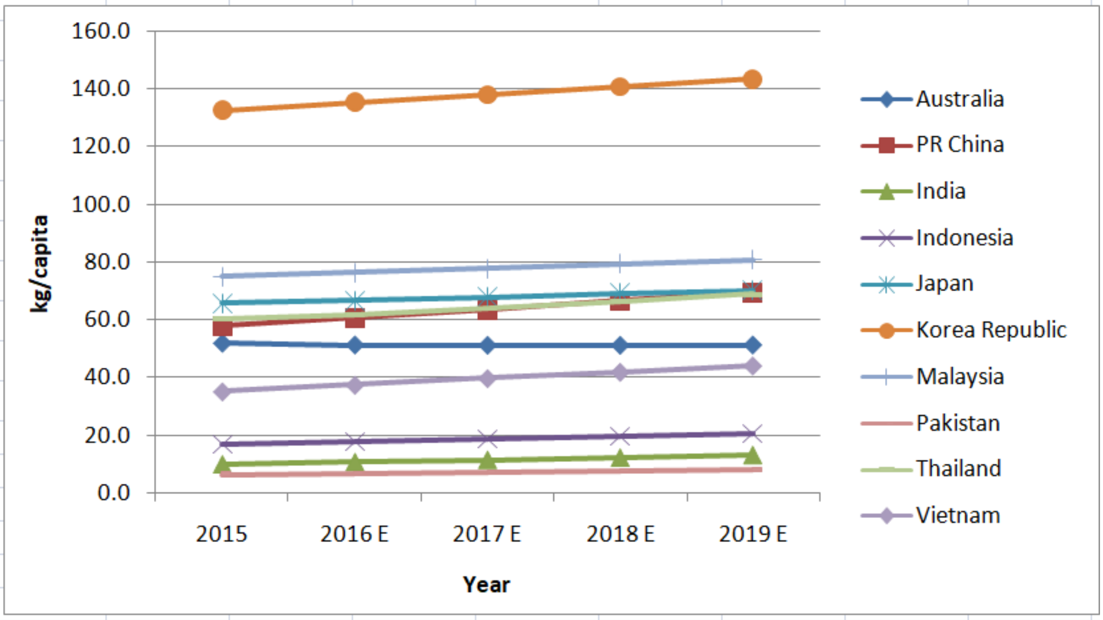


Figure 3.2.1-2: Country wise Plastic Consumption per capita 2015-2019. Source: (Euromap, 2016)

As per 2015 data, the plastic consumption ranges from 0.13 percent to 0.75 percent of the material consumption in Asia and the Pacific region **(Figure 3.2.1-2)** (Euromap, 2016), an indicator of variation in resource usage. The region is an importer of fossil fuel, the feedstock for manufacturing plastics. There is a positive correlation between GDP growth rate and plastic consumption in the region **(Figure 3.2.1-3)**. It indicates that as per capita income increases, plastic consumption also increases.

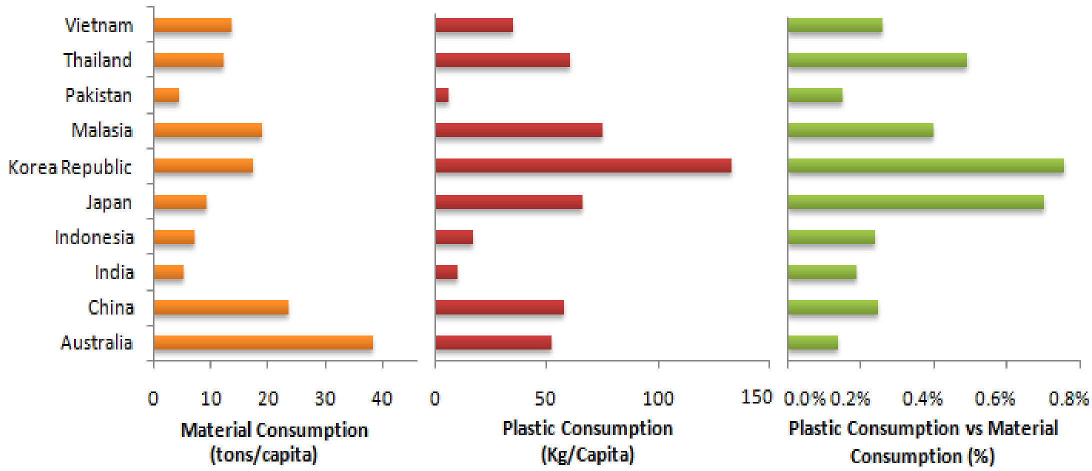


Figure 3.2.1-3: Country wise Plastic Consumption vs Material Consumption (percent) (2015). Source: (Euromap, 2016)

3.2.1.3 Plastic Waste Generation

A strong correlation, also exists between per capita waste generation and the income level of a country (UNEP et al., 2017b). The correlation between gross national income (GNI) and waste generation in some countries in Asia and the Pacific region is shown in **Figure 3.2.1-4**.

The higher the per capita GNI the higher is the per capita MSW generation. Since plastic waste is a part of MSW this trend also correlates to the plastic intensity of Asia and the pacific region. Similar trends have also been observed at city level in the region (UNEP et al., 2017b). Therefore, the higher GNI, higher will be the MSW generation per capita and higher the plastic waste generation per capita.

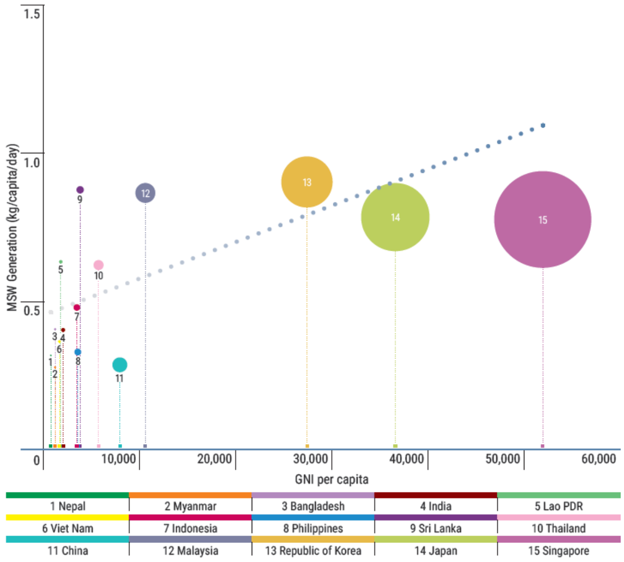


Figure 3.2.1-4: MSW Generation Related to GNI Per Capita in Selected Asian Countries. Source (UNEP et al., 2017b)

Table 3.2.1-1: MSW and Generation and Treatment Data in Asia and the Pacific Region. Source: (UNEP et al., 2017b)

Region	**MSW Generation Rate (tonnesand capitaandyear)**	**MSW disposed at disposal sites** (percent) **and Plastic waste generation rate (tones and per capita and year**	**MSW Incinerated** (percent)
Eastern Asia	0.37	55 percent (0.027 – 0.06)	26 percent
South-Central Asia	0.21	74 percent (0.015 – 0.037)	-
South-East Asia	0.27	59 percent (0.019 – 0.048)	9 percent

The partial geographical coverage of waste collection and its inefficiency in developing countries in Asia and the Pacific region results in huge amount of uncollected plastic waste. **Table 3.2.1-1** indicates that where waste plastics enter the formal waste management system, they are either recycled, or disposed off in controlled landfill or incinerators that may or may not recover electricity, heat or by-products. However, in communities where formal waste management systems does not exist, particularly in informal communities in low- and middle-income countries a substantial proportion of waste plastics are disposed off in uncontrolled dumps, watercourses, or burned openly. Globally, around 14 percent -18 percent of waste plastics generation is collected for recycling (OECD, 2019b; UNCRD, 2009). Another 24 percent is thermally treated by incineration, gasification or pyrolysis, while the remainder is disposed off in controlled, landfill, uncontrolled landfill, or the natural environment (SPREP, 2016b). Polyethylene (HDPE and LDPE) and Polypropylene are the most common polymers found in the waste stream, which account for 40-50 percent of the waste plastics produced in the region.

The plastic waste generation in the region is expected to reach 140 million tonnes by 2030 (UNEP et al., 2017b). It is estimated that plastic waste generation is expected to range from 0.027 to 0.06 tonnes and capita and year in East Asia, 0.15 to 0.37 tonnes and capita and year in South Central Asia and 0.019 to 0.048 tonnes and capita and year in South East Asia. **Table 3.2.1-2** describes the percentage of plastic waste in eleven countries, which are majorly contributing plastic pollution in the region. Source segregation of MSW is less than 50 percent in six countries, while it ranges from 50-70 percent in other countries. Accordingly plastic waste segregation is reported low.

Table 3.2.1-2: Plastic Waste in Countries in the region. Source: (SPREP, 2016b)

Country	**Total MSW Generation (Million tonnes)**	**Source Segregation** (percent)	**Plastic** (percent)
Bangladesh	8.6 (2014)	<50 percent (2019)	7.35
PR China	480 (2013)	<50 percent	>10 percent
India	55	70 percent	8-12 percent
Indonesia	65.03 (2015)	<50 percent (2018)	14 percent
Malaysia	12.8 (2014)	50-70 percent (2018)	25.2 percent
Myanmar	0.84 (2014)	50-70 percent (2018)	17.7 percent
Pakistan	48 (2016)	<50 percent (2019)	9 percent
Sri Lanka	2.5	50-70 percent (2019)	10 percent
Thailand	27.37 (2017)	<50 percent (2019)	18 percent
The Philippines	14.63 (2016)	50 - 70 percent (2019)	10.55 percent
Vietnam	19 (2015)	<50 percent (2018)	10 percent

Table 3.2.1-3 describes the waste generation and composition in selected Pacific islands. The per capita waste generation per year in the Pacific islands shows huge variation and ranges from 0.036 to 0.693 tonnes. Plastic constitutes about 5 to 25 percent of the total waste composition (UNEP et al., 2017b).

Table 3.2.1-3: Waste Generation and Composition in Selected Pacific Island Countries and Territories. Source: (SPREP, 2016b)

Countryand Territory	**State or municipality**	**Year**	**Waste Generation Rate**			**Plastic** (percent)	**Comment on 'other residues'**
			Household waste (kgandpandday)	**Commercial waste**	**Total urban MSW (kgandpandday)[A]**		
American Samoa	Tutuila Island	2011			1.0	12.8	Disposable nappies = 5.1%
FSM	Pohnpei	2011	0.1			25.0	
	Yap	2011	0.5			37.2	
	Chuuk	2011	0.2			22.5	
	Kosrae	2011	0.1			20.0	
Fiji	Nadi	2008	0.4		1.9	7.1	
	Lautoka	2008	0.4		1.1	7.9	
French Polynesia	All	2012	1.2C				
Marshall Islands	Majuro	2014	0.4		1.1	12.5	Disposable nappies = 10.5 %
PNG	Port Moresby [D]	2014	0.36	0.09 kgandm2andday		18.5	
Samoa	Vaitele	2011	0.4	0.01 kgandm2andday		13.0	Disposable nappies = 15.1 %
Solomon Islands	Honiara [D]	2011	0.9	0.09 kgandpandday		19.5	Disposable nappies = 5.7 %
	Gizo	2011				25.2	
Tonga- Vava'u	Vava'u	2012	0.5			13.4	
Vanuatu	Port Vila [D]	2011	0.4			7.9	
	Luganville	2014	1.2	0.18 kgandpandday	1.3	5.0	

Countryand Territory	State or municipality	Year	Waste Generation Rate			Plastic (percent)	Comment on 'other residues'
			Household waste (kgandpandday)	Commercial waste	Total urban MSW (kgandpandday)A		
Unweighted Mean			0.5		1.3	16.5	

Legend: A: Municipal solid waste includes household, commercial and institutional waste
B: Waste characterisation studies completed as part of the J-PRISM Project
C: Includes green waste and special collections
D: Data represents the unweighted average of low-, middle- and high-income areas

3.2.1.4 Plastic Recycling

Various materials from different waste streams are recycled across the region. However, there is a wide variation in terms of the relative amounts, type of waste and technology employed in the process. Developed economies, such as Japan and Singapore have achieved high rates of recycling approximately 20% and 6% respectively facilitated both through supportive institutional mechanisms and the utilization of different methodologies for the extraction and conversion of valuable resources. A small fraction of plastic collection in both formal and informal sector goes for recycling. However, rate of plastics recycling is not monitored by countries in Asia and the Pacific region. Australia and Japan give an indication of the plastic recycling rate in the region (SPREP, 2016b). Recycling rates for waste plastics differ significantly between different polymers, applications and regions. Packaging plastics, and the polymers commonly used in packaging such as PET, HDPE and LDPE, represent the majority of plastics that are collected for recycling. Recycling rates for plastics from other sectors, such as automotive, construction, and electrical equipment, and for other polymers, are substantially lower. Recycling of post-industrial plastics is well-established and has been relatively stable over recent decades (SPREP, 2016b). In contrast, recycling of post-consumer plastics is less common, but has increased steadily since the 1980s as municipal recycling schemes have developed in high income countries (SPREP, 2016b). Post-consumer plastics waste includes all plastic items including single use having short life cycle and others having long "end of life". They arise from domestic activities, such as food packaging, or other consumable goods, as well as commercial sources and through agriculture and construction. Increasingly, plastics are used in the construction activities and manufacture of electrical equipment, further complicating their separation, collection, treatment and disposal (OECD, 2018). Plastics recycling rates **(Figure 3.2.1-5)** in Europe have steadily increased, driven by statutory targets by the European Union. Recycling rates in the United States have increased steadily but have not yet exceeded 10 percent (SPREP, 2016b) Data indicates that plastic recycling rate in Japan is closer to those in the European Union while Australia's recycling rate fell in between the US and European rates (SPREP, 2016b).

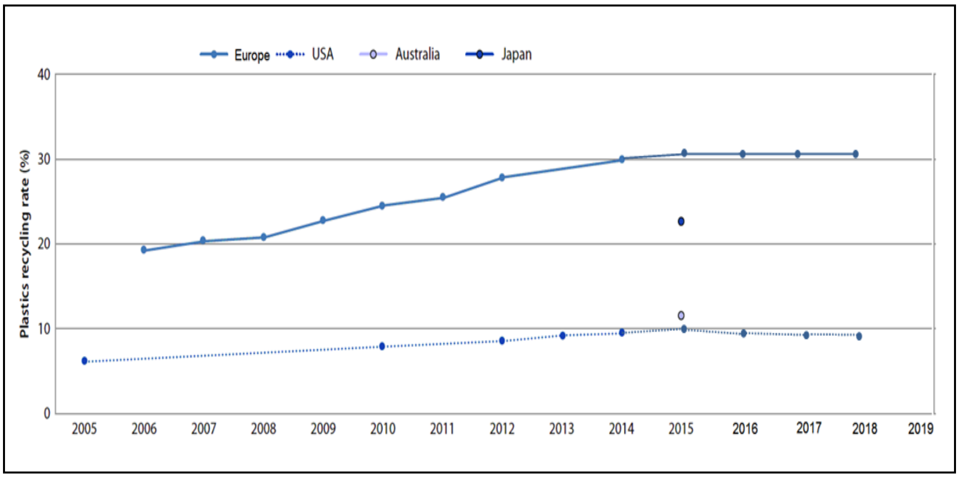


Figure 3.2.1-5: Plastics recycling in the EU, USA, Australia and Japan (2005-15). Source: (OECD, 2018)

Further, in country reporting guidelines, the national reporting varies from country to country considering differences in the definition of recycling rate. as shown in **Table 3.2.1-4**, where recycling rate has been used in the context of exports in Pacific Island countries.

Table 3.2.1-4: Plastic Waste in Countries in Asia and the Pacific Region**.**

Country	Plastic Recycling (percent)
Bangladesh	>70 percent (2018)
PR China	<50 percent
India	>70 percent (2018)
Indonesia	<50 percent (2018)
Malaysia	>70 percent (2018)
Myanmar	>70 percent
Pakistan	50 - 60 percent (2019)
Sri Lanka	50 - 60 percent (2019)
Thailand	>70 percent (2019)
The Philippines	>90 percent (2019)
Vietnam	>70 percent (2018)

Table 3.2.1-5: Recycling Rate in Selected Pacific Island Countries and Territories. Source: (SPREP, 2016b)

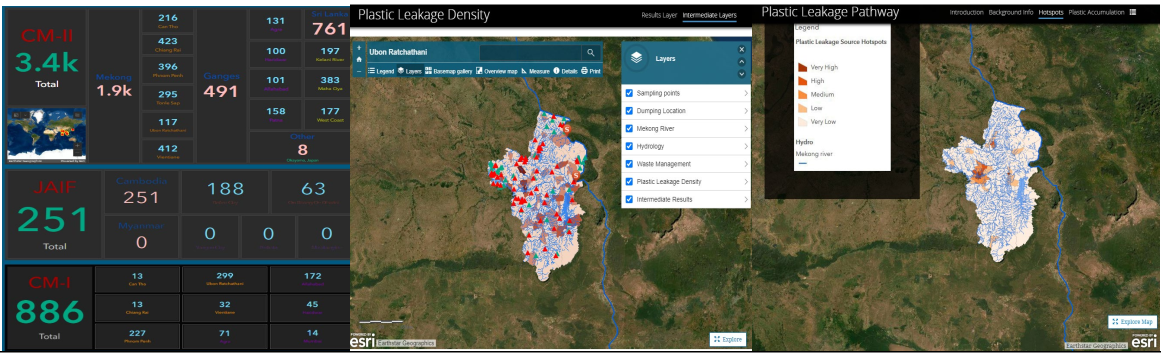
Country and Territory	Potentially recyclable waste (tonnes)	Amount exported or recycled and reused locally (tonnes)	Amount exported or recycled and reused locally (percent)	Quantity landfilled or dumped (tonnes)	Comments
Fiji	66,788	38,081	57 percent	28,707	End-of-life vehicles, white goods, cans, PET bottles, paper and cardboard
Samoa	13,308	4,741	36 percent	8,567	As above
Tonga	6,567	598	9 percent	5,969	As above
Tuvalu	685	103	15 percent	582	As above
Vanuatu	12,591	4,642	37 percent	7,949	As above
French Polynesia	16,300	6,300	39 percent	10,000	Cans, PET bottles, paper and cardboard, glass
Total	116,239	54,465	47 percent	61,774	-

Low segregation rate of mixed plastic waste further adds to the complexity of their treatment and disposal in the region (OECD, 2018). Further, the percentage of plastic recycled does not indicate the type of plastics recycled such as single use or all types of plastics.

Box 3.2.1-1: Mobile Application for on land macro plastic detection in Ganges and Mekong River Basin (UNEP and AIT, 2022)

In Counter MEASURE project funded by Government of Japan and implemented by UNEP's ROAP office in Ganga and Mekong River basin, a mobile application was developed to map the on land plastic waste hotspots and plastic leakage pathway in both the basins.

The mobile-phone application is an easy-to-use survey tool for identifying local plastic hotspots by visual inspection to specify the location, amount, and type of plastic litter found in community. Some common hotspots might include uncontrolled dumpsites, litter spots, and the artificial barriers. The submitted data through this app contributes to the development of countermeasures against plastic pollution with the aim of reducing health risks and environmental load attributed to plastic. This app survey was carried out in both seasons in Mekong and Ganges. In the Mekong basin, a total of 1,900 locations were surveyed, and about 3,450 ton of accumulated waste were visually inspected. In Ganges basin, 491 locations were surveyed, and visual inspections were carried out. The collected samples were analyzed, and polymers were identified using Fourier Transform Infrared (FTIR) technique. The hotspots were mapped, vulnerable zones and leakage pathways were identified. This application not only assisted in monitoring hotspots in a geographical area but also diverting the littered material into recycling chains.



3.2.1.5 National Policies Concerning Plastic Waste

The national governments in the region have initiated policy and regulatory responses at national, regional and global level. The majority of these responses are targeted on single use plastics considering their short life cycle and the scale of their impacts. A summary of country specific regulations for plastic bags in the region are given in **Table 3.2.1-6.**

Table 3.2.1-6: Country with Specific Regulations on Plastic Bags. Source: (UNEP, 2018c)

Australia	Extended producer's responsibility at national level and used packaging regulations and Regulation of plastic bags by States;
Bangladesh	Restrictions on manufacture, sale of all kinds or any kind of polythene shopping bag, or any other article made of polyethylene or polypropylene, imposing absolute ban on the manufacture, and sale;
Bhutan	Restrictions on the import of plastic bags and Extended producer responsibility for wastes;
Cambodia	Handle plastic bags are prohibited from importation, production, distribution and use,

	except for: A – the plastic bags are 0.03 mm or thicker; and B- the plastic bags have a bottom width of at least 25 cm or10 inches. All importation and local production of plastic bags in A and B above shall have permit from the ministry of environment except for non-commercial importation of less than 100 kg, Customers will pay for plastic bags from supermarkets, commercial centers, and all business and service locations and Legislation requires encouragement of use of renewable materials and minimization of waste generation;
PR China	Ban on the import of used plastic bags and single use plastic products and no free plastic shopping bags shall be provided at any commodities retail places, and the price of plastic shopping bags shall be clearly marked and charged separately from the commodity price;
Fiji	Environment and Climate Adaptation Levy shall be charged on plastic bags distributed by businesses. Levy charged on plastic bags is $0.10c per plastic bag and payable by the person to whom a plastic bag is provided;
Malaysia	Investment tax allowance for use of biodegradable materials;
Maldives	Standards set for importers and local producers of biodegradable bags;
Marshall Islands	Unlawful for a person to import, manufacture, sell or distribute plastic shopping bags;
Mongolia	Use of all types of plastic bags which are less than 0.025 mm thick or lesser for package use shall be prohibited in any trade and services;
Nepal	No persons can import, produce, store, sale and distribute plastic bags of thickness less than 30 Micron, Retailers and Individual users to reduce the unnecessary uses and reuse the plastic bag to the extent possible, Retailers need to collect and return all plastic bag to importers and Fines for breach of rules;
Pakistan	Prohibits not only the manufacture of conventional disposable plastic products in Pakistan, but also prevents them being imported into Pakistan. This means that all companies anywhere in the world exporting disposable plastic products to Pakistan made from or packaged in conventional or bio-based PE, or PP, or in PS must make and package them in future with oxo-biodegradable plastic technology from a supplier registered with the Pakistan Government;
Palau	Retail establishments shall not provide plastic bags except those that are bio-degradable or compostable to their customers at point of sale or prior to their exit for the purpose of transporting good. Comes into operation 2019, Retail establishments that sell reusable bags to customers shall price re-useable bags at no greater than 25 percent above the at cost value and By 2018 no individual or business may import plastic product prohibited for distribution;
Papua New Guinea	Ban on non-biodegradable plastic bags. Biodegradable bags are allowed, and the use of bilum bags, made of organic woven material, is encouraged;
Republic of Korea	Prohibition of distribution of packaging for free and Requirements to put in place a recycling plan for specified products;
Samoa	General obligations to regulate wastes. No specific bans;
Sri Lanka	Prohibit the manufacture of polythene or any polythene product of 20 microns or below in thickness for in country use. Polythene or any polythene product of 20 microns or below in thickness can be permitted to be used with the prior written approval of the Central Environmental Authority for (a) the use of specified material for laminating and (b) the use for medical and pharmaceutical purposes in the absence of other suitable alternatives;
Tonga	Levy on plastic bags on importation. Exemptions provided and Waste Management requirements;
Vanuatu	Prohibit the import of non-biodegradable plastic single-use bags, Obligation for local manufacturers of plastic bags to use only biodegradable plastics as of January 31, 2018 and Prohibition of the Manufacture, sell, give or otherwise provide single use bags other than to contain, wrap or carry meat or fish, single use of plastic bags are shopping bags that are made out of polyethylene less than 35 microns thick;
Viet Nam	Environmental protection tax issues against use of plastic bags and Requirements for reduction and waste minimization;

Countries which cover plastic bags as part of solid waste, plastic waste and litter regulations are given in **Table 3.2.1-7.**

Table 3.2.1-7: Regulations Covering Plastic Bags in Other Regulations. Source: (UNEP, 2018c)

Brunei Darussalam	Only regulates disposal at national level (solid waste and litter regulation);
India	Plastic Waste Management Rules, 2016 based on EPR have been enforced. Further, plastic waste management jurisdiction given to urban local bodies in their respective jurisdiction for recycling, Requirements to confirm to standards for plastic waste recycler and recycling of plastic IS 14534, Registration of producer, recyclers and manufacturer, -from the State Pollution Control Board and Responsibility of waste generator to take steps to minimize generation of plastic waste and segregate plastic waste at source in accordance with the Solid Waste Management Rules, 2000 or as amended from time to time;
Indonesia	Law speaks to creation of policy directives on waste reduction, handling and minimization including the development of a road map on extended producer responsibility, Manufacturers are obliged to recycle waste by a. preparing a waste recycling program as part of its business and and or activity; b. using recyclable production raw materials; and and or c. reclaiming garbage from product and product packaging for recycling;
Japan	Recycling plan instituted by law and Extended producer responsibility for designated businesses who are required to reduce waste containers and packaging discharged through rationalization of use of containers and packaging by using recyclable containers and packaging and reducing the excess use of containers;
Kiribati	Issuance of a levy and fund on waste;
Lao People's Democratic Republic	General requirements to separate waste for different purposes such as recycle, reuse, reprocess as new products and elimination with methods and techniques within identified areas base;
Micronesia (Federated States of)	Only regulates disposal at national level (solid waste and litter regulation);
Myanmar	Only regulates disposal at national level (solid waste and litter regulation);
Nauru	Only regulates disposal at national level (solid waste and litter regulation);
New Zealand	Waste Minimization Fund (WMF) provides funding for projects that improve waste management and minimization and Extended Producer Responsibility;
The Philippines	Rules on waste minimization at source and separation;
Singapore	Mandatory requirement to submit waste report and waste reduction plan;
Solomon Islands	Only regulates disposal at national level (solid waste and litter regulation);
Thailand	Only regulates disposal at national level (solid waste and litter regulation);
Timor-Leste	Only regulates disposal at national level (solid waste and litter regulation);
Tuvalu	Only regulates disposal at national level (solid waste and litter regulation);

The two main mechanisms employed by national governments are bans or restrictions on supply and distribution of single use plastics. **Table 3.2.1-8** disaggregates countries according to the different types of bans or restrictions. Eighteen countries in the region have imposed ban or restriction in order to regulate domestic market entry of plastic bags. Two countries such as Fiji and Republic of Korea ban free retail distribution of plastic bags. Bhutan and Palau restrict importation and retail distribution of plastic bags (UNEP, 2018c).

The majority of the countries have opted for partial bans or restrictions, mostly in the form of thickness requirements and material composition. Ten countries in the region have imposed thickness requirement of plastic bags. This table also describes nine countries with requirement of material composition. This requirement is broadly based on bio and non-biodegradable characteristics of the bags. No country in the region has imposed restriction on production volume. Cambodia, Nepal, Marshall Islands, Vanuatu and Palau promote reusable bags.

Table 3.2.1-8: Plastic Bag Bans and Regional Distribution of Countries with Thickness Requirements for Plastic Bags. Source: (UNEP, 2018c)

Type of Restriction	**Countries**
Manufacture, Retail Distribution and Importation (*levy collected on Retail Distribution)	Bangladesh, Cambodia, PR China*, Nepal*, Marshall Islands, Mongolia, Pakistan, Papua New Guinea*, Samoa, Sri Lanka and Vanuatu
Retail Distribution (*with Levy)	Fiji* and Republic of Korea*
Manufacture and Importation	N/A
Manufacture	N/A
Importation	Japan
Retail Distribution and Importation (* with Levy on retail distribution)	Afghanistan, Bhutan and Palau
Country	**Thickness Threshold**
Bangladesh	Ban on plastic bags 20 µm (microns) or less
Cambodia	Ban on plastic bags except for plastic bags 0.03 mm or thicker and with a bottom width of at least 25 cm or 10 inches, subject to permit from the ministry of environment
PR China	Ban on plastic shopping bags less than 0.025 mm in thickness (ultrathin plastic bags)
India	Minimum of 50µm (microns), except for bags made of compostable plastic
Mongolia	Ban on all types of plastic bags 0.025 mm thick or lesser (full ban effective March 1, 2019)
Nepal	Ban on plastic bags less than 30 microns for small bags (7” X 14”) and 40 microns for bigger bags (20 Inches X 35 inches)
Pakistan	Minimum thickness of oxo-biodegradable plastic products of at least 50 microns
Sri Lanka	Ban on plastic bags 20 microns or less, unless with written approval from the Central Environmental Authority
Vanuatu	Ban on plastic bags less than 35 microns thick
Vietnam	Environmental-friendly bags more than 50 microns are exempt from tax
	Material Composition Requirement
Cambodia	Importation and production of bag or packaging material produced from biodegradable or bioplastic substances shall have preferential tax rates
India	Thickness requirement (50 microns) shall not be applicable to carry bags made up of compostable plastic in conformity with the prescribed standard
Pakistan	Ban on plastic products which are non-degradable. Disposable plastic bags must be made with oxo-biodegradable plastic technology from a registered supplier
Palau	Retail establishments shall not provide plastic bags except those that are biodegradable or compostable to their customers
Papua New Guinea	Ban is on non-biodegradable plastic bags. Biodegradable bags are allowed, and the use of bilum bags, made of organic woven material, is encouraged
Republic of Korea	Biodegradable plastic bags may be distributed for free
Samoa	Ban on all plastic bags except biodegradable bags
Vanuatu	Ban on import of non-biodegradable plastic single-use bags; local manufacturers of plastic bags to use only biodegradable plastics as of January 31, 2018.
Vietnam	Environmentally-friendly bags with bio-decomposition ability of at least 60 percent in a period of up to 2 years are exempt from the environmental protection tax

Table 3.2.1-9 describes the type of mandate related to reusable bags, which includes (i) provision of reusable bags to consumers either free of charge or for a fee (ii) exemption of reusable bags from the ban on plastic bags and (iii) Obligation on retailers and and or consumers to opt for reusable bags (UNEP, 2018c).

Four countries, Bangladesh, Cambodia, Pakistan and Republic of Korea in the region expressly provide for exemptions to their ban on plastic bags. The exemptions relate to certain activities and certain products. Republic of Korea exempts plastic bags ban for primary packaging for fresh, perishable or other loose food and pharmaceutical products. Bangladesh exempts them for export. Cambodia exempts from the ban of the importation of plastic bags for non-commercial purposes in small volumes of 100 kg. or less. Pakistan exempts plastic bag use for sanitation or waste storage and disposal. Country specific short summaries of the major features or approaches found in legislation in the region is given below (UNEP, 2018c).

Table 3.2.1-9: Countries with Mandates for Reusable Bags. Source: (UNEP, 2018c).

Country	Type of Reusable Bag Regulation
Palau	Provide to consumers or end-users free of charge for a fee
Cambodia and Nepal	Obligation on retailers and consumers to opt for reusable bags
Marshall Islands	Exemption from the plastic bag ban

The major regulatory approaches using market-based instruments include specific national legislation on plastic bags while others have packaging laws or regulations which govern plastic bags. Other approaches include implementation of extended producer responsibility (EPR), fixing up of recycling targets, fines related to plastic bag legislation and city level regulation of plastic bags. Countries have instituted taxes on the manufacture, import or production of plastic bags. The two common market based approaches adopted across the include: (i) Taxes on manufacturers, Importers and Producers (ii) Levy or fee charged to consumers (UNEP, 2018c).

India is the only country in the region which has imposed a tax on manufacture, production and import of plastic bags. PR China, Republic of Korea, Nepal and Fiji are the other countries which have adopted general or specific legislation which set a defined fee per plastic bag type as well as more discretionary approaches which allow the retailer to determine the fee to be charged for each type of plastic bag. **Table 3.2.1-10** describes country regulations on plastic bags through levies on fees in the region. Malaysia and Vietnam provide fiscal incentives or tax breaks to manufactures to either recycle or produce reusable plastic bags (UNEP, 2018c).

Table 3.2.1-10: Specific Country Regulation on Plastic bags through Levies or Fees in the Region. Source: (UNEP, 2018c).

Countries	Regulation by payment of levies or fees
Fiji	Levy paid by consumer: A levy is charged on plastic bags distributed by businesses prescribed by regulations. the Environment and Climate Adaptation Levy charged on plastic bags is $0.10c per plastic bag. The Levy on plastic bags is payable by the person to whom a plastic bag is provided.
PR China	Fees on the sale of plastic bags: No exact fee requirement is provided by the law, this is determined by the retailer, but the fee for plastic shopping bags cannot be lower than the manufacturing cost or have any discount or be free. No free plastic shopping bags shall be provided at any commodities retail places, and the price of plastic shopping bags shall be clearly marked and charged separately from the commodity price.”

Countries	Regulation by payment of levies or fees
Republic of Korea	Fee on the sale of plastic bags: Act on the promotion of saving and recycling of resources – For Single- use plastic bags and shopping bags -5 cent and bag.
Nepal	Consumer fee: Retailers, super Market and Shopping malls are entitled to charge fee for alternate bag they provided. 0.30 cent to 50 cents

The disposal phase of plastic bags in the region has been addressed by adopting three approaches: (i) extended producer responsibility (ii) recycling targets and (iii) fines related to disposal of plastic bags. All the three approaches are on the responsible collection and disposal by manufacturers or producers of plastic, retailers and distributors and in some cases the consumer. Nine countries, Australia, Bhutan, India, Indonesia, Japan, Republic of Korea, Togo, Tonga and Vanuatu which have implemented EPR based regulation in the region (UNEP, 2018c).

Seventeen countries in the region have instituted recycling targets in various forms. These countries are Australia, Bhutan, Cambodia, India, Indonesia, Japan, Lao PDR, Mongolia, The Philippines, Republic of Korea, Samoa, Togo, Tonga, Tuvalu and Vanuatu. Some countries have set targets on the number of plastic bags to be collected and recycled while have others set targets for local authorities to create waste management plans that include recycling components. Most countries have solid waste and litter legislation to regulate plastics and plastic bags in the region. However, Nepal under Environmental Protection Act 1997, Section 19, imposes a fine of up to NRs 50000 (US$ 500) for breaching the Plastic Bag Monitoring and Control Guideline 2011 (UNEP, 2018c). Australia, Brazil, and India have regulations at the sub national and city level. 59 cities and municipalities, mostly in and around the national capital region in the The Philippines have enacted local ordinances that ban or charge a levy on plastic bags (UNEP, 2018c).

Single use plastics are regulated by targeting bans or restrictions on the manufacture, use, distribution, sale, or trade along their material flow chain in nine countries in Asia and the Pacific region. These countries have enacted bans of some type on the manufacture, distribution, use, sale, and/or import of single-use plastics. **Table 3.2.1-11** describes the type of ban or restriction and legislation related to single use plastics. All types of bans do not apply to all types of disposable plastic products. The most commonly targeted polymers are polystyrene and expanded polystyrene and the most commonly targeted products are for the packaging, carrying and consumption of food. Bans on specific products are most commonly focused on those associated with food service and delivery. This include cup, plates, stirrers, PET bottles, food containers, egg cartons, lunch wrappers, spoons and horticulture nettings (UNEP, 2018c).

Table 3.2.1-11: National bans and restrictions on single-use plastics Source: (UNEP, 2018c).

Country	Type of ban or restriction	Legislation
PR China	Material and product ban: Ban on the import of used plastics for use as raw materials, including plastic bags, films, and nets, and polyvinyl, styrene polymer, PET	Notice on adjusting the managing category of imported wastes" (02and26and2014) Exhibit 1 Prohibited Wastes, No. 80; 2
Fiji	Production and distribution restriction: Facilities must have a plastic bottle permit from work permit committee in order to manufacture or import plastic bottles. Application for permit must include measures taken to collect and recycle bottles.	Environmental Management (Waste disposal and recycling) Guidelines 2007

Country	Type of ban or restriction	Legislation
India	The manufacture, import, stocking, distribution, sale and use of following single use plastic (SUP), including polystyrene and expanded polystyrene, commodities shall be prohibited with effect from 1st July, 2022: (a) Ear buds with plastic sticks, plastic sticks for balloons, plastic flags, candy sticks, ice-cream sticks, polystyrene (Thermocol) for decoration; (b) Plates, cups, glasses, cutlery such as forks, spoons, knives, straw, trays, wrapping or packing films around sweet boxes, invitation cards, and cigarette packets, plastic or PVC banners less than 100 micron, stirrers;	Rule 4(2) of PWM Rules, 2016 (as amended)
Marshall Islands	Material and Product ban: a ban on the importation, manufacture, sale and distribution of polystyrene cups and plates, disposable plastic cups and plates and plastic shopping bags	Styrofoam and Plastic Products Prohibition Act 2016, S. 3
Pakistan	Product ban: Ban on the manufacture, import, sale, and use of non-biodegradable plastic products in the Islamabad Capital Territory	Environment Protection Act 1997 of Pakistan, SRO No 5 (KE) 2013
Republic of Korea	Ban on free distribution: Disposable products, including PET bottles, plastic plates, utensils, cups and other disposable packages cannot be provided free of charge	Article 10 of Act on the promotion of saving and recycling of resources (Control etc., of use of disposable products); 2015
Samoa	Product Ban: Prohibits the import, manufacture, export, sale and distribution of plastic shopping bags, packaging bags and straws effective from the 30th January 2019. Plastic shopping bags under the regulations means a bag made in whole or partly of thin plastic film and contains starch (such as biodegradable bags) or full petroleum or additive used as shopping bags and packing bags used for re packing and storage of products. Exemption have been made for the purposes of food safety and in consideration of food items where plastic and packaging is necessary. The following therefore exempted from the prohibition plastic bag used exclusively to pack or repack cream ice cubes locally produced chips locally produced kekesaica, ava, local biscuits, repacked coffee, tea, sugar, flour and cacoa.	Waste (Plastic Bag) Management Regulation 2018
Sri Lanka	Material and product ban: 1) Ban on the manufacture, distribution and use of food containers, plates, cups, and spoons made from polystyrene and lunch wrappers (a commonly used item in Sri Lanka) made from polyethylene. Separately, 2) the import of disposable polystyrene boxes and polymers of ethylene, styrene and vinyl chloride are controlled.	Executive Order as gazetted No. 2034and34 of September 1, 2017 provided for by Article 51 of the 19th Amendment to the Constitution and the National Environmental Act No. 47 of 1980 as amended, S. 23. 2) Imports and Exports Control Act No. 1, 1969; Gazetted 2044and40 and 2044and41 of September 11, 2017.
Tuvalu	Material and product ban: The manufacture, sale, distribution of plastic foam products (including polystyrene foam, board stock, egg cartons, food containers, disposable plates and cups, and horticulture netting) is banned.	Ozone Depleting Substances Regulations 2010.
Vanuatu	Material and product ban: The manufacture, distribution,	Waste Management Act 24 of

Country	Type of ban or restriction	Legislation
	use, and import of plastic straws and polystyrene products, including takeout boxes, food packaging, disposable plates and cups, and horticultural netting	2014

Table 3.2.1-12 indicate the type of ban the countries have imposed in the region. Four countries, Marshall Islands, Pakistan, Sri Lanka, Vanuatu have imposed ban on manufacture, free distribution and import of single use plastics. PR China has imposed ban on import while South Korea has imposed ban on free distribution. Bans may target the production, distribution or sale, use, or import of single-use plastics. Tuvalu has imposed ban on both free distribution and import of single use plastic (UNEP, 2018c).

Table 3.2.1-12: Bans and Restrictions in Asia and the Pacific Region. Source: (UNEP, 2018c)

RegionandCountry	Ban on Manufacture	Ban on Free Distribution	Ban on Import
PR China			✓
Marshall Islands	✓	✓	✓
Pakistan	✓	✓	✓
Rep. of Korea		✓	
Sri Lanka	✓	✓	✓
Tuvalu		✓	✓
Vanuatu	✓	✓	✓

Market based instruments for single use plastics are applied both on the upstream and downstream side of consumption (UNEP, 2018c). Three countries in the region (India, Marshall Islands and Palau) have enacted some type of tax on single use plastics, as a waste disposal fees or charges, or in the form of higher excise taxes for single-use plastics. The taxes are aimed at managing plastic waste or increasing the rate of post-consumer recovery or recycling, or other environmental and circular economy initiatives. **Table 3.2.1-13** summarizes the type of taxation applicable upstream of consumption (UNEP, 2018c).

Table 3.2.1-13: Types of taxation on single-use plastics. Source: (UNEP, 2018c)

Region	Country	Tax Regulation
Asia and Pacific	India	Excise tax at higher rates for plastic packaging and single-use products including tableware and kitchenware (compared to glass, wood and tin packaging) (Goods and Services Tax Act).
	Marshall Islands	Deposit beverage container fee on each deposit beverage container manufactured or imported into the country (Styrofoam cups and plates and Plastic Products Prohibition and Container Deposit Amendment Act).
	Palau	Deposit beverage container fee on distributors (manufacturers and importers) of filled deposit beverage containers (The Palau Recycling Act).

Market based Instruments (MBIs) downstream of consumption include EPR, deposit refund schemes and recycling mandates (UNEP, 2018c). Nine countries such as Fiji, India, Indonesia, Republic of Korea, Australia, Bhutan, Japan, Palau and Marshall Islands in the region have regulations for the disposal of single use plastic items that includes extended producer responsibility. EPR mandate for target and obligation varies from country to country (UNEP, 2018c).

Seven countries in the region have exclusive regulatory mandates regarding recycling. These regulations vary, with most countries' regulations limited to general requirements e.g. solid waste targets for plastics recycling **(Table 3.2.1-14)** (UNEP, 2018c).

Table 3.2.1-14: Regional Distribution of Countries with Recycling Mandates. Source: (UNEP, 2018c)

Country	Required	Targets	Fiscal Incentives	Description
Fiji	✓	✓		Fiji's recycling mandate includes a facility that imports or manufactures plastic bottles must send returns to the Department of Environment of all import, manufacture, distribution, return and disposal of bottles.
India	✓	✓		India's recycling mandate includes "Responsibility of producers, Importers and Brand Owners. - (3) manufacture and use of non-recyclable multilayered plastic if any should be phased out in two years' time."
Indonesia	✓			
Republic of Korea	✓	✓		As per Act on the Promotion of Saving and Recycling of Resources: Mandatory Recycling Ratio applied to manufacturers, ranging from 0.442 (single- material polystyrene paper) to 0.830 (PET complex materials). Recycling due is 30and100 of the sum of expenses to be incurred in recycling non-recycled wastes out of the mandatory recycling quantity.
Malaysia	✓		✓	Manufacture of biodegradable disposable packaging and household wares and waste recycling activities are listed as promoted products and activities under the Promotion of Investments Act which are eligible for pioneer status and investment tax allowance.
Palau	✓			Palau enacted a national recycling program in which the government administers a beverage container deposit-refund scheme.
The Philippines	✓	✓		

Republic of Korea have enacted national level laws or regulations that ban the use, sale, and manufacture of microbeads in personal care products which end up as marine litter **Table 3.2.1-15** provides the name of the specific microbead law or regulations, products covered prohibition (UNEP, 2018c). The Government of India along with different departments of the Bureau of Indian standards, have placed microbeads category in personal care and in unsafe cosmetic products. However, regulation or a phase out plan is yet to be formulated.

Table 3.2.1-15: Microbead Laws and Regulations. Source: (UNEP, 2018c).

Country	Law or Regulations Name	Prohibition	Specific Description
Republic of Korea	Regulations on safety standards for cosmetics [Annex 1] {No. 2017-114, Notice, Article 3, Dec. 29, 2017,	Cannot sell or manufacture	use of raw materials cannot be used in cosmetics and restrictions on the use of cosmetics should be specified

3.2.1.6 Opportunity of Circular Economy

The magnitude of plastic waste generation in the region offers potential threat to both land and marine environment with linkages to livelihood issues particularly in least developed and pacific islands. A circular economy is restorative and regenerative by design. This ensures closed loop system for materials rather than being used once and then discarded. For plastics this means this means keeping the value of plastics in the economy without leakage into the natural environment. In a new plastics economy plastic never becomes waste or pollution. This is achieved by eliminating all problematic and unnecessary plastic items and being innovative in design to ensure the plastics we do need are reusable, recyclable, or compostable. The redefined plastic economy paradigm offers opportunities to not only deliver better system wide economic and environmental outcomes by creating an effective after-use plastics economy, thereby drastically reducing the leakage of plastics into natural systems (terrestrial and marine) in particular the air, soil, water, seas and oceans but also decoupling from fossil feedstock. Further, the new plastics economy offers an attractive opportunity for the global plastic value chain and governments to collaboratively work towards achieving the sustainable development goals. Moving from plastics economy to circular economy could provide an important basis for new source of funding while contributing towards achieving the SDGs, in particular SDG 9, SDG 11, SDG 12 and SDG 14.

3.2.1.7 Conclusion and Way Forward

This chapter identified several barriers related to regulatory, economic, technology, data and information on plastic waste reduction. To overcome these barriers several interventions were developed broadly under (1) Regulatory; (2) Economic instruments; (3) Technology; (4) Data and information and (5) Voluntary measures by industries. To implement these interventions there is an urgent need to develop a stable interface between the science, policy, and business. The governments are essential in setting up effective collection infrastructure, facilitating the establishment of related self-sustaining funding mechanisms, and providing an enabling regulatory and policy landscape. Businesses have a responsibility beyond the design and use of their packaging, which includes contributing towards it being collected and reused, recycled, or composted in practice. Academia has major role to play in research and development towards new plastic economy. The implementation of the policies and regulations as well as creation of waste plastic management infrastructure coupled with capacity building through regional knowledgebase (database, experts, indicator monitoring, information sharing and awareness) are the major challenges which need to mitigate to achieve sustainable management and reduction of plastic waste.

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3.2.2 E-Waste

3.2.2.1 Introduction and Background

The waste from used electrical and electronic equipment (EEE), widely known as E-waste or WEEE, is one of the fastest growing waste streams in the world. The modern world heavily depends on EEE to drive the economy through high technology sector. The benefits of the high technology sector are well known. However, the environmental and health impacts of poor management of end-of-life EEE are relatively unknown. The United Nations has estimated that the world generated around 62 million tonnes (Mt) of E-waste in 2022 with a projection to reach 82 Mt by the year 2030. Furthermore, only 22.3 percent of the global E-waste generation in 2022 has been documented as formally collected and recycled, while the fate of remaining 77.7 percent (48.2 Mt) is uncertain (Balde et al., 2024). From 2010 to 2019, global E-waste generation grew from 5.3 to 7.3 kg per capita annually (38 percent increase) (UNDESA, 2020a). The issue is compounded by the fact that the average life span of many EEEs is continually reducing due to the availability of products with increased memory, processing power, and attractive design features. The average life span of EEE is estimated to be around 4.5-7.5 years, of which mobile phones and tablets have shortest span around 4-5 years. This has led to the early obsolescence of many EEEs, causing a significant increase in E-waste generation. The E-waste generation in world regions during 2022 is summarised in **Table 3.2.2-1.**

Table 3.2.2-1: E-waste generation in regions in 2022. Source: (Balde et al., 2024)

Region	**Annual e-waste generation (Mt)**	Percent **of world e-waste generation**	**E-waste (kg/person)**
Asia	30.1	48.6	6.4
Americas	14.4	23.3	14.1
Europe	13.1	21.2	17.6
Africa	3.55	5.8	2.5
Oceania	0.71	1.1	16.1

The transboundary movement of E-waste from industrialised nations to emerging and developing economies has caused significant challenges to many nations in Asia and the Pacific region due to a lack of infrastructure and financial resources to deal with the issue. In addition, the domestic consumption of EEE in developing and emerging nations has also risen significantly, further adding to the E-waste quantities. Due to the limited availability of formal E-waste recycling sector in many countries in the Asia and the Pacific region, E-waste is predominantly handled by the informal E-waste recycling sector that utilises poor recycling methods to extract the valuable metals while disposing the toxic compounds into the open environment. Such practices have caused severe environmental and health impacts. The informal workers, aiming to recover valuable materials such as copper and gold, are at risk of exposure to over 1,000 chemical substances (WHO, 2021a). The industrialised countries have successfully developed policies and regulations to solve the E-waste problem based on the Extended Producer Responsibility (EPR) concepts where the manufacturers and importers are required to finance the E-waste recycling operations. The Asia and the Pacific countries are now developing stringent regulations based on EPR concepts.

3.2.2.2 Regional Overview on E-waste in Asia and the Pacific

Definition of E-waste and its sources

E-waste comprises many EEE and its accessories thrown away by households and businesses after their useful life. Generally, E-waste includes any used EEE with an electronic circuit or EEE which utilises electrical power or battery power. **Table 3.2.2-2** describes some of the commonly used items.

Table 3.2.2-2: Classification of E-waste. Source: (Forti et al., 2020a)

Category	Items
Temperature equipment	Refrigerators, air conditioners, freezers
Monitors and Screens	Televisions, laptops, notebooks, monitors, tablets
Lamps	Light bulbs, fluorescent bulbs,
Large items	Washing machines, dryers, dishwashing machines, PV panels, photocopiers, electric stoves
Small items	Microwaves, vacuum cleaners, electric kettles, video cameras, calculators, toys, electrical tools, small medical devices, toasters, shavers, hairdryers, scales, many small EEE used in the kitchen
Small high-tech items	Mobile phones, personal computers, printers, telephones, routers

Generation of E-waste generated by each country

The availability and reliability of data on E-waste generation is very limited in many countries. Most of the existing estimates are based on either sales data or predictions based on the estimated life span of EEE. The most reliable and recent statistics related to global E-waste generation can be found in 'The Global E-waste Monitor 2020' published by the United Nations University.

The **Tables 3.2.2-3 and 3.2.2-4** below summarise the regional and selected country data on E-waste generation during 2022. According to these tables, the Asia and the Pacific region generated nearly 50 percent of the global E-waste quantities in 2022. Among the Asian nations, PR China (12.1 Mt), India (4.1 Mt), Japan (2.6 Mt), the Russian Federation (1.9 Mt), and Indonesia (1.9 Mt) are among the highest E-waste generators in the region (Balde et al., 2024).

Table 3.2.2-3: E-waste generation in Asia and the Pacific countries. Source: (Balde et al., 2024)

Country	**E-waste (2019) (tonnes/year)**	**E-waste (2016) (tonnes/year)**
Afghanistan	32,000	20,000
Australia	583,000	574,000
Bangladesh	367,000	142,000
Bhutan	5,000	2,000
Cambodia	25,000	14,000
PR China	12,066,000	7,211,000
India	4,137,000	1,975,000
Indonesia	1,886,000	1,274,000
Japan	2,638,000	2,139,000
Laos	27,000	7,500
Malaysia	411,000	280,000
Maldives	5,000	2,500

Country	E-waste (2019) (tonnes/year)	E-waste (2016) (tonnes/year)
Mauritius	16,000	11,000
Mongolia	20,000	14,000
Myanmar	76,000	55,000
Nepal	42,000	23,000
New Zealand	101,000	95,000
Pakistan	559,000	301,000
The Philippines	537,000	290,000
The Republic of Korea	930,000	665,000
The Russian Federation	1,910,000	1,392,000
Singapore	121,000	60,000
Sri Lanka	175,000	95,000
Thailand	753,000	393,000
Viet Nam	516,000	141,000

Table 3.2.2-4: Top 10 Asia and the Pacific countries with highest generation of E-waste. Source: (Balde et al., 2024)

Country	E-waste (2022) (tonnes)	Percent of total Asia and the Pacific generation (2022)	E-waste (2016) (tonnes)	Percent of total Asia and the Pacific generation (2016)	Percent increase 2016 -2019
PR China	12,066,000	40	7,211,000	41	67
India	4,137,000	14	1,975,000	11	109
Japan	2,638,000	9	2,139,000	12	23
The Russian Federation	1,910,000	6	1,392,000	8	37
Indonesia	1,886,000	7	1,274,000	7	40
The Republic Korea	930,000	3	665,000	4	40
Thailand	753,000	3	393,000	3	92
Australia	583,000	2	574,000	3	2
Pakistan	559,000	2	301,000	2	86
The Philippines	537,000	2	290,000	2	85
Total	25,999,000	88	16,328,000	93	59

Hazardous materials and precious metals in E-waste

The manufacture of EEE consists of a significant number of materials, a mixture of toxic and valuable substances. For example, the production of printed circuit boards (PCBs), which are essential components of many EEE utilises several heavy metals such as antimony (Sb), silver (Ag), chromium (Cr), zinc (Zn), lead (Pb), and copper (Cu). Lead (Pb), which was dominant in old cathode ray tubes (CRTs), still exists in E-waste streams. Computer central processing units (CPU) contain heavy metals, such as cadmium (Cd), lead (Pb) and mercury (Hg). In addition to the heavy metals, EEE also comprises chemical compounds such as polybrominated biphenyls (PBBs) and polybrominated diphenyl ethers (PBDEs). Although these brominated flame retardants are banned from the manufacturing process where such regulations exist, it is common to see literature that confirms the health impacts of people living close to E-waste recycling sites. E-waste also contains precious metals such as gold, silver (Ag), copper (Cu), platinum (Pt), palladium (Pd), and critical raw materials such as cobalt (Co), indium (In), germanium (Ge), bismuth (Bi) and antimony (Sb), which are considered to diminishing from natural ores.

Issues and challenges of E-waste management in the region

Strict environmental regulations and high labour cost have encouraged industrialised countries to move their E-waste to emerging and developing nations where weak regulatory structures and cheap labour are common. Unfortunately, many recycling facilities in these countries operate in an unsound manner causing severe pollution to open-land and waterways. Typically, the informal E-waste recycling processes extract valuable metals and disposes toxic residues into an open environment causing significant impacts on human health. A large amount of E-waste is exported from industrialised countries to Asian countries, particularly India, PR China, Indonesia, Cambodia, Viet Nam, Sri Lanka, Pakistan, Philippines, and Bangladesh, for recycling. With the recent PR China ban on waste import, most E-waste is now ending up in other Asian nations such as Thailand and Viet Nam.

The informal recycling sector that employs mainly women and children undertake recycling of E-waste with minimum safeguards to their health and safety of handling E-waste. WHO estimates that as many as 12.9 million women are working in the informal sector which put them and their unborn children at risk. More than 18 million children and adolescents (some as young as 5 years of age) are actively engaged in the informal E-waste recycling sector (WHO, 2021b)

The informal E-waste recycling sector employs basic and sometimes rudimentary processes to extract valuable metals components from E-waste. Such practices include open burning of cables, selective extraction of useful metals, etc. The existence of the informal E-waste recycling sector presents challenges to the formal E-waste recycling sector who have invested in advanced technologies to minimise environmental and health impacts of E-waste recycling. The formal E-waste recycling sector is denied the necessary inputs as the informal sector provides incentives to the customers to collect their used EEE.

The human health and environmental impacts of E-waste recycling have been well studied by researchers around the world, in particular, in countries where E-waste recycling is predominantly undertaken by the informal sector. These studies include adverse impacts on soils and sediments, impacts on human health, and impacts on general biota due to poor E-waste management. Hou et al. (2020) conducted a study to investigate the relationship between chronic exposure of Pb and oral anti-inflammatory potential of preschool children living near an informal E-waste recycling site in PR China. They found a strong correlation between excessive Pb exposure and lower oral anti-inflammatory ability of oral sialic acids. J. Liu et al. (2018) evaluated the association of E-waste exposure in children with paediatric hearing ability. The study concluded that early childhood exposure to Pb maybe a risk factor for hearing loss in children living near E-waste sites. The adverse impacts of poor E-waste recycling are not only limited to direct human health. They extend to indirect health impacts as a result of consuming food grown inland contaminated with E-waste recycling. Wu et al. (2019) found a serious health risk associated with paddy cultivation near informal E-waste recycling sites. A study conducted by Alam et al. (2019) to assess the genotoxicity of E-waste leachates at an E-waste dumpsite in Metro Manila, Philippines showed the heavy presence of Cd, Cu, Ni, Pb and Zn in the soil samples of the E-waste recycling sites and the hair of the informal recyclers. Cai et al. (2019) investigated the effect of lead exposure on child sensory integration by correlating the blood levels of children with sensory processing measures living close to E-waste recycling town in PR China (Guiyu). They concluded that Pb exposure in E-waste recycling areas might impact the serum cortisol levels and an increase in the difficulty of child sensory integrations, further confirming the impacts on humans, especially young children.

3.2.2.3 National Regulations, Standards, and Guidelines on E-waste Management

To tackle the adverse impacts on the environment and human health, many countries in the world have developed or in the process of developing regulations, policies, standards, and guidelines related to E-waste management. Initially pioneered by the European Union (EU), the concept of EPR has become the central theme of many of these initiatives. Among the Asia and the Pacific nations, direct E-waste regulations vary significantly. Only 8 countries in the region have fully implemented E-waste regulations while few countries have limited implementation of E-waste regulations or the process of developing one. Most of the countries in the region have no E-waste regulations. E-waste in these nations is managed under existing environmental regulations. **Table 3.2.2-5** summarises the state of E-waste regulations in the region.

Table 3.2.2-5: Status of E-waste Regulations

Status	Countries
Full implementation of E-waste regulations	**<u>Australia:</u>** • Product Stewardship (Televisions and Computers) Regulations 2011 • National Television and Computer Recycling Scheme 2011 **<u>PR China</u>** • Law on the Promotion of Cleaner Production(2002) • Law on the Promotion of Circular Economy (2008) • Law on the Prevention of Environmental Pollution by Solid Waste (issued in 1995, latest revised in 2020) • Administrative Regulation for the Collection and Treatment of Waste Electronic and Electrical Equipment (2009) • Administrative measures on the prevention and control of environmental pollution by WEEE (2007) • Restriction of Hazardous Substances in Electrical and Electronic Equipment (issued in 2006, revised in 2016) • Administrative measures on the qualification of WEEE treatment (2010) **<u>India:</u>** • E-waste (Management) Rules, 2016 • E-waste (Management) Amendment Rules, 2018 **<u>Japan:</u>** • Home Appliance Recycling Law • Small Home Appliance Recycling Law) **<u>Singapore:</u>** Producer Responsibility Scheme (PRS) under Resource Sustainability Act (RSA) fully implement in July 2021 **<u>The Republic of Korea:</u>** • Act on the Promotion of Conservation and Recycling of Resources (commonly known as the Waste Recycling Act) of 1992 • Act on the Resource Circulation of Electrical and Electronic Equipment and Vehicles 2007
Limited implementation or draft stage development of E-waste regulations	**<u>Bangladesh:</u>** Hazardous Waste (e-waste) Management Rules, 2021 under the Bangladesh Environmental Protection Act, 1995 **<u>Cambodia:</u>** Management of Waste Electrical and Electronic Equipment, Sub-Decree No 16 **<u>Indonesia:</u>** Ministerial Decree on National E-Waste Management (under development) **<u>New Zealand:</u>** Product Stewardship Regulations under Waste Management Act (under development for

Status	Countries
	implementation in 2023) **The Russian Federation**: Technical Regulation on Restriction on the use of Certain Hazardous Substances in Electrical and Electronic Equipment (TR EAEU 037and2016) **Thailand:** The draft of the Electrical and Electronic Equipment Waste Management Act, B.E. XXXX, was introduced in 2021 for public consultation. **Viet Nam:** Decision No. 16and2015andQD-TTg (based on the EPR) and Circular No. 34and2017andTT-BTNMT(2017), Circular 36and2015andTT-BTNMT on hazardous waste, Law on Environmental Protection 2020, and Draft Guidance Decree on the EPR for a number of discarded products including electronic and electrical equipment
No E-waste regulations but managed by existing environmental regulations or strategies	**Bhutan:** National Integrated Solid Waste Management Strategy 2014 and National Waste Management Strategy 2019 **Laos:** Environmental Protection Law (2012) **Malaysia:** Environmental Quality (Scheduled Waste) Regulations 2005(E-waste was included and coded as SW110) **Maldives:** Waste Management Regulation (No. R-58and2013) **Mauritius:** Environmental Protection (Standards for Hazardous Wastes) Regulations 2001 **Mongolia:** National Waste Management Improvement Strategy and Action Plan (NWMISAP) 2017-30 **Myanmar:** National Waste Management Strategy and Master Plan (2018-2030) **Nepal:** Solid Waste Management Act, 2011 (SWM Act) and Solid Waste Management Rules, 2013 (SWM Rules) **Pakistan:** Pakistan Environmental Protection Act (1997), the National Waste Policy (2005), and Import Policy Order (2016) **Philippines:** Republic Act (RA) 6969 **Sri Lanka:** National Environmental Act, No. 47 of 1980 and National Waste Management Policy 2019

Some countries in the region have also developed comprehensive guidelines or standards for managing E-waste (see **Boxes 3.2.2-1 and 3.2.2-2**).

Box 3.2.2-1: E-waste Guidelines

Malaysia (DOE Malaysia, 2010)
Guidelines for Classification of Used Electrical and Electronic Equipment 2010) (Second Edition)

Philippines (DENR, 2015)
Guidelines on the Environmentally Sound Management (ESM) of Waste Electrical and Electronic Equipment (WEEE)

India (CPCB, 2016)
The Central Pollution Control Board of India has published the ‘Guidelines on Implementation of E-waste (Management) Rules, 2016

Cambodia
Guideline on Environmental Sound Management of Waste Electrical and Electronic Equipment'

Box 3.2.2-2: E-waste Standards
Australia has released a standard for the collection and recycling of E-waste in Australia and New Zealand. The standard titled "ASandNZS 5377:2013 *Collection, storage, transport and treatment of end of life electrical and electronic equipment*" specifies the way that E-waste should be handled and disposed of in an environmentally sound manner.
The standard also contains guidelines about worker training for the handling of E-waste (Standards Australia, 2013).

Ministry of Environment Japan (MOEJ) has developed "Standards for Collection, Storage, Transport, Recovery, Treatment and Disposal to Ensure Environmentally Sound Management of E-waste" as part of Fact Sheet series on 3R Policy Indicators (IGES, 2013).

3.2.2.4 Sustainable Management of E-waste

Development of infrastructure for formal recycling of E-waste including state-of-the-art recycling facilities

Recycling is one of the most popular options for managing E-waste. Many industrialised countries have realised although E-waste contains many toxic metals and chemical compounds, they also provide valuable metals that have value in the secondary resource market. This has resulted in the development of state-of-the-art formal E-waste recycling facilities adopting advanced technologies. E-waste recycling process typically involves initial dismantling, upgrading and refining. Once the E-waste has been dismantled, shredded and metallic components separated, the final metal recovery is achieved through metallurgical processing which involves smelting the components using heat known as pyrometallurgical processing or dissolving in appropriate solvents known as hydrometallurgical processing. Compared to industrialised countries, formal E-recycling is only starting to emerge in the Asia and the Pacific countries.

Box 3.2.2-3: INDIA

E - Parisaraa

E-Parisaraa Pvt. Ltd has the objective of converting E-waste into beneficial resources using environmentally friendly, locally appropriate technologies. These processes are capable of dismantling toner cartridges, recover gold from printed circuit boards, recover silver from silver-coated components, and shredding printed circuit boards for further processing. E-Parisaraa also recovers other metals such as selenium, indium, cobalt, tantalum and ruthenium using environmentally sound methods. It is India's first E-waste recycler approved from both Central Pollution Control Board (CPCB) and Karnataka State Pollution Control Board (KSPCB) has branches in Mumbai, Bangalore, Gurgaon, Chennai and West Bengal.

Improving the performance of informal E-waste recycling sector

In many developing countries in the Asia and the Pacific region, the informal sector is heavily engaged in activities related to the E-waste recycling chain. They are motivated by precious materials contained in the E-waste stream and its market value. In reality, informal collection of E-waste does not have any major adverse impacts on the environment. Instead they lead to high collection rates and many economic and social benefits to the poor section of the community. The informal sector is also involved in the second stage of the E-waste recycling chain related to dismantling and pre-processing. Even here, there are no major impacts on the environment, instead more economic and social benefits accrue to poor community. However, the major environmental and health impacts occur when the informal sector is involved in the last stage of the E-waste recycling chain where advanced processes and techniques are necessary to extract the valuable components such as metals. Most of the informal E-waste recyclers adopt low efficiency processes resulting in major health and environmental impacts. For example, primitive technologies utilised by informal recyclers to extract raw materials from printed wire boards, wires and other metal bearing components have very low material recovery rates and also result in major environmental impacts. Prohibiting and imposing fines on informal recycling have not helped in countries. The governments have also tried to regulate the informal E-waste recycling sector by licensing them. Given the obvious benefits of the informal E-waste recycling sector, policy makers must take necessary steps to improve the performance of this sector. The complete informal E-waste recycling chain must be thoroughly investigated to seek which steps are environmentally harmless and should remain and which steps should be changed for better downstream environmental and recycling performance.

Box 3.2.2-4: Best-of-the-2-Worlds (Bo2W) (Kuehr and Wang, 2015)

The Solving the E-waste Problem (StEP), an United Nations initiative, describes an innovative model developed for improving the activities of informal E-waste recycling sector where it is argued that affordable and environmentally sound recycling can be achieved in developing countries through the cooperation between local dismantling operations and the global networks of infrastructure that can further refine the materials. Bo2W concept attempts to create a connection between high-income and low-income countries to take advantage of low-cost labour in the latter to initiate the manual disassembly into high-quality material fractions followed by export to high-technology refineries in the former for final processing. According to Bo2W, this could be a 'win-win' situation since workers at manual disassembly plants would accrue benefits such as higher wages and improved occupational health and safety. The high-technology refining facilities would gain access to low-cost but high-quality feedstock.

Box 3.2.2-5: Suggested Approach to partner with informal sector

- Hostile approach to informal sector has limited success (informal sector has flexibility to adapt to newly imposed measures!!)
- Discontinued stances ignore the existence of large informal sector and require producers to collect and treat E-waste (many countries have implemented such EPR schemes)
- Disconnection with informal sector can result in limited amount of E-waste available for formal collection.
- Limited or non-cooperative interactions can result in informal and formal sector operating largely in parallel.
- Broadly synergetic interactions result in deeper form of partnership recognising strengths of both sectors.
- Understand both sectors (Need to survey players, dynamics, constraints, prices, and quantities of both sectors. Oversight of informal sector in a formal EPR management policy is very common)
- Recognise integration as an incremental and continual process (Balancing act needed between full-system perspective and incremental process)
- Engage relevant stakeholders, and design policies co-operatively (Informal sector not included in stakeholder list)

- Focus on minimising key risks and supporting key strengths of informal sector (Pro-actively playing to strengths of informal sector can avoid policy failure)
- Create change by incentivising rather than punishing the informal sector (Informal sector can respond quickly to a realignment of incentives including incentives to do the right thing.)

Box 3.2.2-6: E-waste: From Toxic to Green

The informal E-waste recycling sector is very active in India with over 90 percent of the E-waste handled by this sector. Although the collection and recycling rate is high, the informal sector is not always aware of the environmental and human health impacts of their operation. To address this issue, the Toxic to Green initiative was launched to train the waste pickers for safe disposal and recycling of e-waste. Chintan, an Indian non-governmental organisation, has cooperated with the government sector to develop a partnership with a registered association of waste pickers, to train their members on how to collect and handle e-waste in a safe manner (Chintan, 2022).

Tackling emerging and problematic E-waste streams (e.g. Li-ion batteries, solar panels)

Lithium-ion batteries (LIBs) are predominantly used as electricity storage for applications requiring high energy intensity such as in electric vehicles (EVs). Recent popularity of EVs has led significant growth in the demand for LIBs which require valuable metals such as lithium (Li), cobalt (Co), and nickel (Ni). It is estimated that over 5 million metric tonnes of LIBs are expected to reach their end-of-life by 2030 (Beaudet et al., 2020). Recycling technologies for LIBs are still not adequately developed and hence would become a challenging issue in near future. One option is to reuse or recondition used battery packs for use in second life applications in less demanding applications.

Recent years have seen an exponential growth of solar photovoltaic panels (solar PV panels) in Asia and the Pacific region to deal with climate issues. The global installed solar PV capacity was 222 GW in 2015 with an estimate to reach 4500 GW by 2050 with top three countries in Asia (PR China, India and Japan) (UNEP, 2019). Such growth will result in a significant solar PV panel waste legacy within the next 10-30 years as the life expectancy of most PV panels is about 25-30 years. Asian region alone is expected to add 25 million tons of solar PV panels in coming years (Majewski et al., 2021). A typical solar panel consists of 55 percent glass, 13 percent aluminum, 10 percent adhesive sealant, 3 percent silicon, and 19 percent other including rare metals such as indium, gallium and germanium.

Box 3.2.2-7: Fires caused by Lithium-ion Batteries (LIBs) and countermeasures

LIBs are included in many types of E-waste. It is estimated that the consumption of LIBs in many countries around the world has significantly increased during the last decade. When LIBs are short-circuited or exposed to high temperatures, exothermic reaction can be triggered, resulting in a self-enhanced increasing temperature loop known as "thermal runaway" that can lead to battery fires and explosions (Kong et al., 2018). In recent years, increasing occurrences of waste fires that are caused by improperly discarded lithium-based portable batteries threaten the whole waste management sector in numerous countries (Nigel et al., 2021). In Japan, there have been a number of fire incidents in non-combustible waste treatment facilities and collection vehicles that are believed to be caused by LIBs (MoEJ, 2021). In Europe, the number of fires in the E-waste management chain is growing. Both in recurring fires and severe fires occurring at collection and treatment facilities, mixed E-waste is the most affected waste stream, and damaged batteries are found as responsible for those fires in most cases (Ollion L., 2020). In order to prevent fires caused by LIBs, it is desirable to collect them properly to prevent thermal runaway during the treatment and storage stages. Establishing collection schemes and measures for products that contain LIBs are major issues. In order to properly separate and dispose of LIBs and LIB-containing E-waste by consumers as well as for municipalities and recyclers to properly collect and recycle them, removable design and labeling is necessary from the production stage.

Development of Public Private Partnerships (PPPs) for managing E-waste

The development of Public-Private Partnerships (PPPs) is vital for sustainable management of E-waste. Although the national governments set the targets to achieve recycling of E-waste, the operational responsibility of the system heavily depends upon the financial and human resource potential of the local authority. These local authorities alone are unable to achieve sound E-waste management systems, thus requiring input from the private sector to build the necessary infrastructure, organise the finances, and bring in the technology. The PPPs also benefit the businesses and the community as they can effectively utilise the services provided by the private sector. The private sector can also derive economic benefits from E-waste by reducing risk, enhancing efficiency, and developing new markets while making a considerable contribution to services delivered by the local authorities. PPPs have proven to be hugely successful in enhancing the progress in the E-waste resource recovery and recycling industry.

Box 3.2.2-8: E-waste Alam Alliance Malaysia (DOE Malaysia, 2013)

E-waste Alam Alliance Malaysia was launched on 11 December 2013 by the Deputy Minister of Natural Resources and Environment, Y.B Dato' Sri Dr. James Dawos Mamit. The objectives of partnership are:

- Implementation of collection, segregation and transportation of the waste of E-waste generated from households effectively;
- Develop a system of collection, segregation and transportation of E-waste from households across Malaysia centralised;
- Increase in public awareness will be the responsibility of the waste of E-waste from households;
- Increasing awareness of the producer, seller, distributor of electrical and electronic goods on the importance of being responsible for the management of E-waste from households;
- Encourage manufacturers and vendors and distributors of electrical and electronic waste collection to implement E-waste from households voluntarily and without additional charge;
- Creating a network of cooperation with stakeholders in the management of E-waste from households

E-waste Alam Alliance involves number of stakeholders as described below:

- Six States namely Perak, Selangor, Federal territory (Kuala Lumpur and Putrajaya), Melaka and Johor;
- Local authorities in each state;
- Manufacturers, dealers, retailers, distributors, and importers of EEE in each state;
- Off Site Recovery Facility (Full Recovery Facility);
- National Solid Waste Management Department (JPSPN) and Solid Waste Management and Public Cleansing (PPSPA)
- Charitable non-governmental organizations (NGO's) and community and residents association

Extended Producer Responsibility (EPR) as a funding mechanism for managing E-waste

The Extended Producer Responsibility (EPR) involves making the producer or importer of a product physically and financially responsible for collection and processing of their products after use. EPR shifts the administrative, logistical, and financial responsibility from public sector to the manufacturers or importers of the products. Through this process, it is also expected that manufacturers will take into account practices such as design for the environment in their manufacturing process to minimise the end-of-life processing costs. EPR has been implemented in many industrialised countries with great success in dealing with the E-waste problem. One of most important elements of EPR is identifying the manufacturer or importer. Many countries in the Asia and the Pacific region have either implemented EPR systems or in the process of developing one. EPR systems can take many forms including product take-back schemes, advanced recycling fees, container deposit schemes, etc. (Khajuria, 2015). Most of these schemes are managed by a government appointed Producer Responsibility Organisations (PROs), to administer the system. The manufacturers or importers of electronic and electrical goods pay an annual fee to the PRO-based on their market input. The fee is utilised by the PRO towards the logistics and proper recycling of E-waste through licensed recyclers.

Box 3.2.2-9: Examples of EPR Schemes

Australia: National Television and Computer Recycling Scheme

The National Television and Computer Recycling Scheme (NTCRS) is one of the most effective EPR schemes implemented in Australia under the Product Stewardship Act 2011. The NTCRS came into effect in 2011 under the Product Stewardship (Televisions and Computers) Regulations 2011 to allow Australian households and small businesses access to an industry-funded collection and recycling scheme for televisions and computers. The television and computer industries are obliged to fund the collection and recycling of the proportion of televisions and computers disposed of in Australia each year with the aim of achieving an 80 percent recycling rate in 2026-27. Currently the system is administered by government approved co-regulatory arrangements. **Figure 3.2.2-1** shows roles and responsibilities of each stakeholder under the NTCRS system.

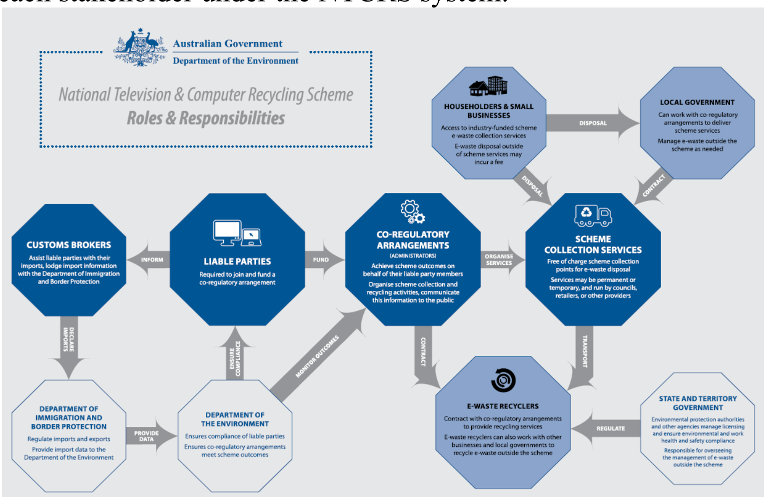


Figure 3.2.2-1 National Television and Computer Recycling Scheme (DCCEEWW Australia, 2011)

India: Samsung Takeback and Recycling

The Samsung takeback and recycling program (STAR) provides free drop-off of Samsung branded products in several locations in Indian cities. They provide fixed drop-off locations for smaller products, such as mobile phones and cameras. For larger items such as televisions, washing machines, and refrigerators, Samsung offers free pick-up service from the customers. The STAR initiative also includes a program to raise awareness among the consumers about the proper recycling of used EEEs. To ensure the success of the STAR program, Samsung has signed contracts with a number of electronics recycling companies in India (Samsung, 2021).

Singapore: EPR Scheme

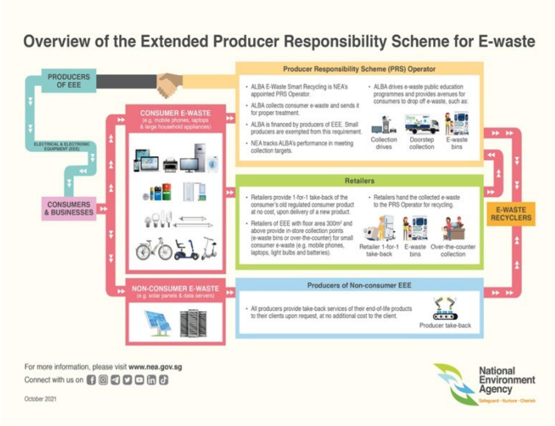


Figure 3.2.2-2 Singapore EPR Scheme (Source: National Environment Agency)

Singapore
The NEA has awarded the licence to operate a Producer Responsibility Scheme (PRS) in Singapore to ALBA Group plc and Co. KG (ALBA). As the PRS Operator, ALBA will collect regulated consumer electrical and electronic waste across Singapore for proper treatment and recycling on behalf of producers, for a period of five years, from 1 July 2021 to 30 June 2026

PR China: WEEE treatment fund and EPR implementation
E-waste management principle in PR China has been developed from "Polluters pay" to EPR gradually. The latest revised version of "Law on the Prevention of Environmental Pollution by Solid Waste" in 2020, article 66 states that the state shall establish an EPR system for such products as EEE, lead-acid batteries and power batteries for vehicles. Five types of EEE, including TV, refrigerators, washing machines, air conditioning units, and micro-computers are included in the first batch of WEEE Treatment Catalogue which took effect in Jan. 2011. In Feb. 2015, another 9 types of EEE, including printers, copying machines, fax machines, electric water heaters, gas water heaters, kitchen ventilators, monitors, mobile phones, and telephones, were added in the WEEE Treatment Catalogue which entered into effect in March 2016. Producers and importers of EEE should pay the fund at a range from 7 to 13 RMB per unit. The WEEE treatment facilities receive a subsidy ranging from 25-100 RMB per unit. Currently, standards for fund payment and subsidy are only issued for the first batch of 5 kinds of WEEE, and expected to change gradually. Since 2012, the standards for fund subsidy have changed three times. In August 2021, National Development and Reform Commission (NDRC) of PR China, combined with Ministry of Industry and Information Technology (MIIT) and Ministry of Ecology and Environment (MEE), issued a Notice on "Encouraging home appliance manufacturers to carry out the action of recycling target responsibility system". Four types of EEE, TVs, refrigerators, washing machines, and air conditionings were selected. The participating manufactures should specify the EEE types and establish 2 recycling annual targets. One target includes annual recycling quantity, annual recycling rate (annual recycling rate equals annual recycling quantity divide and average sales volume in the previous three years), etc. Another target is entitled with action target including annual recycling activities. The notice is voluntary and not mandatory.

Upstream E-waste reduction through Design for Environment (DfE) practices

Design for Environment (DfE), also known as Eco-design, considers the entire life cycle of a product (from raw material extraction to final disposal) to determine the environmental impacts at each stage to propose changes to product design to minimise those impacts. DfE involves designing products for practices such as design for energy efficiency, design for re-use, re-manufacture, disassembly and recycling, and design for resource conservation. To overcome the challenges of environmentally sound recycling of E-waste and to minimise its generation, it is crucial to adopt DfE practices to move away from challenging end-of-pipe treatment methods. Towards this, the substitution of toxic raw materials with non-toxic materials, designing EEEs for easy disassembly and repair, and designing the products for energy efficiency to reduce the power consumption could contribute significantly to reduce the environmental footprint of the E-waste industry.

Box 3.2.2-10: Design for Environment: DELL
Dell is a multinational company that manufactures computers and related products. Their Design for Environment program is one of the most impressive among computer manufactures. Dell's system incorporates DfE at four different stages: Design and Build, Shipping, Use, and Re-use and recycling. During the design and build stage, Dell ensures that the substances they use for their products do not cause any harm to the environment and human health. For example, Dell has phased out medium chained chlorinated paraffins, certain phthalates, and polycyclic aromatic hydrocarbons in addition to the substances banned under the European Union's Restriction of Hazardous Substances Directive (RoHS). During the shipping stage, Dell ensures the use of sustainable packaging materials, smaller transportation footprints, and the use of recyclable materials.

3.2.2.5 General Assessment of E-waste Management in Countries

Australia

The Australian Federal and State governments have worked together with the industry to develop regulations to deal with E-waste. Currently, there are five key policy and regulatory elements that govern the E-waste management in Australia:

- *Recycling and Waste Reduction Act 2020*
- *National Waste Policy 2019*
- *Product Stewardship Act 2011*
- *Product Stewardship (Televisions and Computers) Regulations 2011*
- *National Television and Computer Recycling Scheme 2011 (NTCRS*)

Under the NTCRS, the television and computer industries are required to fund collection and recycling of a proportion of the televisions and computers disposed of in Australia each year, with the aim of delivering a staged increase in the rate of recycling of televisions and computers in Australia from an estimated 17 percent in 2010–11 to 80 per cent by 2026–27. The NTCRS is operated on behalf computer and television industry by government-approved co-regulatory arrangements (PROs) that determine how to deliver the outcomes efficiently. The Recycling and Waste Reduction Act 2020 requires liable parties to fund the recycling of end-of-life television and computer products by becoming a member of NTCRS thorough the PROs. The PROs are also required to contract with recycling services providers that are certified to AS5377: the Australian Standard for collection, storage, transport, and treatment of end-of-life electrical and electronic equipment.

Bangladesh

On June 10, 2021, Bangladesh’s Department of Environment (DoE) published the *Electronic Waste (E-waste) Management Rules, 2021* under the Bangladesh Environmental Protection Act, 1995. The E-waste rule covers the products listed in the Schedule (home appliances, monitoring and control equipment, medical equipment, automatic machines, IT and communication equipment), and establishes obligations for manufacturers, assemblers, collectors, sellers, and consumers of the products. The rule also sets provisions to limit the use of the 10 substances covered by the European Union Restriction of Hazardous Substances (EU RoHS) Directive. The draft rules implement the concepts of EPR where provision is made to provide a payment to the consumer as an incentive from time to time, fixed by the Government, for returning the expired electrical and electronic products, submitting a plan for implementing EPR at the time of registration with application to DoE, and meeting a targeted amount of the E-waste to be collected by each producer or manufacturer for dismantling or reusing according to collection targets specified in the Schedule. Manufacturers are required to establish individual or joint collection centres and set aside funds for the management of E-waste. Currently, recycling of scrap and used electrical and electronic goods is a profitable business in Bangladesh. People take the E-waste to the second hand shop for reuse or to the retailer where they get residual value of their product. Only a very small amounts valuable resources extracted by the informal sector with large amounts of E-waste being disposed in open dumps, rivers, etc. Health and Safety issues related to E-waste are addressed in the new rules. Recently, Department of Environment has taken initiatives to conduct a research study on "Assessment of generating E-waste, its impact on Environment and Resource Recovery potential in Bangladesh. The Ship Breaking and Ship Recycling Rules 2023 (Draft) and Bangladesh Import and Export Policy Order (2015-2018) control E-waste import and export.

Bhutan

Bhutan current has no regulations to deal with E-waste. Bhutan has developed a *National Integrated Solid Waste Management Strateg*y in 2014 and *National Waste Management Strategy* in 2019. However, the waste management procedures have not been effectively implemented even though the responsible authorities for waste management are clearly specified in the Law. The reasons for this include lack of capacity of Thromdes, Dzongkhags and implementing or collaborating agencies and lack of awareness and cooperation of the general public. In Bhutan, the Department of Information Technology and Telecom (DITT) under Ministry of Information and Communication (MoIC) is the implementing agency responsible for managing E-waste. DITT collects E-waste from government offices and return them to the Department of National Properties (DNP) for disposal. Bhutan is planning to amend the E-waste management chapter in the Waste Prevention and Management regulation 2012 in order to achieve environmentally sound management of E-waste.

Cambodia

Cambodia currently has no specific regulations related to E-waste management. Although some regulations related to impacts on human health and the environment exist, they lack the strength to control E-waste activities. In 2016, the Ministry of Environment issued *Management of Waste Electrical and Electronic Equipment, Sub-Decree No 16* to regulate companies that purchase, dismantle and dispose off E-Waste. In 2017, The Ministry of Environment, Cambodia, in collaboration with the Ministry of Environment, Korea developed a *'Guideline on Environmental Sound Management of Waste Electrical and Electronic Equipment'*. The informal E-waste recycling sector is highly active in Cambodia. Their poor recycling operations have resulted in significant damage to the environment and human health. E-waste is individually retrieved by informal sector collectors who sell it either to repair shops for dismantling or to waste traders. The reusable parts are sold and the recyclable parts are passed on to local scrap yard owners for export. The residues left after these operations are disposed to municipal waste systems, burnt or disposed in open dumps. The E-waste operators and junk shop owners have very little knowledge on the negative environmental as well as health impacts of improper treatment and disposal of hazardous substances from E-Waste. Cambodia needs to develop a formal take-back scheme based on EPR to finance the improvements of current operations. The *Waste Management Strategy and Action Plan of Phnom Penh 2018-2035* published by Phnom Penh Capital Administration, Kingdom of

Cambodia in 2018 proposes several action plans to divert the E-waste from leaking into the municipal waste stream through enhancing resource recovery and combating illegal E-waste disposal practices such as open burning and back-yard smelting as cheap methods of resource recovery.

PR China

PR China is the largest producer of E-waste in the world. Given the significant quantities of E-waste to deal with, PR China has developed several environmental laws and regulations to manage this waste stream. The main three main overarching laws that relates to E-waste management in PR China are:

- *Law on the Promotion of Cleaner Production (2002)* that promotes concepts of waste prevention during design and production of EEE and their treatment the end-of-life
- *Law on the Promotion of Circular Economy (2008)* specifies concepts of 3R (Reduce, Reuse, Recycle) during the production, consumption, and other stages of life span of EEE
- *Law on the Prevention of Environmental Pollution from Solid Waste (2004*) stipulates that E-waste treatment plants obtain permits from local environmental protection agencies to safely handle hazardous components of E-waste.

PR China has also adopted a number of Administrative Measures to complement the above laws. The '*Administrative measures on the prevention and control of environmental pollution by WEEE'* issued in 2007 deals with the prevention and control of environmental impacts resulting from disassembly, recycling, and disposal of E-waste with defined responsibilities of relevant stakeholders. The '*Administrative measures on the qualification of WEEE treatment'* issued in 2010 further stipulates the licencing procedure and qualification of E-waste treatment facilities including supervision activities. The '*Administrative measures on the distribution of used electrical and electronic products*' issued in 2013 deals with the procedures related to the purchase or sale of used EEE. PR China also passed following two laws to further strengthen E-waste management:

- *Ordinance on Management of Prevention and Control of Pollution from Electronic and Information Products (2006)* - referred to as PR China's RoHS Directive
- *Administrative Regulation* for the Collection and Treatment of Waste Electronic and Electrical Equipment (2009) – referred to as PR China's WEEE Directive, came into force in 2011 with emphasise on EPR, centralised disassembly of E-waste, and qualification of recycling plants.

In 2016, PR China issued the '*Restriction of Hazardous Substances in Electrical and Electronic Equipment*' which superseded PR China's ROHS issued in 2006. The new RoHS proposed a compliance management list to control the use of hazardous substances in EEE.

India

India is the second highest generator of E-waste in the Asia and the Pacific region. India's Central Pollution Control Board (CPCB) published the '*Guidelines for Environmentally Sound Management of E-waste in India'* in 2005. The guideline deals with the identification of various sources of E-waste with recommended procedures for handling it. India's Ministry of Environment and Forest (MoEF) enacted the '*E-waste (Management and Handling) Rule of 2011,* ' which came into force in May 2012. The Rule requires manufacturers to take responsibility for collecting and financing the E-waste management system through the EPR concept. In 2016, India developed the new '*E-waste (Management) Rules, 2016*' (the EWM Rules, 2016), which superseded the 2011 rule and came into effect from October 2016. The revised Rule further improved the EPR concept. In 2018, the Ministry of Environment, Forest and Climate Change (MoEFandCC) amended the 2016 Rules by introducing E-waste collection targets to be met according to a graduating scale from 10 percent in 2018 to 70 percent in 2023. The amended Rule *'E-waste (Management) Amendment Rules, 2018'* has the provision of registering a PRO for managing the EPR system. Currently, the informal sector dominates India's e-waste recycling industry.

E-Waste (Management) Rules were notified on 2nd November, 2022. These rules will replace E-waste (Management) Rules, 2016 and will be effective from 1st April, 2023. These rules will launch a new Extended Producer Responsibility (EPR) regime for e-waste recycling. The salient feature of new rules is as under:

- Applicable to every manufacturer, producer, refurbisher, dismantler and recycler.
- All the manufacturer, producer, refurbisher and recycler are required to register on portal developed by CPCB.
- No entity shall carry out any business without registration and also not deal with any unregistered entity.
- Authorization has now been replaced by Registration through online portal and only manufacturer, producer, refurbisher and recycler require Registration.
- Schedule I expanded and now 106 EEE has been include under EPR regime.
- Producers of notified EEE, have been given annual E-Waste Recycling targets based on the generation from the previously sold EEE or based on sales of EEE as the case may be. Target may be made stable for 2 years and starting from 60 percent for the year 2023-2024 and 2024-25; 70 percent for the year 2025-26 and 2026-27 and 80 percent for the year 2027-28 and 2028-29 and onwards.
- Management of solar PV modules and panel cells added in new rules.
- The quantity recycled will be computed on the basis of end products, so as to avoid any false claim.
- Provision for generation and transaction of EPR Certificate has been introduced.
- Provisions for environment compensation and verification and audit has been introduced.
- Provision for constitution of Steering Committee to oversee the overall implementation of these rules.

Under the E-Waste Management Rules, provision for reduction of hazardous substances in manufacturing of Electrical and Electronic Equipment (EEE) has been provided.

Indonesia

Indonesia's environmental regulations come under the *Environmental Protection and Management Act No 32and2009*. Currently there is no specific legislation to deal with E-waste although the regulations have incorporated management of hazardous waste. The hazardous waste regulations in Indonesia cover two major types of waste: industrial and household. The policy on industrial hazardous waste is regulated by Government *Regulation No 101and2014 on Hazardous Waste Management*. The household waste management activities are regulated by *Act No 18and2008*. In 2020, the Indonesian government issued *Government Regulation No 27*, which covers specific types of household waste, including E-waste. Furthermore, development of a Ministerial Decree on National E-Waste Management is currently underway. In Indonesia, informal recycling sector has a prominent presence which include unregulated and unregistered small businesses, groups, or individuals. For example in Java almost 90 percent of the total E-waste generated from households, offices, and commercial areas, is handled by the informal sector.

Japan

Japan is the third highest generator of E-waste in the Asian region. Japan has a long history of waste reuse and recycling due to the shortage of natural resources. The first Japanese law on recycling, *Law for Promotion of Utilisation of Recyclable Resources*, or LPUR came into force in 1991 to promote recycling and design for resource recovery. In 2000 LPUR was amended to *Law for Promotion of Effective Utilisation of Resources* to include waste prevention, eco-design, and design for recycling. Japan's regulations on E-waste are covered by two laws as below:

- *Home Appliance Recycling Law*
- *Small Home Appliance Recycling Law*

The 'Home Appliance Recycling Law', effective from April 2001, covers air conditioners, refrigerators and freezers, televisions, and washing machines and clothes dryers. The consumers cover the cost of recycling. The consumers pay a collection fee when they drop off their used product to finance the collection, transport, and recycling costs. The retailers are responsible for collecting used home appliances, and the manufacturers are responsible for the recycling of them. The consumers are required to return their above-used appliances to retailers or municipalities and pay the required fees.

The 'Small WEEE Law' came into force in 2013 to cover all household appliances such as personal computers, cameras, video game consoles, and mobile phones that are not covered by the 'Home Appliances Recycling Law.' The scheme is funded by the Government. The law requires consumers to deliver the used small appliances to the retailer of the designated collector. Manufacturers are also required to reduce the recycling costs by improving design and using recyclable materials in their production.

In 2006, an amendment to the 'Law for the Effective Utilisation of Resources' was adopted to introduce the Japanese version of EU's RoHS Directive. This is referred to as J-MOSS or JIS C 0950 and covers televisions, refrigerators, washing machines, clothes dryers, microwaves, and unit air conditioners. The amendment requires the manufacturers to label their products and provide information on the six substances covered by EU's RoHS.

Lao PDR

Lao PDR currently has no national legislation on E-waste management and disposal. Furthermore, Laos has no proper inventory of E-waste generation with no collection system and a poor institutional capacity for managing rapidly increasing E-waste quantities. A considerable amount of E-waste is illegally dumped in drains and rivers. *Environmental Protection Law (2012)* is the national legalisation defining waste and its use in Lao PDR. The Hazardous waste regulations –Article 68 is the only legislation which covers certain aspects of E-waste management.

Malaysia

Malaysia currently has no specific rules or regulations directly related to managing E-waste. E-waste management in Malaysia is governed by the Department of Environment (DOE) under the Ministry of Natural Resources and the Environment. Under the *Environmental Quality (Scheduled Waste) Regulations 2005* regulations 77 categories of scheduled or hazardous waste types were identified, in which E-waste was included and coded as SW110. In January 2008, the Department of Environment (DOE) issued the '*Guidelines for Classification of Used Electrical and Electronic Equipment in Malaysia'* for assisting all stakeholders involved in E-waste management to identify and classify the used products according to the regulatory codes. E-waste generated from industries can be sent to formal E-waste recovery facilities licensed by the DOE. These facilities comprise of advanced resource recovery facilities as well as partial recovery facilities and built and operated by private companies.

Maldives

Maldives currently has no direct regulations to manage the E-waste stream. E-waste is regulated under the *Waste Management Regulation (No. R-58and2013)* which enforces the Basel Convention. The national waste management policy and the waste management regulation emphasise the introduction of EPR. EPR is proposed to be introduced under the proposed Waste Management Act.

Mongolia

Mongolia's E-waste quantities are rising rapidly. Currently, there are no data, policies, regulations, and collection systems to manage this waste stream. The roles of the state and local government for E waste management are not clear. The *Law on Waste (2017*) passed in May 2017 allows the government to approve action plans to implement the national programme on waste management. A *National Waste Management Improvement Strategy and Action Plan (NWMISAP) 2017-30* has been developed to stimulate the solid waste management sector in the country. The strategy covering E-waste provides a strategic vision and direction for sustainable waste management from 2017 until 2030.

Myanmar

Myanmar has no national inventory, policies or regulations on E-waste. E-waste quantities have been rising with most of it being handled through informal treatment and recycling practices that result in major environmental pollution and public health impacts. Poor recycling practices such as backyard dismantling of E-waste into various components, open burning for segregating organic and inorganic components, and use of acids to extract valuable metals are common operations. Myanmar's *National Waste Management Strategy and Master Plan (2018-2030)* aims to provide a national policy framework to move from conventional waste management practices to more sustainable waste management based on the 3Rs. It includes a series action plans to achieve a zero waste and a circular society by 2030. Myanmar is currently preparing a Hazardous Waste Management Master Plan to develop a regulatory framework for hazardous waste.

Nepal

Nepal currently has no regulations or policies to manage E-waste. The *Solid Waste Management Act, 2011* (SWM Act) and *Solid Waste Management Rules, 2013* (SWM Rules) enacted by the government attempts to maintain a clean and healthy environment by minimising the adverse effects of solid waste on public health and the environment. Although the Act covers E-waste, regulations are not being strictly implemented by concerned authorities. The informal E-waste recycling sector is very active in Nepal where recycling is undertaken by waste pickers and scrap dealers who separate the reusable parts and illegally export them for proper recycling in other countries.

New Zealand

New Zealand currently does not have regulations to deal with E-waste directly. However, it has a legislative framework which potentially enables proper management of E-waste. New Zealand's waste management sector is regulated by the *Resource Management Act 1991* and the *Local Government Act 2002*. In addition, New Zealand's *Waste Strategy 2010* outlines strategic goals reduce the harmful effects of E-waste and manage it efficiently. Recently, the government has declared six priority products for regulated product stewardship under the Waste Minimisation Act which includes E-waste. The applications for accreditation and consultation on regulations for those schemes are anticipated in the latter half of 2021 with expected operations in 2023.

Pacific Island Countries

The Pacific Island region, consisting of 22 countries and territories (PICTs) face unique challenges due to their geographical spread. Limited availability of suitable land on small islands and atolls for constructing landfills, remoteness, relatively small populations, causing issues of economies of scale for waste management technologies, rapid urbanisation, and, limited institutional and human resource capacities, are among the key challenges faced by PICTs. Currently, individual countries manage their E-waste streams without elaborate regulatory mechanisms resulting in significant stockpiles awaiting management. The PacWaste (Pacific Hazardous Waste) Project funded by the EU and coordinated by the Secretariat of the Pacific Regional Environment Programme (SPREP) has conducted E-waste assessments in eight participating countries across the Pacific region. Resulting reports have identified and prioritised future actions to assist PICTs in improving E-waste management.

Pakistan

Pakistan currently has no laws or regulations to deal with the E-waste problem. The *Pakistan Environmental Protection Act (1997)*, the *National Waste Policy (2005),* and *Import Policy Order (2016)* have provisions to deal with E-waste imports to Pakistan. The informal E-waste recycling sector is very active in Pakistan with open burning of E-waste becoming a common activity.

The Philippines

The high growth of domestic consumption of EEE has created a significant E-waste issue in the Philippines. Most of the E-waste is handled by the informal recycling sector which consists of several registered and unregistered junkshops with the Metropolitan Manila Development Authority. The Philippines currently has no formal inventory of E-waste generation or proper collection systems. The Department of Environment and Natural Resources has published the *'Guidelines on the Environmentally Sound Management (ESM) of Waste Electrical and Electronic Equipment (WEEE)* 'under the Republic Act (RA) 6969. The law seeks to regulate the importation, manufacture, processing, handling, storage, transportation, sale, distribution, use, treatment, and disposal of toxic chemicals and hazardous wastes that pose risks to human health and the environment.

The Russian Federation

The Russian Federation current does not have a specific legislation on E-waste management. Hence, the regulatory and judicial support, supervision and accounting of E-waste are being carried out according to the general law on waste management. Low E-waste collection rates, lack of essential specific policy and regulations, including the eco-design of electrical products, lack of activities on raising the public awareness, and lack of producers' interest in establishment of collective compliance schemes are some of the challenges faced by the Federation in managing E-waste. However, Russian Federation, in 2020, has developed its own Restriction of Hazardous Substances (RoHS) regulations, Technical Regulation on Restriction on the use of Certain Hazardous Substances in Electrical and Electronic Equipment (TR EAEU 037and2016), which apply to several product groups.

Singapore

In March 2018, Singapore's National Environment Agency (NEA) announced that it will establish a regulatory measure by 2021 to ensure efficient management of E-waste in Singapore incorporating the EPR concept. The proposed system required the producers engage with a PRO, licensed by NEA, to meet their obligations for collection and treatment of E-waste. Accordingly, with effect from 1 July 2021, the management of regulated consumer E-waste came under the Producer Responsibility Scheme (PRS) where producers bear the responsibility for the collection and treatment of their products when they reach end-of-life. The system is implemented through the *Resource Sustainability Act (RSA*), administered by the NEA. ALBA E-waste Smart Recycling Pte Ltd has been appointed as the PRS operator for a period of five years, from 1 July 2021 to 30 June 2026, to collect regulated consumer electrical and electronic waste across Singapore for proper treatment and recycling on behalf of producers.

The Republic of Korea

The Republic of Korea is among the largest exporters of electronics and information technology products in the world. The Republic's regulations related to E-waste dates to 1992 when a waste deposit–refund system was introduced. The "Act on the Promotion of Conservation and Recycling of Resources" (commonly known as the Waste Recycling Act) of 1992 was the first law in the Republic of Korea to regulate its E-waste. In 2003, EPR scheme was introduced to make the producers responsible the entire life cycle of their products. In 2007, Republic of Korea's National Assembly passed the '*Act on the Resource Circulation of Electrical and Electronic Equipment and Vehicles'* which has similarities to European Union's RoHS, WEEE, and ELV (End-of-Life Vehicles). The Republic of Korea's EPR system depends on three main actors: Ministry of Environment (MOE), the Republic of Korea Environment Corporation (KECO) and the electrical and electronic manufacturers. KECO monitors compliance of the system by obliging the producers and importers to report sales and imports as well the waste collected and recycled. KECO manages the system through appointed PROs selected based on financial stability and potential contribution to the recycling industry's development.

Sri Lanka

The authority responsible for managing E-waste in Sri Lanka is the Central Environmental Authority (CEA) under the Ministry of Environment and Natural Resources (MENR). The regulatory framework for the managing E-waste in Sri Lanka is mainly governed by the *National Environmental Act, No. 47* of 1980 and its subsequent amendments. According to this Act, E-waste recyclers must obtain an Environmental Protection Licence (EPL) from CEA. Furthermore, *Extraordinary Gazette Notification No. 1534and18 of 2008* requires that E-waste generators, collectors, recyclers and disposers obtain a "Scheduled Waste Management Licence" from the CEA. In 2010, the CEA launched the National E-waste Programme for manufacturers, importers and brand owners to set up a collecting mechanism for E-waste. Accordingly, importers of electronic consumer durables were required to sign a

MOU with the CEA, to collect and dispose of E-waste. In 2019, the Sri Lankan government approved the *National Waste Management Policy* in which E-waste management is included.

Thailand

Thailand's E-waste management system is challenged by the lack of general awareness about E-waste, incomplete inventories, lack of environmental sound management practices especially dismantle and waste disposal by informal sectors, and lack of specific laws and regulations on E-waste. To overcome these challenges Thai government passed the National Strategic Plan on Integrated Management of E-waste in July 2007. In 2014, Thailand's Pollution Control Department (PCD) commenced the development of a new legal framework for managing E-waste based using EPR concept. In April 2021 PCD released the draft of the Electrical and Electronic Equipment Waste Management Act, B.E. for public consultation. PCD has been working on the bill for many years and a previous public consultation took place in August 2018. The new draft prescribes that target products shall be specified by the announcement of the Committee on E-waste Management.

Viet Nam

Viet Nam lacks an official inventory of E-waste generated in the country. Although some form of EPR regulations to deal with E-waste is in operation, the implementation has not been effective. Among the main issues related to E-waste management in Viet Nam open burning of E-waste, sub-standard recycling of circuit boards, and open dumping of residues from recycling are having a major impact on the environment. In August 2013, the Prime Minister of Viet Nam signed the *Decision No. 50and2013andQD-TTg* which requires the enterprises manufacturing or importing electrical and electronic products to be responsible for collection, transport, and processing of E-waste. This decision has now been replaced by the Prime Minister's *Decision No. 16and2015andQD-TTg* based on the EPR concept which came into effect in July 2016. To guide the implementation of Decision 16and2015andQD-TTg, the Ministry of Natural Resources and Environment (MONRE) issued *Circular No. 34and2017andTT-BTNMT* dated 4 October 2017 on take-back and treatment of discarded products. The Circular regulates types, quantity, and location of the collection points; technical requirements for the collection points; the process of management of the collection points; collection, storage, transportation, and treatment of discarded products; reports, data on take-back and treatment of discarded products, etc. Although there are clear regulations on the process, technical requirements, volume and quantity for the disposal and recovery and recycling of hazardous waste products as well as electronic equipment, in practice, the e-waste flow control and management still faces many difficulties, especially the waste stream coming from consumers and households.

Recently, Viet Nam issued the new Law on Environmental Protection (LEP) in November 2020 which included regulations (articles 54 and 55) on EPR mechanism. According to the Law, producers and importers must collect and recycle e-waste based on their released volume on the domestic market. In the Draft Guiding Decree of LEP, specific E-wastes such as lamps, computers and laptops, monitors and screens (cameras, recorders), large houseware items (televisions, washing machines, refrigerators, freezers, etc), and PV panels are regulated to be collected and recycled. The recycled targets are to be set for each type of E-waste for each company and there are 03 options for producers and importers to choose, including: (i) producers and importers to implement recycling by themselves; (ii) to contract with a Professional Recycling Organization or; (iii) to pay a certain amount to the Viet Nam Environmental Protection Fund). Furthermore, Vietnam EPR Office and a National EPR

Council will be set up to manage and monitor the implementation of responsibilities of producers and importers.

3.2.2.6 Opportunities for Circular Economy

E-waste is widely considered as a problem due to the adverse environmental and health impacts that occur due to rudimentary methods adopted during the recycling process. However, if adequately recycled using safe and advanced formal technologies, E-waste also presents an opportunity to extract valuable and precious metals. The extraction of minerals contained in E-waste, known as above-ground mining, requires only a fraction of energy compared to mining them from natural ores.

E-waste contains up to 69 elements in the periodic table, including precious metals (e.g. gold, silver, copper, platinum, palladium, ruthenium, rhodium, iridium, and osmium), Critical Raw Materials (CRM) (e.g. cobalt, palladium, indium, germanium, bismuth, and antimony), and non-critical metals, such as aluminium and iron. The UN estimates that the value of selected raw materials in E-waste amounts to USD 57 billion during 2019. Iron (24 billion USD), copper (11 billion USD), gold (9 billion USD), aluminium (6 billion USD) are considered to be the highest value materials contained in E-waste (Forti et al., 2020a). Currently, only 17.4 percent of the global E-waste generation is documented as formally collected and recycled (Forti et al., 2020a).

E-waste provides an excellent opportunity to implement the concepts of circular economy. According to World Economic Forum, a circular economic model "is restorative or regenerative by intention and design. It replaces the end-of-life concept with restoration, shifts towards the use of renewable energy, eliminate the use of toxic chemicals which impair reuse and return to the biosphere, and aims for the elimination of waste through the superior design of materials, products, systems, and business models". Hence, from a resource recovery and recycling point of view, RandD plays an important role by eliminating the toxic materials in EEE and thereby increasing the efficiency of the recovery processes.

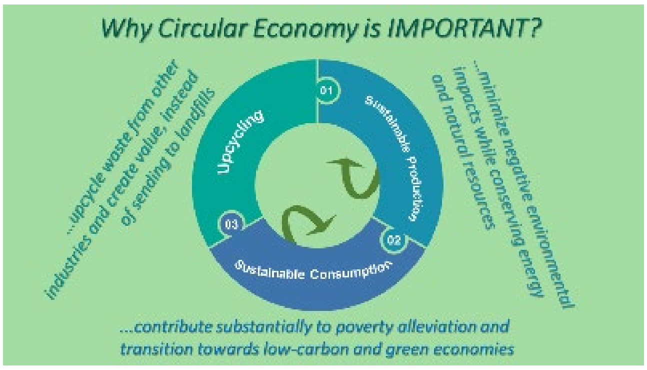
Khajuria (2018) describes following benefits of circular economy for effective management of E-waste:

- E-waste management in circular economy has the potential to increase jobs and decrease the damaging environmental impact from rare earth metals.
- Continue to reuse more old devices and using its different components in new products that have benefits towards circular economy.
- By having a reusable, efficient and sustainable economic model will ensure benefit economy of country.
- Recycling of E-waste reduces the lifecycle toxicity and greenhouse gas (GHG) emissions and further helps to reduce global warming by preventing discarding E-waste with municipal waste.

Box 3.2.2-11: Tokyo 2020 Medal Project
The Tokyo Organising Committee of the Olympic and Paralympic Games (Tokyo 2020) conducted the "Tokyo 2020 Medal Project" to collect small electronic devices such as used mobile phones from all over Japan to produce the Olympic and Paralympic medals. During the period April 2017 and March 2019, 100 percent of the metals required to produce around 5,000 gold, silver and bronze

medals were extracted from small electronic devices contributed by people from all over Japan. Every single medal awarded to athletes during the Tokyo 2020 Games is made from recycled metals.

Box 3.2.2-12: Government on India's Initiatives on Circular economy in E-waste sector (Khajuria et al., 2022)



Government of India has formulated an action plan for implementation of Circular economy (CE) principles in the E-waste sector to expedite focus on CE and to ensure the transition from a linear to a CE in the country. CE offers an alternative industrial system to highly extractive, resource-intensive, take-make-dispose linear economy principle to replace end-of-life concept with restoration, regeneration, usage of superior design of materials, products, systems and business models for waste elimination.

The action plan recommends adoption of CE principles in EEE sector considering whole life cycle stages of the products while focusing on end-of-life management, recycling and secondary raw materials utilization. The action plan is aimed to lay strong foundation for expansive adoption of CE principles in the sector to retain value of resources, products and materials at their maximum use, minimizing wastage at each life-cycle stage and extracting the maximum value through reuse, repair, recover, remanufacturing of products and materials at the end of each service value.

The material acquisition, design and other CE principles for electronics sector are also considered under the action plan for long-term recommendations and envision to bring out a "Sustainable Product Policy", Green Skill Development Programme, Green public procurement (GPP) in-line with global frameworks and best practices. India is the third largest consumer of raw materials globally and estimated to consume nearly 15 billion tonnes of material by 2030 with the current pace of economy. Since EEE manufacturing consumes significant amount of materials including critical raw materials, precious metals and rare earth elements. CE approach will fulfil the resource needs for the country.

The action plan will evolve an institutional arrangement to track critical materials, setting up material sampling labs to assess the secondary material presence in products, provide incentive for using secondary raw materials in manufacturing and incentivize the future manufacturing investment for including recyclable design, adopting internationally harmonized resource efficiency and circular economy. Scheme is proposed to upgrade informal sector to formal economy for boosting collection and better segregation and enriching materials value. International standards including EU's CEN and CENELAC standards are also proposed for adoption in entire value chain.

3.2.2.7 Conclusion and Way Forward

The UN estimates the generation of E-waste will more than double to reach approximately 111 MT by 2050 (Parajuly et al., 2019a), majority of it to be contributed by the Asia and Pacific countries. Countries in Asia and the Pacific region are experiencing a major problem with the ever-increasing amount of E-waste, as they lack the policies and infrastructure to deal with the issue in a sustainable way. Only a very small number of nations in the region have fully developed and implemented regulatory systems to manage E-waste. Majority of the nations are still struggling to move towards a sustainable E-waste management system.

The Ha Noi 3R Declaration – Sustainable 3R Goals for Asia and the Pacific for 2013-2023, has developed goals and indicators to assist the policy makers in the region to improve their E-waste management systems. **Table 3.2.2-6** below describes the relevant goals and indicators that are relevant to E-waste.

Table 3.2.2-6: Ha Noi 3R Declaration – Sustainable 3R Goals for Asia and the Pacific for 2013-2023 that are related to E-waste (UNCRD, 2013d)

Goal 13: Ensure environmentally-sound management of E-waste at all stages, including collection, storage, transportation, recovery, recycling, treatment, and disposal with appropriate consideration for working conditions, including health and safety aspects of those involved.	
Indicator **HNG 13-1**	Formal standards, certification system, and licensing procedures established and enforced
Indicator **HNG 13-2**	Technical support services made available to informal sector and SMEs involved in E-waste management, that have raised awareness of workers and employers on the hazards of E-waste management and recycling at all stages
Indicator **HNG 13-3**	Presence of, and access to, appropriate health-care services for informal sector workers.
Indicator **HNG 13-4**	Number of state-of-the-art recycling facilities for E-waste (such as mobile phones at their end-of-life).
Indicator **HNG 13-5**	Guidelines on environmentally-sound management of E-waste at all stages, including occupational safety and health standards, appropriate work spaces, and infrastructure, and protective working equipment developed and incorporated into local regulatory frameworks
Goal 15: Progressive implementation of "extended producer responsibility (EPR)" by encouraging producers, importers, and retailers and other relevant stakeholders to fulfill their responsibilities for collecting, recycling, and disposal of new and emerging waste streams, in particular e-waste.	
Indicator **HNG 15-1**	New EPR policies enacted, or existing policies strengthened
Indicator **HNG 15-2**	List of (or number of) products and product groups targeted by EPR nationally

The trends and developments regarding the progress made by each country towards achieving the Ha Noi 3R goals are difficult to measure given the lack of reporting. The best estimates such progress relates to Ha Noi 3R Goals Indicator HNG 15-1 where information is available on the state of EPR development. **Table 3.2.2-7** below classifies the countries based the level of implementation of EPR regulations. Apart from seven countries in the region, remaining about 18 countries still have not fully developed full EPR type regulations.

Table 3.2.2-7: Implementation of EPR regulations for E-waste management in Asia and the Pacific countries: Progress towards HNG 15-1

Full implementation of EPR Regulations	**Partial or Draft EPR Regulations**	**No EPR Regulations**
Australia, the PR China, India, Japan, Singapore, the Republic of Korea,	Bangladesh, Cambodia, Indonesia, New Zealand, the Russian Federation, Thailand, Viet Nam Malaysia	Bhutan, Laos, Mauritius, Maldives, Mongolia, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka

Asia and the Pacific countries are experiencing significant challenges due to a lack of policies, infrastructure, and financial resources. Although E-waste is a problem due to its hazardous components, it is also a solution to the depletion of the natural resources that manufacturers of EEE depend on. Proper management of E-waste using the principles of circular economy is vital towards harvesting these secondary sources. If undertaken correctly, recycling of E-waste can also provide an excellent business opportunity. In many Asia and the Pacific countries, recycling is undertaken by the informal waste recycling sector that lacks skilled operations. The formal E-waste recycling sector is very limited in these countries. In particular, the transfer of technology to Asia and the Pacific countries needs to consider the informal sector's dominance and success. Innovative models that allow the informal sector to be involved in the process by adopting safe recycling practices while hazardous operations are transferred to formal recycling recyclers are the key to a successful E-waste management program. Many Asia and the Pacific countries favour EPR for developing regulations to deal with the E-waste. Most industrialised countries have had much success in implementing EPR successfully. The proper implementation of EPR requires several pre-conditions to be met. Due to the informal sector operations, implementation of EPR in Asia and the Pacific countries has become very challenging.

The Ha Noi 3R Declaration is due to expire in 2023. It is now necessary to align the new goals with the targets within SDGs that are relevant to E-waste. **Table 3.2.2-8** below summarises the SDG Goals, Targets, and Indicators associated with E-waste.

Table 3.2.2-8: SDG Goals, Targets, and Indicators associated with E-waste.

SDG Goal	SDG Target	SDG Indicator
Goal 3. Ensure healthy lives and promote well-being for all at all ages	**3.9** By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination	
Goal 6. Ensure availability and sustainable management of water and sanitation for all	**6.1** By 2030, achieve universal and equitable access to safe and affordable drinking water for all **6.3** By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	
Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	**8.3** Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services **8.8** Protect labour rights and promote safe and secure working environments for all workers, including migrant workers, in particular women migrants, and those in precarious employment	**8.4.1** Material footprint, material footprint per capita, and material footprint per GDP **8.4.2** Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP
Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable	**11.6** By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management	**11.6.1** Proportion of municipal solid waste collected and managed in controlled facilities out of total municipal waste generated, by cities
Goal 12. Ensure sustainable consumption and	**12.4** By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed	**12.2.1** Material footprint, material footprint per capita, and material footprint per

SDG Goal	SDG Target	SDG Indicator
production patterns	international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment **12.5** By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse	GDP **12.2.2** Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP **12.4.2** (a) Hazardous waste generated per capita; and (b) proportion of hazardous waste treated, by type of treatment **12.5.**1 National recycling rate, tons of material recycled
Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development	**14.1** By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution	

The trends and developments of above SDG indicators related to E-waste among Asia and the Pacific countries are difficult to measure and report given the limitations and non-avilability of relevant data. The Global E-waste Monitor 2020 published by the United Nations University reports E-waste recycling rates for countries that have reported on E-waste collection and recycling data. The E-waste collection and recycling data is the closest measure to determine the progress towards SDG Indicator 12.5.1. **Table 3.2.2-9** below shows the progress made by few countries within the Asia and the Pafic region towards SDG Indicator 12.5.1 by reporting on the E-waste recycling percentages.

Table 3.2.2-9: E-waste recycling in Asia and the Pacific countries: Progress towards SDG Indicator 12.5.1. Source (Balde et al., 2024)

Country	E-waste (2022) (tonnes/year)	E-waste collected and recycled (tonnes/year)	E-waste collected and recycled (Percentage)
Asia and the Pacific Region	30,000,000	3,600,000	12 percent
Australia	583,000	292,000	50 percent
PR China	12,066,000	1,951,000	16 percent
India	4,137,000	596,000	14 percent
Japan	2,638,000	613,000	23 percent
the Republic of Korea	930,000	443,000	47 percent

Countries such as Japan and the Republic of Korea have made significant progress towards achieving SDG 12.5.1 by advancing the collection and recycling processes for E-waste. It should be noted here that E-waste recycling rate is extremely low in India. Over 95 percent of India's E-waste processing is undertaken by the informal sector, hence it is not formally reported.

As a way forward, Asia and the Pacific countries need to develop well defined national E-waste management strategies that are closely aligned to SDGs. Such an approach should not only look at solving the existing environmental and health impacts of E-waste but should also reduce E-waste through principles of circular economy. The strategy should also create enabling conditions for the private sector to develop business and economic opportunities to recover the materials from E-waste. The strategy should take into account the financial, institutional, political, and social aspects of the country, focusing on how to synergise the informal E-waste recycling sector with the formal sector. It is necessary to align the new goals of Ha Noi Declaration with relevant SDG targets. **Table 3.2.2-10** below suggests some goals for achieving sustainable management of E-waste together with linked SDG targets.

Table 3.2.2-10: Proposed Ha Noi Declaration Goals and links to SDG Targets

Proposed Goal	SDG Target
Elimination of hazardous substances during production of EEE, and during dismantling and processing of E-waste	3.9
Formalisation of the informal E-waste recycling sector to create decent working conditions and environmentally sound management of E-waste	8.3
Recognition of the informal E-waste sector and integrating into a formal waste management system thereby protecting their labour rights	8.8
Establishment of proper institutional infrastructures for collection, storage, transportation, recovery, treatment and disposal of E-waste in cities to reduce the adverse per capita environmental impacts due to unsound management of E-waste	11.6
Eliminate open dumping and open burning of E-waste and use of poor chemical processes to separate valuable materials in E-waste	12.4
Design EEE with circularity in mind to prevent E-waste generation at the end-of-life and implement EPR systems to achieve recycling of E-waste	12.5

References Chapter 3.2.2

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3.2.3 Chemical and Hazardous Waste

3.2.3.1 Regional overview in Asia and the Pacific

In Basel Convention the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, “Wastes” are substances or objects which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law. Accordingly “hazardous wastes” are:(a) Wastes that belong to any category contained in Annex I, unless they do not possess any of the characteristics contained in Annex III; and(b) Wastes that are not covered under paragraph (a) but are defined as, or are considered to be, hazardous wastes by the domestic legislation of the Party of export, import or transit. In this part, an assessment of chemical and hazardous waste and its management is carried out for countries based on Ha Noi 3R Declaration.

i. Definition

No evidence shows that the term “chemical hazardous waste” is defined in any acts or regulations in Asia and the Pacific countries. Chemical hazardous waste is usually one entry of hazardous waste. Definitions of “hazardous waste” or related terms of countries in the Asia and the Pacific region are listed as follows.

No official definition is available in Kiribati, Marshall Islands, Federated States of Micronesia (F. S. Micronesia), Solomon Islands, and Timor-Leste.

Table 3.2.3-1: Definition of "hazardous waste" in the Asia and the Pacific countries and regions

Country And Region	Definition	Source
Australia	Hazardous waste means: (a) waste prescribed by the regulations, where the waste has any of the characteristics mentioned in Annex III to the Basel Convention; or (b) wastes covered by paragraph 1(a) of Article 1 of the Basel Convention; or (c) household waste; or (d) residues arising from the incineration of household waste; does not include wastes covered by paragraph 4 of Article 1 of the Basel Convention.	Hazardous Waste (Regulation of Exports and Imports) Act 1989
Bangladesh	Hazardous substance means the substance which by reason of its chemical or bio-chemical properties is such that its manufacture, storage, discharge or unregulated transportation can be responsible for the damage of environment.	Bangladesh Country Fact Sheet, 2005
Bhutan	Hazardous waste means a waste a) which because of its quantity, concentration, persistence or physical, chemical or infectious characteristics may cause or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness, or pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed and b) belong to any of the categories listed in Annexes to the regulation on hazardous waste under the Act.	Waste Prevention and Management Act of Bhutan, 2009
Brunei Darussalam	Hazardous waste means (i) waste prescribed by any regulations made under the Order, where the waste has any of the characteristics mentioned in Annex III to the Basel Convention; or(ii) waste that belongs to any category contained in Annex I to the Basel Convention, unless it does not possess any of the characteristics contained in Annex III to that Convention.	Hazardous Waste (Control of Export, Import and Transit) Order 2013
Cambodia	Hazardous waste refers to radioactivity substances, explosive substances, toxic substances, inflammable substances, pathogenic substances, irritating substances, corrosive substances, oxidizing substances, or other chemical substances which may cause the danger to human (health) and animal or damage plants, public property and the environment. The hazardous waste may be generated from dwelling houses, industries, agricultural activities, business and service activities, mining, etc.	Sub Degree 36 on Solid Waste Management 1999
PR China	"Hazardous wastes" means solid wastes included in the national catalogue of hazardous waste or solid wastes which, according to the identification standards of hazardous wastes, are determined as having the hazardous property.	Law on the Prevention and Control of Environmental Pollution by Solid Waste (revised in 2020)
Fiji	Hazardous waste means toxic, inflammable, corrosive, reactive, infective, or explosive waste, and includes waste is potentially hazardous to human health or the environment.	Environment Management Act 2005
India	Hazardous waste is defined as any waste which by reason of characteristics such as physical, chemical, biological, reactive, toxic, flammable, explosive or corrosive, causes danger or is likely to cause danger to health or environment, whether alone or in contact with other wastes or substances and shall include - (i) waste specified under column (3) of Schedule I; (ii) waste having equal to or more than the concentration limits specified for the constituents in class A and class B of Schedule II or any of the characteristics as specified in class C of Schedule II; and (iii) wastes specified in Part A of Schedule III in respect of import or export of such wastes or the wastes not specified in Part A but exhibit hazardous characteristics specified in Part C of Schedule III.	Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016
Indonesia	Hazardous waste is the residue from process and industries operation and the remain of an activity containing Hazardous and Toxic Materials. Hazardous and toxic waste, shall mean any waste containing dangerous and toxic material, which due to its characteristics and concentration and amount, either directly or indirectly, may damage and pollute the living environment	Government Regulation Number 19 of 1994

Country And Region	Definition	Source
	and endanger human.	
Japan	Explosive, toxic, or infectious waste which is hazardous to health or living environment has been specified in specially controlled waste (specially controlled municipal solid waste and specially controlled industrial waste).	Waste Management and Public Cleansing Law
The Republic of Korea	Hazardous waste means substances falling under any of the following:(a) Wastes subject to export or import restrictions: Substances prescribed by Presidential Decree, which are wastes provided for in the Annexes, etc. of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (hereinafter referred to as the "Convention") and substances stipulated in a bilateral, multilateral, or regional agreement under Article 11 of the Convention that it is necessary to restrict the export or import of such substances and the transit of such substances across the Republic of Korea;(b) Wastes subject to export or import control: Substances prescribed by Presidential Decree because the export or import control thereof is needed, which are wastes other than wastes subject to export or import restrictions among wastes under subparagraph 1 of Article 2 of the Act.	Wastes Control Act
Lao PDR	Toxic and hazardous wastes contain one or more toxic substances or characteristics or releases substances that have corresponding characteristics are categorized as follows: explosive, flammable, oxidizing, toxic or harmful to health (acute or chronic, irritating, carcinogenic, mutagenic), infectious, corrosive, toxic to the ecosystem (eco-toxic).	Article 37 of Chapter 3 in Part III of the Environment Protection Law
Malaysia	Hazardous Waste is known as scheduled waste and refers to any waste falling within the 107 categories (grouped into specific and non-specific sources) of hazardous waste listed in the First Schedule of the EQA, 1974. These wastes must be rendered as inert as possible prior to disposal.	Environmental Quality Act 1974
Maldives	Hazardous waste means types of waste that possess the properties specified under Annex (j) of this regulation, including explosives, flammable liquids and solids, substances or wastes having self-ignition properties, substances which, in contact with water has ability to self-ignite or emit flammable gases, oxidising, organic peroxides, toxic or poisonous substances, infectious substances extremely hazardous to health, corrosives, and ecotoxic.	Ministry of Environment, Climate Change and Technology
Mongolia	Hazardous waste shall mean waste containing explosive, toxic, flammable, caustic or reactive substances that produce toxic gas in interaction with air or water, infectious, harmful in the long term or short term to humans, livestock, animals or plants and having potential adverse impact on environment, and waste producing hazardous excretion after disposal.	The Hazardous Wastes Rules, 1989
Myanmar	Hazardous Substance means a substance or object which may affect health including substance which may be created and used as a biological weapon, substance which may be used as a nuclear weapon, inflammable, explosive, oxidizing and peroxidizing, toxic, pathogenic, radioactive, genetic transforming, corrosive, irritating objects, whether chemical or not, which can be harmful to human being, animal, plant, property or environment.	The Environmental Conservation Law - The Pyidaungsu Hluttaw Law No. 9 and 2012
Palau	Hazardous waste means any waste or combination of wastes which due to their chemical nature pose a substantial present or potential hazard to human health or the environment because such wastes are non-degradable or persistent in nature, or because they may otherwise cause or tend to cause detrimental cumulative effects to human health and the environment. Hazardous wastes are classified on the basis of their biological, chemical, and physical properties. Hazardous wastes are defined as being toxic, reactive, ignitable, corrosive, infectious, or radioactive, or any combination of these characteristics.	Solid Waste Management Regulations
Papua New Guinea	Hazardous wastes have inherent chemical and physical characteristics (toxic, ignitable, corrosive, and carcinogenic) and can cause significant adverse effects; and Radioactive waste is highly toxic; exposure to radiation can cause illness and even	Environment Act 2000

Country And Region	Definition	Source
	death.	
The Philippines	Hazardous waste refers to “solid waste or combination of solid waste which because of its quantity, concentration, or physical, chemical or infectious characteristics may: (1) cause, or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or (2) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed.”	Toxic Substances, Hazardous and Nuclear Wastes Control Act
Samoa	Hazardous wastes include the wastes and substances specified in Schedule 2 if they are prohibited in Samoa in accordance with the applicable international conventions, or have been imported or used in Samoa in a manner which breaches the relevant conventions, and: (a) Any wastes which are, or which have the potential to be, toxic or poisonous, or which may cause injury or damage to human health or the environment;(b) Any specific substance, object or thing determined under section 6 to be a hazardous waste; and(c) Any other matter or thing deemed under international conventions to be hazardous wastes or to have the characteristics of hazardous wastes.	Waste Management Act 2010
Singapore	Hazardous wastes are managed as toxic industrial wastes. Toxic industrial wastes are wastes which by their nature and quality may be potentially detrimental to human health and the environment and which require special management, treatment and disposal.	Management Of Toxic Industrial Wastes
Thailand	Hazardous wastes contain or contaminate with hazardous materials or exhibit the hazardous characteristics including flammable, corrosive, reactive, toxic, or having the specified constituents.	Pollution Control Department
Tonga	Hazardous waste means (a) any waste which are, or which have the potential to be, toxic or poisonous, or which may cause injury or damage to human health or to the environment;(b) any specific substance, object or thing determined under any law to be a hazardous waste;(c) any other matter or thing deemed under international conventions applicable to the Kingdom of Tonga to be hazardous waste, or to have the characteristics of hazardous waste; and(d) any waste provided under the Hazardous Waste and Chemicals Act 2010 as hazardous waste.	Environment Management (litter and waste control) Regulations 2016
Tuvalu	Hazardous waste includes:(a) any wastes which are, or which have the potential to be, toxic or poisonous, or which may cause injury or damage to human health or the environment, including engine oils or other lubricating oils used in relation to machinery, and oil based paints and any chemical used in relation to paints;(b) any specific substance, object or thing determined under this Act or any law to be a hazardous waste; and(c) any other matter or thing deemed under international conventions applicable to Tuvalu to be hazardous wastes or to have the characteristics of hazardous wastes from time to time.	Waste Operations and Services Act
Viet Nam	Hazardous wastes mean wastes containing elements that are toxic, radioactive, contagious, flammable, explosive, abrasive, poisonous or otherwise harmful.	Law on Environmental Protection 2020

ii. Types of chemical and hazardous waste by sources

Countries in the Asia and the Pacific region do not classify chemical waste separately or manage it according to one kind of hazardous waste. Hazardous wastes can be liquids, solids, gases, or sludges. They can be discarded commercial products, like cleaning fluids or pesticides, or the by-products of manufacturing processes. Sources of hazardous wastes include industries, petroleum refineries, transportation, coke-ovens, blast furnace sludges, scrubbing sludges and biological waste generating laboratories, thermal etc. Different countries have their own classification standards for chemical and hazardous waste, and sources can include industrial, agricultural, medical, and household aspects.

- **PR China:** It usually refers to industrial hazardous waste generated as a by-product of the manufacturing process, medical waste, small-scale generation of hazardous waste from households, institutions and commercial establishments, and occasionally small amounts of radioactive waste, for example, smoke detectors and medical process waste.
- **Sri Lanka:** The hazardous wastes are basically classified as: Industrial Waste, Healthcare Waste, Transport Sector hazardous waste, Electronic Waste.
- **Viet Nam:** According to Circular 02and2022andTT-BTNMT dated January 10, 2022 on Detailing the implementation of a number of articles of the Law on Environmental Protection, hazardous wastes can be classified into 19 categories of waste by their sources, and in which chemical hazardous wastes include waste resulting from exploration, mining, quarrying, and treatment of minerals, petroleum, and coal; waste from manufacture, formulation, supply, and use of inorganic chemicals and organic chemicals and coatings (paints, varnishes and enamels), adhesives, sealants and printing inks; wastes from chemical surface treatment and coating of metals and other materials; oil waste and waste from liquid fuels, organic solvents, refrigerants and propellants.
- **The Philippines:** From 2014 onwards, the hazardous waste classification is based on DAO 2013-22, Revised Procedures and Standards for the Management of Hazardous Wastes (Revising DAO 2004-36),the types of hazardous waste include:1) Waste with Cyanide; 2) Acid Waste; 3) Alkali Waste; 4) Waste with Inorganic Chemicals ; 5) Reactive Chemical Waste; 6) Inks, Dyes, Pigments, Paint, Latex, Adhesives, Organic Sludge; 7) Waste Organic Solvent; 8) Putrescible Organic Waste; 9) Oil; 10) Containers ; 11) Immobilized Waste ; 12) Organic Chemicals; 13) Miscellaneous Waste
- **Cambodia**: From the inventory of hazardous waste, wastes related to chemical hazardous waste are: Oil waste from oil refinery, use of lubrication oils, washing oils; Acid waste; Alkalis waste; Waste from production and use of inks and dyes; Explosive waste; Inorganic fluorine waste; Cyanide waste; Asbestos waste; Phenols waste; Ethers waste; Waste from production and use of solvents; Waste from production and use of dioxin and furan; Radioactive waste;

iii. Quantification and generation of chemical and hazardous waste in the region

Data constraints are reported for hazardous waste generation in Asia and the Pacific region as shown in **Figure 3.2.3-1** (Basel Convention reports dashboard) (UNEP, 2022b). The dashboard is the only global database that uses the Basel Convention definition of hazardous wastes. This database was created under the mandate of paragraph 3, Article 13 of the Basel Convention, which requests Parties to submit annual reports regarding the generation, transport and management of hazardous wastes. The main limitation of the Basel Convention Database is the uneven national reporting practice across countries and years. Industrialized countries, particularly EU countries, generally comply with the national reporting requirement, but the United States, the biggest industrialized country, is not a Party to the Basel Convention and does not submit national reports. Many developing countries submit national reports at various frequencies, but some large ones often only report waste generation instead of traded volumes. Most least developed countries are not able to inspect the movements of hazardous wastes across their borders, and the few shipments that involve them are usually exports from these countries to industrialized countries (reported by the latter). In this part, all data are aligned with official data on the Basel Convention reports dashboard. Hazardous wastes generation in the Asia and the Pacific region exhibited an overall rise from 2011 to 2019. PR China shared a considerable part of the total generation of hazardous wastes in Asia and the Pacific region. In 2017, the apportion of PR China reached a peak at 56.56 percent. In other years, the percentage of PR China varied from 23.21 percent to 50.62 percent. In 2018, Kyrgyzstan had a sudden increase in hazardous waste generation and accounted for the largest part of hazardous wastes generation, which is 69.57 percent. For other countries, no significant increase was observed in 2018. Thailand, Malaysia, and Uzbekistan also held a significant part of the total generation of hazardous wastes.

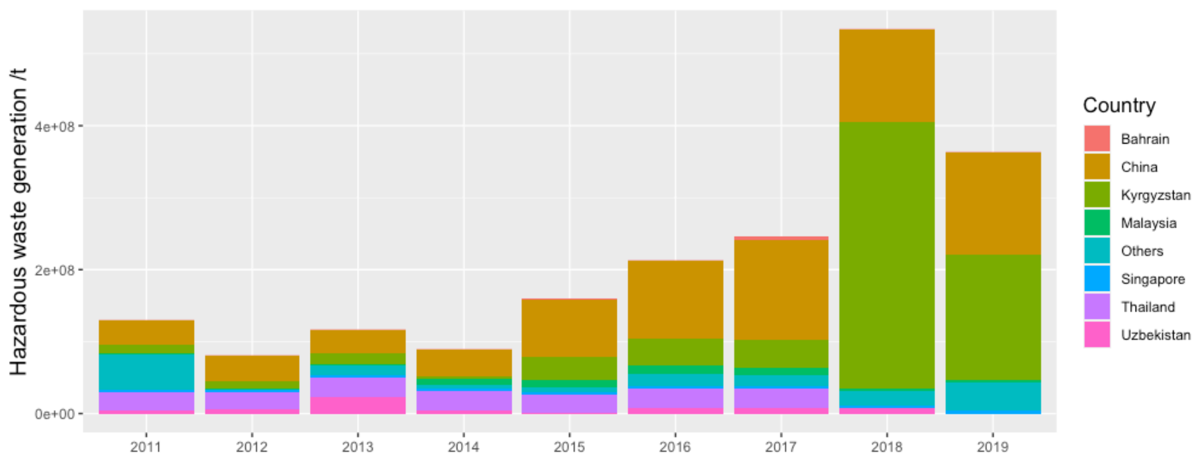

Figure 3.2.3-1: Hazardous waste generation in Asia and the Pacific region in 2011-2019

As an example of assessment on market size, the global hazardous waste management market accounted for $26.35 billion in 2019 and is expected to reach $48.06 billion by 2027 growing at a compound annual growth rate of 7.8 percent during the forecast period (Globe Newswire, 2020). Some of the key factors propelling market growth include a growing number of awareness programs for waste management, rapid urbanization and industrialization along with the rising population, increasing waste disposal activities, and government initiatives for waste management. However, the requirement of high capital investments is restricting the market growth. According to the market forecast, the hazardous wastes generation in the Asia and the Pacific region was expected to reach 66.18 million tons in 2027. By 2030, 88.81 million tons hazardous wastes would be produced in Asia and the Pacific region.

The COVID-19 pandemic might have brought about particular impacts in the areas of (1) redistribution of waste production, and (2) changes in waste treatment activity. With national and local-level lockdowns instituted to stem the virus's transmission and the concomitant slowdown of economic activity, waste production shifted from the industrial and commercial sectors to residential areas. A World Bank study estimated a 40 percent increase in the volume of medical waste, as well as an increase in hazardous waste, likely due to higher production from pharmaceutical and medical sectors (Sinha et al., 2020).

iv. Chemical and hazardous material consumption in the region

An appreciable part of hazardous wastes in the region is generated from the consumption of pesticides. In this part, the use of pesticides is analyzed as the chemical and hazardous material consumption in the Asia and the Pacific region, attempting to give a glimpse from the upstream of hazardous wastes. Pesticides use in the Asia and the Pacific region are shown in Figure 3.2.3-2 (FAO, 2022). The consumption of pesticides in the Asia and the Pacific region had been increasing from 2001 until 2012. Since 2010, the use of pesticides in the region has been fluctuating between 4,400,000 and 4,600,000 t and show a slight decrease since 2017. No significant rise in the use of pesticides can be observed in the last decade (2010-2020). Eastern Asia accounts for the largest use of pesticides in the region, followed by Southeastern Asia, Southern Asia, and Western Asia.

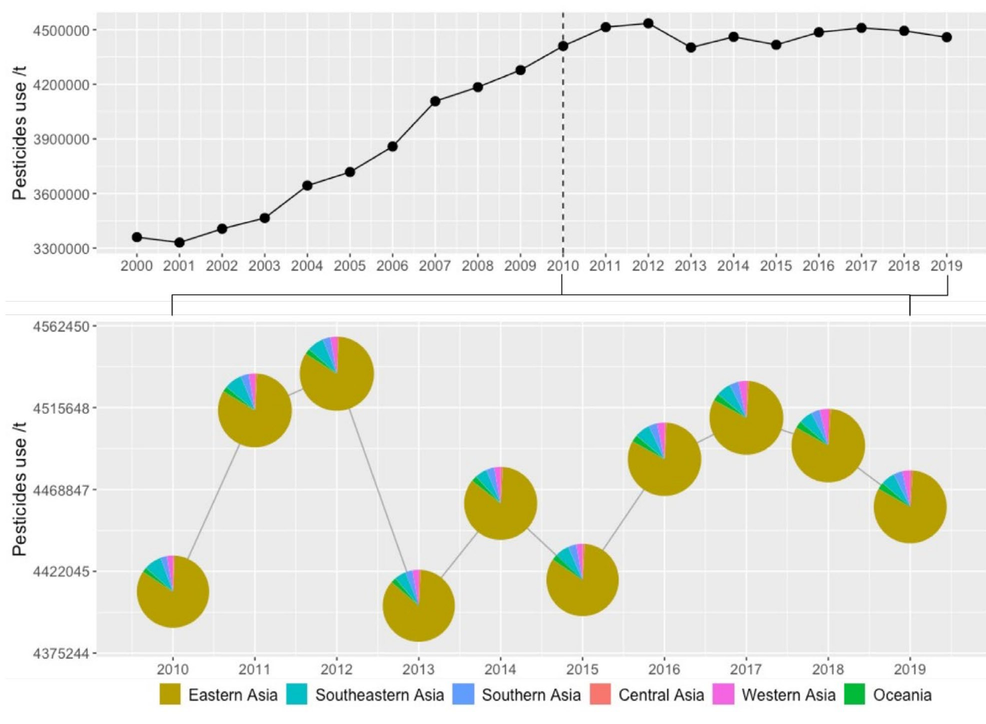

Figure 3.2.3-2: Pesticides use in Asia and the Pacific region in 2000-2019. Source: (FAO, 2022)

The consumption of hazardous materials did not correspond with the generation of hazardous wastes in the Asia and the Pacific region since hazardous waste is not only generated by hazardous materials but also from other sources, while the consumption of hazardous materials does not necessarily produce hazardous wastes. While, a conclusion could be found that hazardous waste generated from the use of pesticides might not increase these years, with that Eastern Asia is the biggest consumer.

v. Chemical and hazardous material and waste trade in the region

The Ha Noi 3R Goal 14 emphasizes effective enforcement of established mechanisms for preventing illegal and inappropriate export and import of hazardous waste, including transit trade. Under the goal, one of the indicators is reduction in the number of incidents of illegal export and import of E-waste against a measured baseline in a specific year. The illegal incidents are hard to monitor and the data can be barely attained.

As the flow of products, materials, and waste has become global due to its legal and illegal transport, the persistent chemicals and hazardous compounds contained within them are also transferred globally. Improper recycling results in negative impacts on the environment and on human health. In a case study in Bui Dau, northern Vietnam, higher contamination (up to 14,000 ng/g-dry) by flame retardants and some persistent organic pollutants could be observed in surface soils and river sediments near the E-waste recycling workshops or open burning sites, while low concentrations (up to 10 ng/g-dry) were found in the soils from footpaths around rice paddies (Matsukami et al., 2015).

Since barely no data on chemical and hazardous materials on the same scale is available, this research takes one of the chemical and hazardous materials, which mainly refers to pesticides, as an example to show its trade in the Asia and the Pacific region (Data from UN comrade and the commodity code is 382484). It includes Chemical products, mixtures and preparations; containing aldrin, camphechlor, chlordane, chlordecone, DDT chlorfenotane, 1,1,1-trichloro-2,2-bis, dieldrin, endosulfan, endrin, heptachlor or mirex (UN Comtrade, 2022). All data are reported to the United Nation by the countries.

Trades of chemical and hazardous materials in Asia and the Pacific region is shown in Figure 3.2.3.-3. The Philippines accounted for most of the imported hazardous materials in Asia and the Pacific in 2019 and 2020. The Philippines reported, 61488 t and 11208 t of hazardous material that were imported in 2019 and 2020 respectively. Lao PDR reported 988 t imported hazardous materials in 2018. Australia and Malaysia reported 145 t and 150 t imported hazardous materials in 2017 respectively. No more than 100 t imported hazardous materials were reported by other countries in Asia and the Pacific region. In 2017, Malaysia shared the most apportion about 1540 t of exported hazardous materials in Asia and the Pacific region was reported. In 2018, 190 tons of hazardous materials were reported by Malaysia. In 2019, 3985 tons of that was reported by Viet Nam. The Philippines accounted for the most of exported hazardous materials in 2019 and 2020, which was 848 tons and 40 tons respectively.

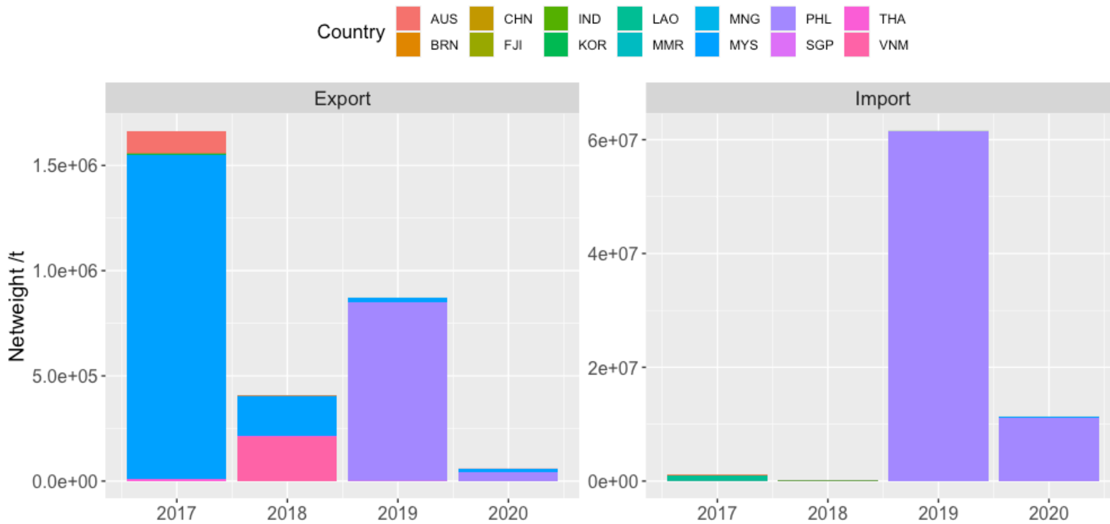

Figure 3.2.3-3: Imported and exported net weight of hazardous materials in Asia and the Pacific region in 2017-2020. Source: (FAO, 2022)

The trade flows of hazardous materials among countries in Asia and the Pacific region is shown in Figure 3.2.3.-4. According to UN comtrade database, 14 countries in Asia and the Pacific region reported import and export activities with other Asia and the Pacific countries from 2017 to 2020. In 2017, Malaysia was the biggest exporter and most of the hazardous materials were exported to India. Lao PDR and the Republic of Korea were two big importer and the goods were imported from PR China and Thailand. In 2018, Lao PDR was the biggest importer and Viet Nam was the top exporter. In 2019 and 2020, the Philippines was the largest importer and most of the goods were imported from the Republic of Korea, PR China, and Viet Nam.

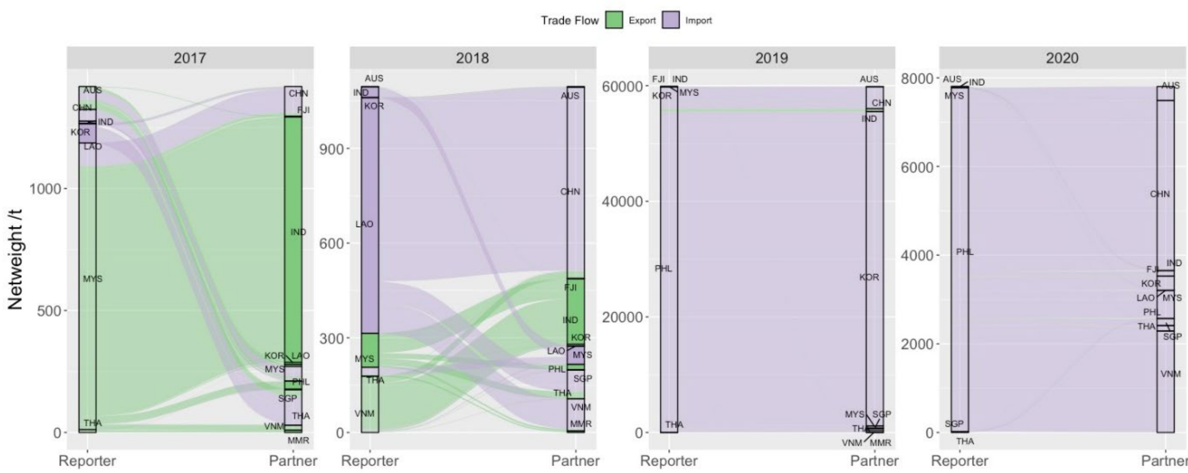

Figure 3.2.3-4: Trade flows of hazardous materials in Asia and the Pacific region in 2017-2020. Source: (FAO, 2022)

Beyond the hazardous materials, the trade or transboundary movement of hazardous wastes shall be paid attention. The trade flow of hazardous wastes reported by the countries in the Asia and the Pacific region to Basel Convention is shown in Figure 3.2.3.-5 (UNEP, 2019a). The total amount of traded hazardous waste is much higher in 2019 than 2020 since some countries did not report. According to the available data, in 2019, Indonesia was the biggest exporter, followed by Australia in 2020. In the Asia and the Pacific region, Republic of Korea (3,183,849 t in 2019) and Japan (626,683 t in 2019), which were the most developed countries in the region, were the biggest importers. Most hazardous wastes from other Asia and the Pacific countries were exported to these two countries. Other big importers included the Philippines (34,516 t in 2019), Singapore (5790 t in 2019), and Indonesia (11,215 t in 2019).

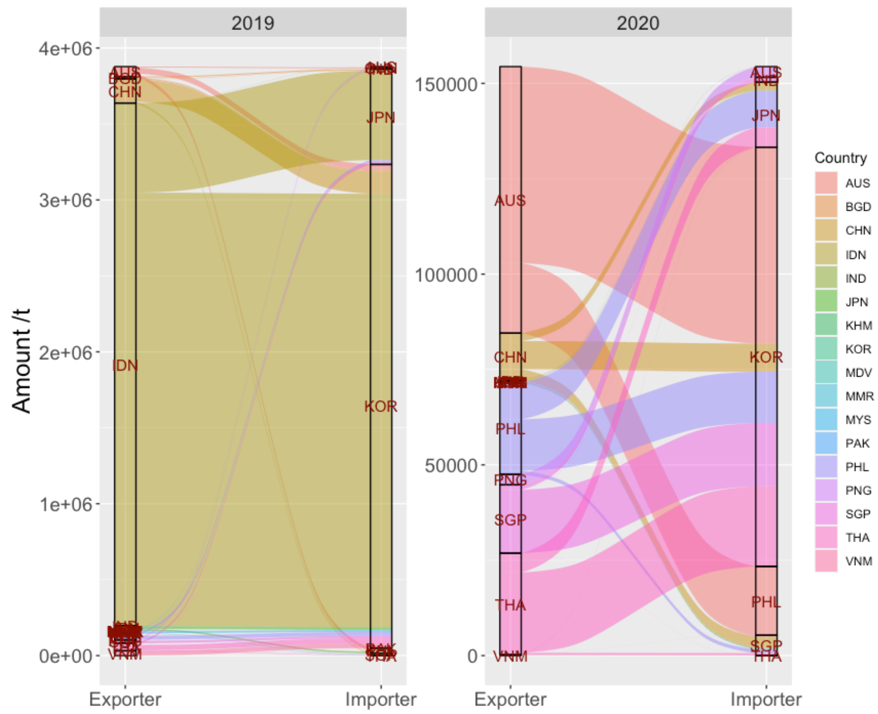

Figure 3.2.3-5: Trade flows of hazardous waste in Asia and the Pacific region in 2019-2020. Source: (FAO, 2022)

In 2018, PR China enacted a waste import ban and threw chain reactions on other countries in Asia (CFR, 2020). Southeastern Asian countries have dealt with it in different ways. The impact of it compounded with COVID-19 needs longtime monitoring and cannot be simply elaborated in this part due to the lag of data. Three challenges are faced by countries in the Asia and the Pacific region when dealing with the trade of chemical and hazardous waste (IPEN, 2021). Firstly, many developing countries in the Asia and the Pacific region are already facing a waste crisis due to domestic waste. Poor implementation and enforcement of laws, coupled with limited resources and deficiency of waste management infrastructure create a deadly mix resulting in this crisis. More wastes from trade would definitely aggregate the problem. Secondly, countries in the Asia and the Pacific region already need to deal with other environmental issues as one of the most biodiverse and ecological and natural resource-rich regions in the world. This reality gives more urgency to the need for a regional response to the hazardous waste trade. Thirdly, Asia is also the most vulnerable area in the world that is susceptible to climate crisis. The risks brought about by climate change, and the need to meet climate adaptation and mitigation goals, are also related to the issue of hazardous waste trade

vi. Negative impact on public health and environment

Negative impact on public health

The occurrence of adverse health impact is dependent on the way the hazardous substances enter the body. Some hazardous substances absorb rapidly through the skin, while others cannot be absorbed. The toxicity of a chemical also determines the effect on the body. There are many hazardous substances which are toxic in very small amounts, whereas others can have large volumes of exposure before there is a reaction. Up to 300 man-made substances have been found in the average human. Having hazardous substances in the human body causes adverse reactions to fetus, children, adolescents, adults and the elderly but the reaction each may have varies. Fetus and young children are more susceptible to adverse reactions than an adult because their developing organs may be permanently damaged. Some potential health conditions in people of all ages include: behavior abnormalities, cancer, physiological malfunctions (e.g., kidney failure, reproductive impairment), genetic mutations, physical deformations, and birth defects (MLI, 2019).

If dumped indiscriminately in any environmental media, hazardous wastes may have both short- and long-term effects on both human and ecological systems. In addition, improper treatment, storage, and disposal of hazardous wastes can result in contamination during possible exposures with potential adverse health and environmental impacts. In general, any chemicals can cause severe health impairment or even death if taken by humans in sufficiently large amounts. On the other hand, there are chemicals of primary concern which, even in small doses, can cause adverse health impacts. The potential for adverse health effects in population contacting hazardous wastes may involve any organ system, depending on the specific chemicals contacted, the extent of exposure, the characteristics of exposed individual (e.g. age, sex, genetic makeup), the metabolism of the chemical involved, and presence or absence of confounding variables such as other diseases.

Negative impact on environment

If chemical hazardous waste is not handled or disposed of properly, both the environment and nearby individuals are put at risk by its potentially corrosive, toxic, flammable or explosive nature. When chemical hazardous waste get washed into the soil it quickly contaminates the ground water. This groundwater seeps into lakes, rivers and other important water sources, which makes it unfit for consumption and purpose. Invariably, exposure to chemicals escaping into the environment can lead to a reduction of life expectancy and possibly a period of reduced quality of life (due to anxiety from exposures, diseases, etc.). An uncontrolled waste disposal practice can therefore be perceived as a potential source of several health and environmental problems.

Industry has become an essential part of modern society, and waste production is an inevitable outcome of the developmental activities. There is ample evidence that improper disposal of these wastes may cause contamination of air (via volatilization and fugitive dust emissions); surface water (from surface runoff or overland flow and groundwater seepage); ground water (through leaching and infiltration); soils (due to erosion, including fugitive dust generation and deposition and tracking); sediments (from surface runoff and overland flow seepage and leaching) and biota (due to biological uptake and bioaccumulation). Contamination of ground water by landfill leachate (a water-based solution of compounds from the waste) poses a risk to downstream surface waters and wells. It is considered to be the major environmental concern associated with the landfilling of the waste (Misra and Pandey, 2005).

3.2.3.2 Overall assessment on national policies, regulations, standards and inventory in Asia and the Pacific

This section studies the regulations and classification of chemical and hazardous waste in Asia and the Pacific region countries, the standards and protective measures of informal and formal workers, the international conventions of chemicals and hazardous waste developed, as well as the activities carried out for bilateral or multilateral framework agreements, so as to comprehensively evaluate the policies, regulations, standards and lists related to chemicals and hazardous wastes in countries in Asia and the Pacific region.

i. National policies and regulations including policy and institutional issues and technical gaps

The Ha Noi 3R Goal 9 indicates that developing proper classification and inventory of hazardous waste is a prerequisite towards sound management of hazardous waste. In the Asia and the Pacific region, more than 25 countries have developed hazardous waste classification systems or catalogues to achieve sound hazardous waste management. The policy system in some Asia and the Pacific countries tends to be more and more specified since exceptional regulations on some of the hazardous wastes are issued. However, for some countries, specialized legislation on chemical and hazardous waste has not been executed.

In PR China, the Law on the Prevention and Control of Environmental Pollution by Solid Waste was promulgated and implemented in April 1996, which provides special provisions on the prevention and control of hazardous waste pollution. Based on the law, PR China has formed a relatively perfect hazardous waste management system, and established systems such as hazardous waste identification, management plan, transfer form, application and registration, hazardous waste license, operation report, emergency plan, identification and export approval. In addition, a series of standards and technical guidelines for hazardous waste storage, incineration and landfill have been formulated, covering the whole process of hazardous waste generation, storage, transportation, transfer, utilization and disposal.

In Indonesia, according to GR no. 101and2014, hazardous waste management is an activity consisting of reducing, storing, collecting, transportation, utilization, treatment, and landfilling. The Ministry of Environment and Forestry has released summaries of licenses regarding documents of hazardous waste utilization, treatment, transportation, and landfilling.

In Bangladesh, a regulatory framework is in place for management of Hazardous Industrial Waste (e.g., Lead Acid Battery Recycling and Management Rules 2006; Medical Waste–Management and Processing–Rules 2008; Hazardous Waste and Ship-Breaking Waste Management Rules, 2011). The Lead Acid Battery (LAB) Recycling and Management Rules brought major improvement in collection and recycling of LAB which used to be opened for lead recovery by informal sector workers with their exposure to serious health hazards.

In India, in order to ensure safe storage, treatment and disposal of hazardous wastes in an environmentally sound manner without causing adverse effect to environment and human health, Government. of India notified, the Hazardous Wastes (Management and Handling) Rules, in the year 1989 under the Environment (Protection) Act, 1986 and these rules were amended from time to time and have recently been revamped with notification of Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016. Treatment, storage and disposal facilities have been developed for the disposal of hazardous waste at 22 different places in 10 States.

Based on the comparison of policies and main contents of hazardous waste management in various countries, the following common points are obtained: Firstly, the policies are established following the national environmental laws, regulations and international conventions, and on this basis, regulations of hazardous waste utilization, treatment, transportation, and landfilling are released. Secondly, in order to implement the principle of whole process management as well as "reduction, recycling and harmless", it gets linked to solid waste management (source reduction, recycling and disposal) as the focus of harmless management, not just the harmless disposal process. Thirdly, state agencies responsible for environmental affairs are responsible for issuing relevant technical documents, and private companies focus on collection, transportation, and disposal. There are 15 countries which have issued policies and regulations specifically for the management of chemical and hazardous waste (see Table 3.2.3-3).

Table 3.2.3-2: Status of countries and regions with separate chemical and hazardous waste regulations

Countries	Regulations
Australia	• Hazardous Waste (Regulation of Exports and Imports) Regulations 1996 F2017C00535 (SR 1996 No. 284) • Hazardous Waste (Regulation of Exports and Imports) (Fees) Regulations 1990 F2017C00541 (SR 1990 No. 130) • Hazardous Waste (Regulation of Exports and Imports) (Imports from East Timor) Regulations 2003 F2017C00566 (SR 2003 No. 56) • Hazardous Waste (Regulation of Exports and Imports) (OECD Decision) Regulations 1996 F2017C00560 (SR 1996 No. 283) • Hazardous Waste (Regulation of Exports and Imports) (Waigani Convention) Regulations 1999 F2017C00549 (SR 1999 No. 7)
Bangladesh	• The Environmental Conservation Act 1995 • Bangladesh Environmental Conservation Rules (ECR) 1997 • Lead Acid Battery Recycling and Management Rules 2006 • Medical Waste – Management and Processing – Rules 2008 • Hazardous Waste and Ship Breaking Waste Management Rules 2011 • Ship-Breaking and Recycling Rules 2011 • E-Waste Management Rules (Draft) 2020 (Final stage of approval) • Medical Waste Management Rules 2008 (Draft preparation is in progress) • Solid Waste Rules 2020 (Prepared draft is under review)
PR China	• Law of the PR China on the Prevention and Control of Environmental Pollution by Solid Waste (Amended in 2020) • Measures for the Administration of Hazardous Waste Operation License (Amended in 2016) • Management measures for hazardous waste transfer (Entry into force in 2022)

Countries	Regulations
	• Administrative Measures for Examination and Approval of the Export of Hazardous Waste (Amended in 2019) • National Hazardous Waste List (Amended in 2021) • Hazardous Waste Exemption Management List (Amended in 2021) • Identification Standard for Hazardous Waste (GB5085.1-7-2007) • Technical specifications on identification for hazardous waste (HJ 298-2019） • Standards for Pollution Control on Hazardous Waste Incineration (GB 18484-2020) • Standards for Pollution Control on Hazardous Waste Storage (GB 18597-2001) • Standards for Pollution Control on Hazardous Waste Landfilling (GB 18598-2019) • Specifications for Collection, Storage, Transportation of Hazardous Waste (HJ 2025-2012) • General specifications of engineering and technology for hazardous waste disposal (HJ 2042-2014) • Technical specifications for Centralized Incineration Facility Construction on Hazardous Waste (HJandT176-2005)
India	• the Environment (Protection) Act,1986 • the Hazardous Wastes (Management and Handling) Rules,1989 • Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2008 • Guidelines on Co-processing of Hazardous Waste in Cementand PowerandSteel Industry, 2010 • the Proposals for Utilization of Hazardous Waste under Rule 11 of the Hazardous Waste (Management, Handling and Transboundary Movement) Rules,2015
Japan	• Waste Management and Public Cleansing Law • Law for the Control of Export, Import and Others of Specified Hazardous Wastes and other Wastes (Basel Convention Act) • Act on Special Measures concerning Promotion of Proper Treatment of PCB Wastes
The Republic of Korea	• the Wastes Control Act • The Act on Registration and Evaluation, etc of Chemical Substances(K-REACH) • Chemical Control Act(CCA) • Consumer Chemical Products and Biocides Safety Act • Occupational Safety and Health Act(OSHA)
Lao PDR	• Decision on the Management, Monitoring, and Inspection of the Treatment and Disposal of Contaminated and Hazardous Waste No. 3649andMONRE
Mongolia	• Law on prohibition of importing, transit and export of hazardous waste, 2000 • A rule on classification, collection, temporary storage, transportation, treatment of hazardous wastes, 2002 • Regulation and procedures on disposal and landfill of hazardous waste of business entities, and requirements on waste containers and waste disposal sites, 2006 • Payment calculation methodology for hazardous waste, 2006 • Classification and characteristics and hazard level of waste, 2006 • Regulation on labeling hazardous waste, 2006 • Regulation on national reporting and inventory of hazardous waste, 2009 • (UNSD, 2010)
Myanmar	• Master Plan for Hazardous Waste Management in Myanmar • Baseline Report on Existing Policies, Legislation and Institutional Arrangements for Hazardous Waste in Myanmar • Notification on Specifying Types of Hazardous Wastes • Procedure on Transboundary Movement of Hazardous Wastes • Healthcare Waste Management in Myanmar • Waste Inventories • Evaluation of feasible treatment options for hazardous wastes • Report of Capacity Building by Project on Hazardous Waste Management

Countries	Regulations
The Philippines	• An Act to control Toxic Substances and Hazardous and Nuclear Wastes • DAO 92-29 "Hazardous Waste Management" DENR AO – Series of 2004 • DAO 28 Series of 1994 Interim Guidelines for the Importation of Recyclable Materials Containing Hazardous Substances • Interim guidelines for the importation of recyclable materials containing hazardous substances • Regulations of Republic Act 6969 • (EMB Philippines, 2022)
Singapore	• The Environmental Public Health (Toxic Industrial Waste) Regulations 1988
Sri Lanka	• Hazardous Waste Regulations – gazette, 1996 • Hazardous Waste Guidelines available (formed in 2012)
Thailand	• Industrial Waste Disposal B.E. 2548 (2005) • the Hazard Substance Act B.E. 2535 (1992) • The Ministerial Regulation B.E. 2537
Tonga	• Waste Management Act 2005 • Hazardous Waste and Chemicals Act 2010
Viet Nam	• Law on Environmental Protection 2014 (LEP 2014) • Decree 38and2015andND-CP on waste and scrap management • Circular 36and2015andTT-BTNMT on management of hazardous waste • Inter-ministerial circular 58and2015andBYT-BTNMT on medical waste management

However, Bhutan, Brunei Darussalam, Cambodia, Fiji, Indonesia, Maldives, Papua New Guinea, Samoa, and Tuvalu, have only issued regulations on waste management, but no special system and standard for hazardous waste, so the management system is not perfect (Table 3.2.3-4).

Table 3.2.3-3: Status of countries without separated chemical and hazardous waste regulations

Countries	Regulations
Bhutan	• Waste Prevention and Management Regulation 2012
Brunei Darussalam	• Brunei Darussalam law applicable to toxic chemicals
Cambodia	• The Sub-Decree on Solid Waste Management（1999）
Fiji	• Environment Management Act (EMA), 2005 • Environment Management (Waste Disposal and Recycling), 2007
Indonesia	• Law no. 4and1982 on Basic Provisions for Managing the Living Environment GR no. 101and2014
Maldives	• Environment Protection and Preservation Act of Maldives (Law No: 4and93)
Palau New Guinea	• The Environmental Quality Protection Act (1981) • Solid waste management regulations (1996) • The Recycling Act (2006)
Samoa	• Waste Management Act 2010
Tuvalu	• Part VII of the Environment Protection Act 2008 • Waste Operations and Services Act 2009

In addition, some countries still have challenging issues in policies and regulations. Some countries which have backward treatment technology, large amount of hazardous waste and lack of treatment facilities, result in the stockpiling of a large number of hazardous waste. The standard system of hazardous waste pollution control in some countries is not perfect, and there is a lack of corresponding technical and economic policies. In addition, the national hazardous waste base is not clear, and there is a lack of perfect statistical system, so it is difficult to grasp the specific situation of hazardous waste generation, discharge, storage, disposal and utilization. For example in Viet Nam, inventory of hazardous waste has not been implemented consistently and until now there has been no national inventory with official data on hazardous waste (UNCRD, 2017); there is no facility to dispose certain categories of hazardous waste in Sri Lanka, and needs to establish a hazardous waste management facility. Agency cooperation, inspection and monitoring technologies are ignorant of waste producers or processors as mentioned in the notifications or guidelines in Thailand (UNCRD, 2020a). Currently there is no law in Brunei Darussalam, and only limited facilities exist to deal with hazardous waste. There is presently no waste classification system in Brunei Darussalam and apart from the occasional arrangements for special disposal of hazardous wastes, waste generated are either disposed together with household refuse and common landfill sites or discharged in waste water to water courses. There is a need for a comprehensive law to cover the entire life cycle of chemicals from the time of their manufacture, import, sale and use, classification, labelling, packaging, handling, storage, transportation and disposal . Regulations regarding hazardous waste exist in Bangladesh, but it is the enforcement of regulations that is of greater concern. There is no secured landfill site available for disposal of hazardous industrial waste, and also no facility for treatment and recycling of hazardous waste in Bangladesh.

ii. Occupational safety and health standards of waste workers

Health is a fundamental human right and a key indicator of sustainable development. Sustainable development goal 3 (SDG3) is “Ensure healthy lives and promote well-being for all at all ages”. SDG3 states to significantly reduce deaths and illnesses caused by hazardous chemicals and air, water and soil pollution by 2030. Labour standards embedded in waste management contracts (in particular safety of workers) is set as an indicator to the Ha Noi 3R Goal 23. In recent years, notable progress has been made, but significant challenges remain. At minimum business has a responsibility to respect all human rights, including the right to health. Small, medium and large companies can both benefit from and contribute to achieving healthy societies. In the Republic of Korea, the Occupational Safety and Health Act was promulgated to regulate the use of chemicals in workplace with a goal of protecting workers from exposure to hazardous chemicals.

According to the International Labor Organization (ILO) Green Jobs Report in 2013 (ILO, 2013). An estimated 20 million people world-wide earned their living from recycling waste. ILO also estimated that 4 million of the 19-24 million people in the waste management and recycling sector were formally employed (World Bank, 2020). The waste workers are also exposed to infectious diseases from medical waste, heavy metals, chemical vapors, heat and cold, falls and other injuries.

In many developing countries the authorities could not give their attention to the waste workers due to the various reasons such as, lack of proper planning, weak waste management system, awareness and unequal resource distribution. Furthermore, waste workers are often at the bottom of the social ladder and cannot make their voice heard to the authority. It also discourages them benefitting from different services that are available for example, education and health care. Waste workers suffered from different diseases and face many health problems, such as:

- Respiratory symptoms: Running nose, sneezing and coughing, frequent headache
- Musculoskeletal symptom: tiredness, backache, body pain

- Other symptoms: skin rashes, vomiting and diarrhea.

Moreover, large proportion of waste workers also face emotional and mental health problem and there is an evidence of depression of varying severity among the waste workers. Thus, creating safe working environment and educating them about healthy lifestyle choices and safe working environment can play an important role for reducing the occupational health risks of waste workers (Black et al., 2019).

iii. Protective measures of informal and formal workers with regulatory framework

The number of workers in informal and formal sectors with access to social security and health care services under Goal 32 is related to workers' health. The theme of World Health Assembly resolution (WHA) 60.26 is "Workers' Health: Global Plan of Action", and the aim is to urge Member States to work towards full coverage of all workers, particularly those in the informal sector, agriculture, small enterprises and migrant workers with essential interventions and basic occupational health services for primary prevention of occupational and work-related diseases and injuries. WHO's proposed a strategy to improve health coverage of workers including those working in small companies and the informal sector in the following strategic directions (WHO, 2017).

1) Increasing skills of primary care providers to provide basic occupational health services.
2) Expanding the coverage and improving quality of specialized occupational health services in big and medium-sized companies and industrial zones.
3) Establishing connections between occupational health services and primary care centres.
4) Developing workplace health initiatives, tools and methods.
5) Including occupational health in the pre- and in-service training of all frontline health providers and certain medical specialists.
6) Developing roadmaps for scaling up access of workers to essential interventions and services, as defined nationally.

Some activities by informal workers are carried out before the solid waste reaches the final disposal sites for the separation of recyclable materials. They usually perform their work in a very primitive way without any protective measures for their health and safety. Informal workers are exposed to hazards and unhealthy work place environment which they are not fully aware of. This could lead to high risk of infection and disease transmission (Aljaradin et al., 2015). Currently, specialized occupational health services are available only for 15 percent of workers across the world, primarily in big companies that offer health insurance and employment injury benefits. With the ongoing global job crisis, more and more people seek labour in the informal sector without any insurance cover and no occupational health services. Many such workers often work in hazardous conditions and suffer work-related diseases, injuries and disabilities (WHO, 2017). Therefore, many countries formulated regulatory occupational health and safety standards to protect informal and formal workers.

WHO released The Health and Safety Practices for Health-care Personnel and Waste Workers, containing the standards of waste worker's protection (WHO, 2018a). It aims at proper training of workers, in health and safety to ensure that workers know and understand the potential risks they will face from the direct contact with waste and the importance of consistent use of personal protection equipment as well. Moreover, it recommends providing equipment and clothing for personal protection, such as: 1) Helmets, with or without visors; 2) Face masks; 3) Eye protectors or safety goggles; 4) Overalls (coveralls); 5) Industrial aprons; 6) Leg protectors or industrial boots; 7) Disposable gloves or heavy-duty gloves.

iv. International conventions of chemicals and hazardous waste

For several decades, the international community has recognized the need for action to advance the sound management of chemicals and waste. Since around the time of the Rio Summit and in the following decades, the international community has taken concerted action through multilateral treaties on some of the most harmful chemicals and on some issues of global concern. The Ha Noi 3R Goal 26 indicates that countries in the Asia and the Pacific region shall facilitate the international circulation of re-usable and recyclable resources as well as remanufactured products as mutually agreed by countries and in accordance with international and national laws, especially the *Basel Convention*, which contributes to the reduction of negative environmental impacts and the effective management of resources. One of the indicators requires the existence of framework for bilateral and multilateral cooperative activities toward efficient, legal, and appropriate trade of circulative resources. In the Asia and the Pacific region, six conventions on chemical and hazardous wastes have been adopted and implemented, while six conventions on hazardous waste and chemicals have entered at global level. These conventions are presented in **Table 3.2.3.4**.

Table 3.2.3-4: International Conventions of Chemicals and Hazardous Waste

Global Treaties		**Entry into force**	**Number of Parties (by 28 Dec. 2021)**
1	The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes	5 May. 1992	189
2	Kyiv Protocol on Pollutant Release and Transfer Registers	8 Oct. 2009	43
3	Minamata Convention on Mercury	10 Oct. 2013	137
4	Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade	24 Feb. 2004	165
5	The Stockholm Convention on Persistent Organic Pollutants	17 May. 2004	185
6	Strategic Approach to International Chemicals Management	06 Feb. 2006	
Asia and the Pacific treaties (InforMEA, 2022)		Entry into force	Number of Parties (by 28 Dec. 2021)
1	ASEAN Agreement on Transboundary Haze Pollution	09 Nov. 2003	10
2	Apia Convention	25 Jun. 1990	5
3	Jeddah Convention	19 Aug. 1985	7
4	Kuwait Regional Convention	30 Jun. 1979	8
5	Noumea Convention	18 Sep. 1990	12
6	Waigani Convention	21 Oct. 2001	12

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes

The Basel Convention restricts international trade in hazardous and other wastes. The Convention covers hazardous wastes, which are defined by their source (such as wastes from wood-preserving chemicals) and their constituents (such as mercury, lead and asbestos), as well as by their hazardous characteristics (such as explosive, flammable or toxic). The Convention lists wastes that are presumed to be hazardous and non hazardous. It consists of a preamble, 29 articles and 9 annexes. The Convention also applies to “other wastes”, which include household wastes and the remains of incinerated household waste. Wastes are defined as substances or objects that are disposed of, are intended to be disposed of, or are required to be disposed of by provisions of national law. In 2019, waste plastics was added into ANNEX II.

Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade

The Rotterdam Convention covers the pesticides and industrial chemicals that have been banned or severely restricted for health or environmental reasons by two or more Parties and which the Conference of the Parties has decided to subject to the PIC procedure. There are a total of 53 chemicals listed in Annex III, 35 pesticides (including 3 severely hazardous pesticide formulations), 16 industrial chemicals, and 1 chemical in both the pesticide and the industrial chemical categories. Its main objective is to promote joint responsibility and cooperation among parties in the international trade of certain hazardous chemicals in order to protect human health and the environment from harm, and to promote the exchange of information on the characteristics of these chemicals through national decision-making procedures on the import and export of these chemicals, so as to contribute to their environmentally beneficial use.

The Stockholm Convention on Persistent Organic Pollutants

The objective of the Stockholm Convention is to protect human health and the environment from persistent organic pollutants. The Chemicals listed under the Stockholm Convention fall into three categories, namely elimination (Annex A: Aldrin, Chlordane, Chlordecone, etc), restriction (Annex B: DDT, and Perfluorooctane sulfonic acid, its salts and perfluorooctane sulfonyl fluoride) and unintentional production (Annex C: Hexachlorobenzene (HCB), Hexachlorobutadiene (HCBD), Pentachlorobenzene, etc.).

Minamata Convention on Mercury

"Hg" in the Minamata Convention refers to elemental mercury (Hg (0), CAS No. 7439-97-6). The Minamata Convention controls mercury mainly in terms of mercury supply sources and trade, mercury-added products, production processes using mercury or mercury compounds, artisanal and small-scale gold mining, mercury emissions and releases, and mercury waste.

Kuwait Regional Convention

The Kuwait Regional Convention for Co-operation on the Protection of the Marine Environment from Pollution adopted the Protocol on the Control of Marine Transboundary Movements and Disposal of Hazardous Wastes in 1998. The Marine Emergency Mutual Aid Centre (MEMAC) was established within the framework of the Convention. The high priority has been put on combatting oil and hydrocarbon pollution is also reflected in the protocol on land-based sources.

Noumea Convention

During the Conference of the Plenipotentiaries on the 10th of November 2006, the Parties to the Noumea Convention adopted two new protocols as new instruments to implement the provisions of the Convention. The two protocols, respectively the "Protocol on Oil Pollution preparedness, response and cooperation in the pacific region" and the "Protocol on hazardous and noxious substances pollution, preparedness, response and cooperation in the pacific region", constitute new commitments of the Parties to take effective regional actions for the prevention of marine pollution from two specific clusters of pollutants: oil, and hazardous and noxious substances.

Waigani Convention

The Waigani Convention is an Annex-driven Convention: the obligations for the Parties to reduce and control movement and production of hazardous wastes extend to all the wastes contained in Annex I (Categories of wastes which are hazardous wastes), or those that possess the characteristics contained in Annex II (List of hazardous characteristics). The objective of the Waigani Convention is to reduce and eliminate transboundary movements of hazardous and radioactive waste, to minimize the production of hazardous and toxic wastes in the Pacific region and to ensure that disposal of wastes in the Convention area is completed in an environmentally sound manner.

v. Existence of framework for bilateral and multilateral cooperative activities

In addition to bilateral and multilateral agreements, activities undertaken within the framework of bilateral and multilateral cooperation toward efficient, legal and appropriate trade of circulative resources are also addressed in the Ha Noi 3R Goal 26. There are two main activities that are implemented in the Asia and the Pacific region with participation of most countries. The organising and performing of multilateral cooperative activities have been moving smoothly in these years, trending to a closer coordination in the region.

The Asian Network for Prevention of Illegal Transboundary Movement of Hazardous Wastes (MoEJ, 2022a).

The Asian Network was established by the Government of Japan in 2003. It is an informal network among the Competent Authorities to the Basel Convention in Asia, which aims at facilitating exchange and dissemination of information on transboundary movements of hazardous wastes and assisting countries in implementing the Basel Convention under each country's system. The wide range of discussion topics has been set according to the needs of the countries, outcomes of discussion at the Conference of the Parties (COP), or progress of Partnership Programme carried out under the Basel Convention. This will provide useful information that can contribute to capacity building of the participating countries for control on import and export and environmentally sound management of hazardous waste and other waste. The annual face-to-face Asian Network workshops have been organized since 2004, and 18 times of conferences have been held so far.

The Environmental Network for Optimizing Regulatory Compliance on Illegal Traffic (ENFORCE) (UNEP, 2019b)

The Environmental Network for Optimizing Regulatory Compliance on Illegal Traffic (ENFORCE) was launched at the eleventh meeting of the Conference of the Parties to the Basel Convention, which took place in Geneva, Switzerland, from 28 April to 10 May 2013. In its decision BC-11and8 on the Committee for Administering the Mechanism for Promoting Implementation and Compliance of the Basel Convention, the Conference of the Parties adopted the terms of reference for ENFORCE, elected members, invited additional members to the network. In accordance with its terms of reference, the membership of ENFORCE is composed of one representative from each of the five United Nations regions that are parties to the

Convention, and four representatives from the Basel Convention regional and coordinating centres, based on equitable geographical representation. In addition, the terms of reference lists organization and entities that are eligible to become additional members.

3.2.3.3 Circular economic opportunities of chemical and hazardous waste

In order to demonstrate their renewed commitment to realizing a promising decade (2013-2023) of sustainable actions and measures for achieving resource efficient society and a green economy in the Asia and the Pacific region through the implementation of the 3Rs, the countries in the Asia and the Pacific resolved to voluntarily develop, introduce and implement policy options, programmes and projects towards realizing the 33 sustainable 3R goals in the region. These goals were declared as the part of "Ha Noi 3R Declaration Sustainable 3R Goals for Asia and the Pacific for 2013-23" at the 4th Regional 3R Forum in Asia held in Ha Noi, Vietnam in 2013.

In this section, assessment of the situation of each country by the Ha Noi goals according to the reports submitted by Asia and the Pacific countries in several 3R and Circular Economy Forums and other available information and articles has been carried out. 3R economic opportunities in chemical and hazardous waste are first introduced. Then information on the illegal dumping and disposal in the region is provided. After that, assessments of the treatment technology and capacity of countries in the region are listed. Though circular economic opportunities are rarely observed in the region, the information and assessments are necessary for future work. Several case studies are given in the next part, trying to offer some insights into the management of hazardous waste, especially in the illegal activities and informal sector. The last part provides further information on the implementation and enforcement of the 3R policy of each country and a general assessment is drawn out.

i. 3R economic opportunities in chemical and hazardous waste

The Ha Noi 3R Goal 17 declares to improve resource efficiency and resource productivity by greening jobs nation-wide in all economic and development sectors. Indicators under the goal includes energy efficiency schemes, product standards, guidelines on greening, and the number of green jobs and decent jobs. However, economic opportunities from chemical hazardous waste are scarcely observed. A change in thinking from traditional linear economic models (i.e. manufacture-use-dispose) to more circular economic models is necessary and valuable. In some Asian countries, advanced finesses have been performed to improve green product or energy efficiency.

Japan: Based on the concept of the Act on Promoting Green Procurement, "Eco-Mark" a product standard system, has been applied to product with a small burden on environment in a supply chain, and it enables consumer to select environmentally-sound product and producer continue to improve their product to be fitted into green society.

Singapore: National Environment Agency launched the Mandatory Energy Labelling Scheme (MELS), starting with household air-conditioners and refrigerators in 2008, to help consumers compare the energy efficiency of energy consuming products, thereby empowering them to make more informed purchasing decisions. The scheme has since been extended to clothes dryers, televisions and lamps. To raise the average efficiency of appliances in the market, household refrigerators, air conditioners, clothes dryers, and lamps supplied in Singapore must also meet the Minimum Energy Performance Standards (MEPS). This helps to protect consumers from being locked into the high energy costs of operating inefficient appliances. MEPS and MELS requirements are regularly reviewed to ensure that it is kept pace with developments in appliances' energy efficiency and MELS provides adequate differentiation of appliance models to reflects energy efficiency improvements in the market.

Viet Nam: The Law on Environmental Protection2020, effective from early 2022, has an article on circular economy (Article 142), which facilitate economic development in waste management. The Article stipulates that ministries, ministerial-level agencies, and provincial-level People's Committees implement circular economy integration right from the stage of developing strategies, master plans, plans, programs and projects on development; waste management, reuse and recycling. Production, business and service establishments are responsible for establishing a management system and taking measures to reduce resource exploitation and waste and improve the level of waste reuse and recycling right from the stage of project development, design, production and distribution of products and goods. Under the Law, Decree No. 08and2022andND-CP detailing a number of articles of the Law on Environmental Protection has set out the criteria, roadmap and incentive mechanisms for circular economy development.

ii. Amount of illegal dumping and inappropriate disposal of chemical and hazardous waste and its sites

The Ha Noi 3R Goal 25 declares to protect public health and ecosystems, including freshwater and marine resources by eliminating illegal activities of open dumping, including dumping in the oceans, and controlling open burning in both urban and rural areas. The number of cities with open dumping and open burning, the number of major rivers with open dumping and direct discharge of untreated domestic waste and industrial effluents, and biological oxygen demand of major rivers and lakes are the three indicators under this goal. However, barely no data on illegal dumping or inappropriate disposal is available. In countries with developed legislation, some specified actions have been launched to fight against illegal activities on hazardous waste, but illegal activities of open dumping are still common in the Asia and the Pacific region and the Goal 25 is far from achieved. Available information on national reports is elaborated as follows (UNDESA, 2020b).

In Bangladesh, wastes illegally dumped by foreign ships were transferred into the territorial seas of Bangladesh. In Cambodia, hazardous waste is safely stored, transported and disposed at secure dumpsites designated by the Ministry of Environment. But provincial towns and urban areas in Cambodia still do not have solid waste collection services. Each household therefore manages its own waste, through burning, burrowing or through illegal disposal on vacant land, rice fields or into water bodies. In Japan, the total number of illegal dumping cases in 2018 was 131. Ministry of the Environment continues to expand illegal dumping eradication campaign and strength monitoring, dispatch expert in waste regulations into local government for advising and consulting, in order to strength prevention of illegal waste activities. In the Philippines, due to lack of technical and financial constraints, it is reported that many enterprises in the country are still operating illegal disposal facility (The National Solid Waste Management Commission, 2016). It is difficult to collect the amount of waste disposed of at national level.

iii. Treatment technology, methods and capacity, and final disposal

The number of facilities certified by authorized bodies for environmental standard certification is stressed as an indicator of Ha Noi 3R Goal 26. For most countries in the Asia and the Pacific region, not enough facilities are available for hazardous waste disposal currently. The disposal capacity cannot correspond to the generation of hazardous waste in many countries. On an average, South Asia, the waste collection coverage is about 51 percent, on average (Kaza et al., 2018). The service coverage highly varies by county and city (UNEP, 2019d). Countries in the Asia and the Pacific region are trending to put efforts on eliminating improper disposal of hazardous waste.

Cambodia: According to Ministry of the Environment, six waste incinerators are in operation in Phnom Penh, of which five are for burning scrap-cloths an drags in garment factories to operate the steam ovens (at 249.60 tons annually), and one incinerator burns other industrial waste at 3,276 tons annually. The onsite incinerators are operated with low technology without air pollution control systems. A total of about 3,525.60 tons of industrial solid waste are annually burned in factory incinerators. In rural areas, only one landfill in Ansnoul District, Kandal province has been designed for hazardous waste disposal. The landfill covered two hectares of land but it was closed in 2009, and a new landfill has been in operation from September 2009 that covers five hectares of land.

PR China: By the end of 2019, 4195 hazardous waste (including medical waste) permits were issued by the nation. The collection and disposal capacity of the hazardous waste (including medical waste) of approved enterprises reached 128.96 million tons/year; the actual collection and disposal volume in 2019 was 35.58 million tons, of which 24.68 million tons are utilized, 2.13 million tons are disposed by landfill, 2.47 million tons are disposed by incineration, 1.79 million tons are disposed by cement kiln, and 2.52 million tons are disposed by other means. 1.18 million tons medical waste is disposed. Hazardous wastes can be fully disposed off in the country.

Indonesia: The first centralized hazardous waste treatment plant in Indonesia began operating 1994. More than 90 percent of waste entering this facility is disposed off into a double-liner landfill. This facility was meant initially to accept all waste categorized as hazardous. Since this facility is the only certified hazardous waste landfill in Indonesia, nearly all hazardous waste generated by medium and large-scale industries that is not recycled, is transported to this facility. It was presumed that from the planned operation area in 2001, there would be 67,000 tons of sludge deposits from industrial waste treatment processes per year, and 18,000 tons of liquid waste containing solvents, oil-spill or used oil per year.

Malaysia: In 2012, a total of 446 off-site recovery facilities have been licensed. The most issued licensed are for E-waste (153 facilities), oil and mineral sludge and spent coolant (58 facilities), heavy metal sludge and rubber (37 facilities), used container and contaminated waste and ink and paint and lacquer (34 facilities), solvent (31 facilities), and acid and alkaline (27 facilities). The management of scheduled waste is considered to be proper when the most of the waste generated is recovered by the off-site recovery facilities. Only approximately 4 percent are handled by KualitiAlamSdn. Bhd.

The Philippines: The Philippines lacks technology for addressing all types of industrial and hazardous waste management. Pilot level technology demonstration existing in the country, needs to be scaled up and replicated. There are 1,952 health care facilities nationwide in 2008 registered as hazardous waste generators. This has to be monitored closely to avoid illegal collection and dumping of healthcare waste in disposal facilities.

Singapore: The valuable components of a large amount of toxic industrial wastes (TIW) generated and collected in Singapore by the licensed collectors are extracted and recovered before the TIW is disposed. Such wastes include spent solvents, spent etchants and waste oils. Those wastes that cannot be recycled or recovered are treated and the residues are disposed of at the Semakau Landfill. The TIW collectors are required to be licensed by NEA and the waste movement is tracked by an e-Tracking System. Currently, there are approximately 200 TIW collectors which are licensed to collect specific types of TIW. Of the 200 collectors, about 10 also operate a wide range of TIW treatment facilities.

Thailand: Hazardous waste were mostly industrial wastes (81.5 percent) and were sold to recycling shops, which might improperly dispose them while the household hazardous waste is disposed along with general waste. There are at least 142 infectious waste incinerators in the country. Most of which were not properly equipped to treat air pollution in accordance with regulations or treat infectious waste in order to reduce health and environmental risks. This could expose incinerator workers to potential health risks and affect the environment as well. Therefore, it is necessary to assess the capacity of every hazardous waste incinerator in the country in order to gather useful information and plan a management system.

Viet Nam: By the end of 2020, there were 117 licensed enterprises for hazardous waste treatment with a total capacity of about 2 million tons/year, 85 percent of the total amount of generated hazardous waste were collected and treated properly (MONRE, 2021).

iv. Insights from various case studies

Impact of illegal dumping on circular economy—a case study from Thailand (Otwong et al., 2021)

According to a nationwide survey, as of 2015, all factories in Thailand generated 37.4 million tons of industrial waste, including 2.8 million tons of hazardous waste and 34.6 million tons of nonhazardous waste. The quantities of estimated hazardous industrial waste based on manufacturing activity increased from 2008 to 2016.The proportion of illegal dumping (3.37 percent – 62.5 percent) was as significant as the proper CE management options (i.e., reuse, recycling, and W2E). Moreover, illegal dumping worsened in the following years, i.e., from 2014 to 2016. For this reason, while illegal dumping has rarely been incorporated into material flows according to the CE principle, it becomes a substantial factor that must be accounted for with respect to Thailand. From 2008 to 2015, 105 cases of illegal dumping incidents were reported.

Box 3.2.3.-1 Three major adverse effects of illegal dumping of hazardous industrial waste on the circular economy (CE) development

- First, illegal dumping of recyclable waste causes an apparent loss of valuable resources from the CE's technical system.
- Second, illegal dumping of hazardous waste causes soil and water contamination that compromises the CE's value of the bio- logical cycle. Contamination may be so severe that soil and water cannot be used to safely produce food and feedstock in biological cycles.
- Third, illegal dumping of hazardous industrial waste and its adverse effects on communities cause public rejection of existing and future recycling facilities as a whole.

Strengthen the management of hazardous waste—a policy case from PR China (State Council of China, 2021)

In 2021, the State Council issued "The Implementation Plan for strengthening the supervision of hazardous waste and the utilization and disposal capacity" which consist of ten parts. The first part is the general requirements. By the end of 2025, a system including strict prevention of source, strict control of the process, and strict punishment of consequences shall be established. The second to the ninth parts put forward main tasks, including improving the regulatory system and mechanism of hazardous waste, strengthening the control of hazardous waste at source, strengthening the supervision in collection and transfer of hazardous waste and other processes, strengthening the supervision of waste hazardous chemicals, improving the basic guarantee capacity of centralized hazardous waste disposal, promoting the high-quality development of hazardous waste utilization and disposal industry, establishing a medical waste emergency disposal system, strengthening the hazardous waste environment risk prevention and control capabilities. The tenth part is the safeguard measures, including compacting local and departmental responsibilities, increasing inspection efforts, and strengthening education and training.

Box 3.2.3.-2 Three main measures in reforming the management of hazardous waste

- The responsibility of enterprises shall be confirmed. The legal representative or the actual controller shall be responsible for the generation, collection, storage, transportation, utilization, and disposal of hazardous wastes. Hazardous waste-related enterprises shall openly show information about hazardous waste pollution prevention and control.
- The local governments take main responsibility for the governance of hazardous waste and strengthen the leadership of supervision and improvement of disposal capacity. The local government shall incorporate the prevention and control of environmental pollution by hazardous waste into the annual report on environmental conditions and the completion of environmental protection goals and report it to the people's congress or the standing committee.
- The relevant departments shall perform their supervisory according to the division of responsibilities. Different departments shall enhance the coordination and communication with each other to form a joint force for work.

A bridge linked industrial symbiosis and urban infrastructure—a case study from India (Chertow et al., 2019)

A study from India developed an algorithm based on lifecycle assessment tools for determining a city's industrial symbiosis potential that is, the sum of the wastes and byproducts from a city's industrial enterprises that could reasonably serve as resource inputs to other local industrial processes. This investigation focused on public benefits to Mysuru city of India by converting the maximum quantity of resources recoverable by local enterprises into an estimate of the capacity of municipal infrastructure conserved in terms of landfill space and water demand. The method demonstrated how industrial symbiosis links private production and public infrastructure to improve the resource efficiency of a city by creating an opportunity to extend the capacity of public infrastructure and generate public health co-benefits.

Box 3.2.3.-3 Three key improvements in urban infrastructure by industrial symbiosis

- Mysuru's symbiosis potential is equivalent to 38 percent of the mass of non-hazardous industrial byproducts produced in the district. This represents 90 percent of the total annual landfill capacity and 14 percent of the wastewater treatment capacity of Mysuru City.
- To optimize for CO_2 reductions, industries with a lot of plastic waste (manufacturers of electric motors, generators, wiring, etc) should facilitate exchanges with the local beverage and synthetic fiber industries, that might be able to use some of that material. The wiring industry is actually the most connected in terms of potential exchanges with other industries.
- Mysuru's industrial symbiosis potential corresponds to possible reductions of 74000 Mt of CO_2 and 100 kg of PM_{10} annually. It is clear that the benefits from this can accrue to entire cities and surrounding area, by increasing the capacity of infrastructure, potentially forestalling the need for new investments, and creating health and climate co-benefits.

(4) Roles of informal sector in the Asia and the Pacific region

Box 3.2.3.-4Role of informal sector in the Asia and the Pacific region

- **Bangladesh**: Separation of waste and recycling in Bangladesh is still an informal phenomenon. One macro level estimate on the extent of recycling by the informal sector reports that the informal sector is responsible for recycling from 4 percent to 15 percent of the total solid waste generated in different cities and urban centers. This recycled amount saves about $15.29M annually. The informal sector involvement in resource recovery reduces the problem associated with uncollected waste to an extent.
- **Cambodia**: The informal recycling sector is very active in the collection and separation of value materials for recycling. In Phnom Penh collected recyclables are estimated to reach 39.7 tons/day, or 4.3 percent of the total waste generated in the Phnom Penh municipality.
- **India**: Informal rag picking is prominent in India. In India recycling initiatives through both the informal system by rag pickers and formal system are carried out and reached a level of 27 percent recycling as in 2016.
- **Indonesia**: Indonesia has a long-established informal waste management system which goes back generations and is still in operation. Indonesian citizens have long been familiar with public trading used goods such as used clothes, especially conducted by the informal sector. Waste generated by industry that belong to hazardous categories will certainly be dealt with by the formal sectors.
- **The Philippines**: In 2009, the government formulated the "National Framework Plan for the Informal Sector in Solid Waste Management" with other international organizations. It envisages the informal waste sector as an empowered and recognized partner in the implementation of 3R and it hopes to integrate this sector in the solid waste management system by "providing them with a favorable policy environment, skills development and access to a secured livelihood, employment and social services."
- **Thailand**: The recycling business has been informally established in Thailand for decades. Local waste collectors or scavengers use a tricycle to roam around town to trade used materials from villagers with money or used clothes.

v. 3Rs for reducing negative environmental impacts (UNDESA, 2020b)

Indicators from Ha Noi 3R Goals on the management of hazardous waste regulations include (1) proper classification and inventory of hazardous waste developed; (2) there are well-trained customs officials tracking illegal export and import. For most countries in the Asia and the Pacific region, hazardous wastes are not managed appropriately. The level of management varies largely from country to country. According to the country reports submitted to the regional 3R and Circular Economy Forum, Japan, PR China, Australia, the Republic of Korea, Bangladesh, Singapore, and Thailand have sound regulations on the management of hazardous waste. The classification of hazardous waste is clear. These countries have officers working for customs to control the transboundary movement and have cooperative activities with other countries. From the perspective of regulations, hazardous wastes can be controlled well in these countries.

India, Indonesia, Cambodia, Malaysia, Myanmar, Bhutan, F. S. Micronesia, the Philippines, Sri Lanka, and Viet Nam have partly implemented 3R policies on hazardous waste management. However, some of these countries lack a full classification of hazardous wastes, some are lack of specific regulations on the management of hazardous waste, and some do not have enough officers working on supervisory. The management level in these countries is not good enough. Some countries claim that capacity building is ongoing.

For other countries, especially countries in the Pacific, no classification or regulation on hazardous wastes has been issued. Hazardous wastes are usually managed with municipal waste. Most countries in the Asia and the Pacific region have been implementing 3R policies on waste management. The recent development of 3R policies and actions on management of hazardous waste country by country are as follows.

Bangladesh: The project, Safe and Environmentally Sound Ship Recycling in Bangladesh – Phase I, consists of five work packages, covering studies on economic and environmental impacts of ship recycling industry and on the management of hazardous materials and wastes. Hi-Tech Park Authority established in 2010 is responsible for the establishment and expansion along with management, operation and development of Hi-Tech Parks within the country. Under this project, e-waste and other hazardous wastes recycling facility will be established. Although waste collection, transportation and disposal do not go well with the 3R goals and strategies, the 3R practices to an extent are prevalent throughout each of these processes of waste management. Waste collection rate, at 55 percent on an average for urban Bangladesh, implies that a lot of uncollected waste contribute to environmental problem in Bangladesh. The informal sector involvement in resource recovery (estimated at 15 percent for Dhaka city) reduces the problem associated with uncollected waste to an extent.

Cambodia: The amount of collected waste has been decreasing yearly because of increasing 3R activities, particularly re-use and recycling activities. Recyclable industrial wastes such as scrap cloth are sold to waste buyers who come to buy recyclable waste from factories.

PR China: The government tried to move up the "waste management hierarchy" to promote 3R (waste reduction, reuse and recycle), before other waste disposal methods are pursued. Facing the rapid increase in waste generation, waste disposal has made considerable progress, waste disposal facilities gradually move from urban to rural counties, expanding the scope of services, with a rise in the waste disposal rate. In 2019, the Ministry of Ecology and Environment executed a special campaign of hazardous wastes, investigating the operating condition of hazardous wastes in more than 400 chemical industrial parks and more than 20,000 hazardous waste enterprises that held hazardous waste permission in key industries to eliminate potential environmental risks.

India: Total waste handling capacities (disposal capacity) of facilities is much less than the present generation of land-disposable hazardous waste. The guidelines for co-processing of hazardous wastes in cement plants have been prepared. By integrating co-processing and treatment of wastes in energy and resource rich industry, the country can forego or significantly reduce investments in expensive incinerators, save non-renewal fossil fuels and raw material, reduce green-house gases, increase waste treatment capacity, reduce the impacts of such hazardous wastes and also reduction in land fill requirements.

Indonesia: Hundreds of industries that generate hazardous waste exist in Indonesia. They are mostly in the chemical industry, mining, food processing, textile, and others. The first centralized hazardous waste treatment plant in Indonesia began operating 1994. It was located in Cileungsi - Bogor. More than 90 percent of waste entering this facility is disposed off into a double-liner landfill. This facility was meant initially to accept all waste categorized as hazardous from industries. The rise in material consumption also leads to increased hazardous waste generation. Based on the Department of Communication and Informatics of East Java (2013), there has been a rise in hazardous waste generation up to 7,000 tons/month. This phenomenon encourages the government to build other waste treatment facilities so they can handle the issues and prevent environmental damage. Besides, 3R-based waste management system in Balikpapan has been disseminated to 53 cities throughout Indonesia (UNCRD, 2018a).

F. S. Micronesia (FSM): By specific programs, the officers were able to implement a chemical management training (2016) and strengthen objectives through the development of a National Guidance and Action Plan for Chemical management in the FSM. FSM operates small scale recycling centers as there are four main recycling centers. Challenges include the necessary funding to put in place a Chemical Management System. Due to lack of funding from the Convention, FSM have not implemented some activities that are relevant for us to meet the obligations under the Convention.

Malaysia: As a developed country, Malaysia is aiming for a 30 percent recycling rate by 2020. Major recycling industries include metal, paper and plastic industries. The Solid Waste Management and Public Cleansing Corporation (SWCorp) was established to complement and ensure the successful implementation of the National Solid Waste Management Policy. In general, the policy aims to create a comprehensive, integrated, cost-effective and sustainable solid waste management system in line with society's demands for environmental conservation and public well-being.

Myanmar: Myanmar has endorsed the National Waste Management Strategy and Master Plan (2018-2030) and Hazardous Waste Management Master Plan (2020). The plans include development of city-wide solid waste strategies to explore development of circular economies that enhance efficiencies within and between urban water, energy and food systems, with benefits for agricultural productivity and power generation; taking into account specific vulnerabilities of formal and informal waste workers and exposure to pollutants for low-income and marginalized communities; development of sanitary landfills, and facilities to dispose or repurpose plastic and other non-organic commercial and industrial wastes with high calorific and nutritional value, incl. development of Refuse-derived Fuel.

Singapore: In August 2016, Singapore implemented the initiative to restrict the use of six hazardous substances in electrical and electronic equipment. The initiative is adapted from EU's Restriction of Hazardous Substances regulation and took effect on 1 June 2017. The purpose of the initiative is to increase the potential recyclability of incineration ash by reducing the presence of heavy metals in the waste stream. It also helps to divert the incineration ash from disposal at the Semakau Landfill thereby extending its lifespan.

Thailand: Industrial Waste Management Projects are on performing: 1) efficiency improvement for the sorting and recycling facilities of the used electrical and electronics products; 2) improvement and development of the management information systems (MIS) for the industrial waste; 3) capacity building and development for the industrial hazardous waste processors; 4) assistance on the industrial waste management and tracking for the renewal of factory registration license.

Viet Nam: Most of the household hazardous wastes are collected and transported together with non-hazardous waste to the landfill. Recycling activities are common in craft villages. however, they are informal with backward technologies and usually cause major pollution which impacts the environment and public health. Serious impacts have been observed in paper, metal, plastics and electronic waste recycling villages in Hung Yen and Bac Ninh provinces.

Pacific Island Countries: For Pacific island countries, no classification or specific rules or regulations is available for hazardous wastes. In these countries, hazardous wastes are usually managed together with municipal waste or healthcare waste. They are mostly disposed by landfill. There is no 3R policy on the management of hazardous waste (ABD, 2022b).

3.2.3.4 Conclusion and way forward

Countries in the Asia and the Pacific region are experiencing a major problem with the ever-increasing volume of hazardous waste, as they lack the policies and infrastructure to deal with the issue in a sustainable way. Only a very small number of nations in the region have fully developed and implemented regulatory systems to manage hazardous waste. Most of the nations are still struggling to move towards a sustainable hazardous waste management system.

The Ha Noi 3R Declaration – Sustainable 3R Goals for Asia and the Pacific for 2013-2023, has developed goals and indicators to assist the policy makers in the region to improve their hazardous waste management systems. **Table 3.2.3-5** below describes the relevant goals and indicators that are related to hazardous waste. **Table 3.2.3-6** describes achievements of Ha Noi goals on hazardous waste.

Table 3.2.3-5: Ha Noi 3R Declaration – Sustainable 3R Goals for Asia and the Pacific for 2013-2023 that are related to hazardous waste.

Goal 9: Develop proper classification and inventory of hazardous waste as a prerequisite towards sound management of hazardous waste.	
Indicator **HNG 9-1**	Proper classification and inventory of hazardous waste developed.
Goal 14: Effective enforcement of established mechanisms for preventing illegal and inappropriate export and import of waste, including transit trade, especially hazardous waste and e-waste.	
Indicator **HNG 14-2**	There are well-trained customs officials tracking illegal export and import.
Goal 26: Facilitate the international circulation of re-usable and recyclable resources as well as remanufactured products as mutually agreed by countries and in accordance with international and national laws, especially the Basel Convention, which contributes to the reduction of negative environmental impacts and the effective management of resources.	
Indicator **HNG 26-1**	Existence of framework for bilateral and multilateral cooperative activities toward efficient, legal, and appropriate trade of circulative resources.
Indicator **HNG 26-2**	Number of facilities certified by authorized bodies for environmental standard certification.
Indicator **HNG 26-3**	Market size of waste management and recycling industry.
Indicator **HNG 26-4**	Number of eco-industrial parks.

Table 3.2.3-6: Achievements of Ha Noi Goals on hazardous wastes (MoEJ, 2023; UNDESA, 2020b)

Goal	Goal 9	Goal 14	Goal 26			
Indicator	**9-1**	**14-2**	**26-1**	**26-2**	**26-3**	**26-4**
Australia	√	√	√	-	$7.3B	3
Bangladesh	√	√	√	-	-	-
Bhutan	×	√	-	-	-	-
Brunei Darussalam	-	-	√	-	-	-
Cambodia	×	√	-	3.5K	-	2
PR China	√	√	√	1.3B	$13B	13
Fiji	×	×	-	-	-	-
India	√	×	√	15M	$1.3B	7
Indonesia	○	×	-	17M	$140M	4
Japan	√	√	√	-	$379B	26
Kiribati	×	×	-	-	-	-
The Republic of Korea	√	√	√	-	$25B	6
Lao PDR	×	×	-	-	-	-
Malaysia	×	×	-	2.9M	-	1
Maldives	×	×	-	-	-	-
Marshall Islands	×	×	-	-	-	-
F. S. Micronesia	×	×	-	-	-	-
Mongolia	×	×	-	-	-	-
Myanmar	×	×	-	-	-	-
Palau	×	×	-	-	-	-
Papua New Guinea	×	×	-	-	-	-
The Philippines	√	×	-	-	$10.5M	7
Samoa	×	×	-	-	-	-
Singapore	√	√	√	-	$172M	1
Sri Lanka	√	×	√	-	-	-

Goal	Goal 9	Goal 14	Goal 26			
Solomon Islands	×	×	-	-	-	-
Thailand	√	√	-	-	-	-
Timor-Leste	×	×	-	-	-	-
Tonga	×	×	-	-	-	-
Tuvalu	×	×	-	-	-	-
Viet Nam	○	√	√	1.3M	$3.8B	2

Note: √ well-achieved; ○ partly-achieved; × poorly-achieved; - information unavailable

According to available information, Pacific Island countries do not have specific policies or facilities to deal with hazardous waste. Australia, Bangladesh, PR China, Japan, Singapore, and Thailand have fully developed mechanism to navigate hazardous waste problems. For other countries, the sound environmental management of hazardous waste is still in process. The achievement of Ha Noi 3R Goals manifests an obvious imbalance among different regions in Asia and the Pacific. Countries in the East Asia better achieved the goals. These countries have well-developed laws and regulations on the management of hazardous wastes, and the supervisory system is established. Countries in South and Southeast Asia mostly achieved part of the goals. The implementation and supervisory need further enhancement. Island countries in the Pacific Ocean can hardly achieve the goals. To attain a better achievement of sustainable goals and a sound management on chemical and hazardous waste, a more functioning coordination needs to be established in the Asia and the Pacific region. Especially, the coordination between East Asia and Southeast Asia. Both East Asia and Southeast Asia shall help Pacific Island countries build a more resilient mechanism against chemical and hazardous waste.

As a way forward, to align to SDGs and 3R goals, the Asia and the Pacific countries need to develop a more functioning mechanism for recycling and disposing hazardous wastes. Hazardous wastes shall be supervised strictly before they are properly treated since serious environment and health problems might be induced by illegal disposal. Specification on disposing hazardous wastes shall be stipulated by both researchers and government officers. Policy makers shall synthesize the informal sector with the formal sector when constructing the mechanism. Besides, publicizing data and information on generating, collecting, disposal, and movement of hazardous waste is necessary not only for assessing the implementation of BRS conventions but also for researchers to give policy advice. Pacific island countries might need more help from those countries who have developed a functioning hazardous waste management system. Aiming at achieve a cleaner and more sustainable environment and society in the Asia and the Pacific region, endeavour of each country and cooperation among the region are both imperative.

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3.2.4 Construction and Demolition Waste (including Disaster Waste)

3.2.4.1 Regional overview in the Asia and Pacific region

Asia and the Pacific region consist of countries in Asia as well as pacific region. This section covers major countries in the Asian region like Japan, Korea and PR China and selected countries in the Pacific that are members of the Secretariat of the Pacific Regional Environment Program (SPREP). SPREP is mandated to promote cooperation in the South Pacific Region and aid to protect and improve the environment and to ensure sustainable development for present and future generations. SPREP has 26 member governments including 21 Pacific Island countries and territories. The Pacific islands region is in the western, northern, and central Pacific Ocean and consists of 14 independent countries and eight territories delineated into three major ethnic regions: Melanesia, Micronesia, and Polynesia. The region has a population of around 10.57 million inhabitants that occupy just over 550,000 km^2 of land ranging from large volcanic landforms to low-lying atolls and raised coral islands **Table 3.2.4-1**. The demographic and economic profile of these countries is given in Table **3.2.4-1**.

Table 3.2.4-1: General characteristics of the countries in Asia and the Pacific region (SPC, 2020a, 2020b; WPR, 2020)

No	Countryand Territory	SPREP	Land area (km^2)	Population		Density (persons andkm^2)	GDP	
				Last census	count		Per capita (USD)	Year
MELANESIA								
1	**Fiji**	●	18,333	2017	884,887	56	6,152	2019
2	**New Caledonia**	●(T)	18,576	2019	271,407	67	37,448	2018
3	**Papua New Guinea**	●	462,840	2011	7,275,324	13	2,854	2019
4	**Solomon Islands**	●	28,230	2009	515,870	20	2,295	2019
5	**Vanuatu**	●	12,281	2016	272,459	25	3,260	2019
MICRONESIA								
6	**Federated States of Micronesia**	●	701	2010	102,843	150	3,830	2018
7	**Guam**	●(T)	541	2010	159,358	327	34,513	2018
8	**Kiribati**	●	811	2015	110,136	146	1,636	2016
9	**Marshall Islands**	●	181	2011	53,158	302	4,337	2019
10	**Nauru**	●	21	2019	11,550	557	11,666	2018
11	**Commonwealth of the Northern Mariana Islands**	●(T)	457	2010	53,883	124	23,550	2018
12	**Palau**	●	444	2015	17,661	40	15,673	2019
POLYNESIA								
13	**American Samoa**	●(T)	199	2010	55,519	285	11,245	2018
14	**Cook Islands**	●	237	2016	14,802	65	24,913	2019
15	**French Polynesia**	●(T)	3521	2017	275,898	79	22,308	2018
16	**Niue**	●	259	2017	1,591	6	18,756	2018
17	**Samoa**	●	2,934	2016	195,979	68	4,284	2019
18	**Tokelau**	●(T)	12	2016	1,499	125	6,882	2019
19	**Tonga**	●	749	2018	100,651	133	5,081	2019
20	**Tuvalu**	●	26	2017	10,566	408	4,223	2019
21	**Wallis and Futuna**	●(T)	142	2018	11,558	80	11,674	2015
OTHERS								
22	**PR China**	✕	9,388,211	2022	1,447,008,900	154	10,434	2020
23	**Japan**	✕	364,555	2022	125,742,463	344	40,193	2020
24	**The Republic of Korea**	✕	97,230	2022	51,319,899	528	31,631	2020
25	**Australia**	●(M)	7,617,930	2022	2,5971,792	3	51,692	2020
26	**France**	●(M)	547,557	2022	65,530,768	120	39,030	2020
27	**New Zealand**	●(M)	263,310	2022	4,885,328	19	41,441	2020
28	**United Kingdom**	●(M)	241,930	2022	68,394,282	283	41,059	2020

No	Countryand Territory	SPREP	Land area (km²)	Population		Density (persons andkm²)	GDP	
				Last census	count		Per capita (USD)	Year
29	United States of America	●(M)	9,147,420	2022	334,152,019	37	63,593	2020

✗ *= Not a member of SPREP; T = Territory; M = Metropolitan Member*

i. Definition

Construction and demolition waste (CDW) in Asia and the Pacific

CDW includes all the waste produced by the construction, demolition and maintenance of buildings and infrastructure including roads and bridges. It contains a wide variety of materials such as concrete, bricks, clay tile, wood, glass, metals, and plastic (**Figure 3.2.4-1**). CDW management comprises a lot of terms and definitions, which are not clear and uniform. In many countries, CDW is not included in municipal solid waste (MSW).The EU Commission and USEPA have established definitions presented in various directives and resolutions, while many countries in the Asia and the Pacific region do not have clear definitions and concepts. Therefore, it is necessary to present various countries CDW definition and classification items in Asia and the Pacific countries (**Table 3.2.4-2**).

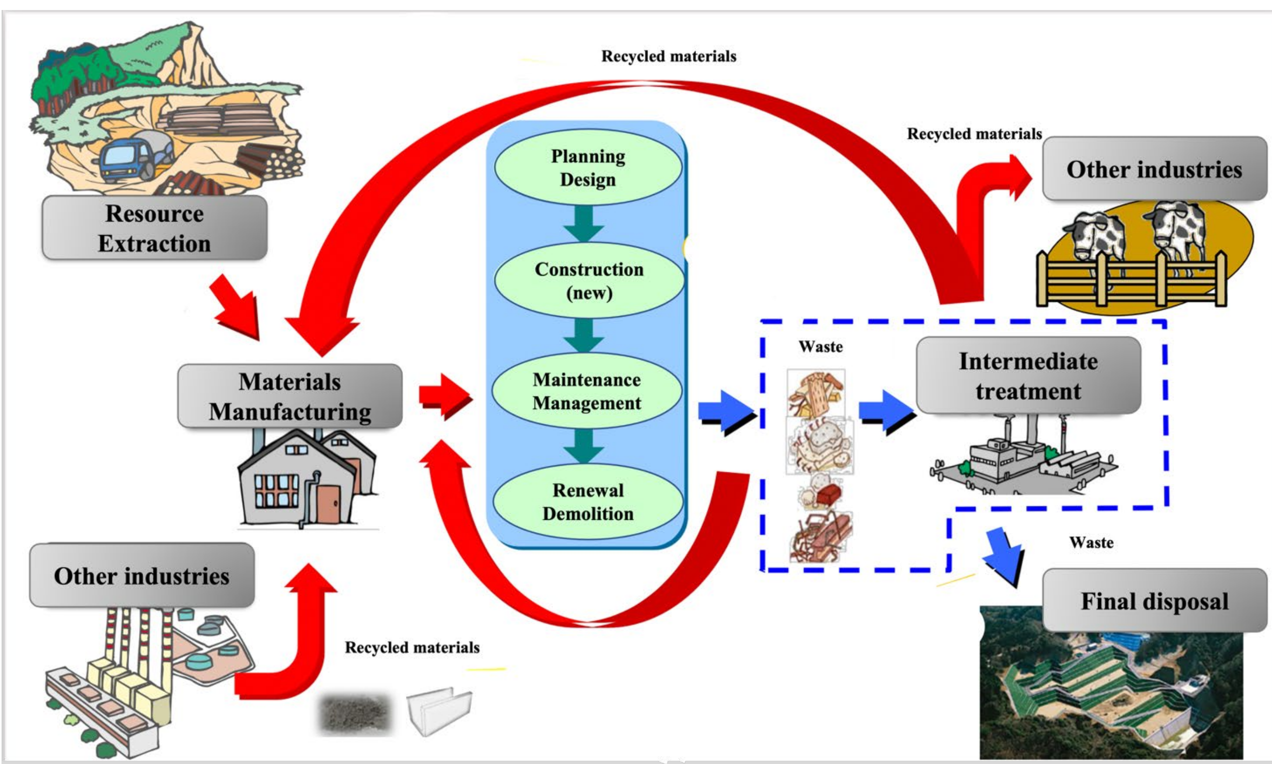


Figure 3.2.4-1: Construction Material Recycling Flow. Source (MOEJ, 2018)

Table 3.2.4-2: Definition and classification of CDW in Asia and the Pacific countries

Country	Definition and classification of CDW
PR China	Definition: • China MOHURD (2005) defined CDW as: waste soil, waste material and other waste generated during construction, reconstruction, expansion works and demolition of various types of buildings, building structures and pipe networks by building units and construction contractors (ABD, 2018). Classification: • CDW is mainly divided into four categories, according to the source of the waste: solid waste from excavation, demolition of old buildings, construction site and housing decorations. These types of wastes consists of wastes such as waste mortar, brick scrap, concrete block, scrap tile, coating material, plastics, wood, and packaging (ABD, 2018).
Japan	Definition: • CDW refers to waste generated during construction work (MOEJ, 1990) Classification: • General waste: General waste generated from offices • Industrial waste: waste plastics, rubber scraps, metal scraps, glass and ceramic scraps, debris, sludge, wood chips, paper scraps, fiber scraps, waste oil. Specially controlled industrial waste: waste oil, waste PCBs, and PCB contaminated materials, waste asbestos, etc (MOEJ, 1990).
The Republic of Korea	Definition: • Bricks and tiles generated from the construction work are categorized as construction and demolition debris (Kim, 2021). Classification (Kim, 2021): • Combustible: timber, synthetic resin, fiber, wallpaper • Noncombustible: concrete, asphalt, brick, block, roofing, soil and stones, sludge, metal, glass, tile, ceramic • Combustible and noncombustible mixed: board, panel, mix CDW waste • Others
Australia	Definition: • CDW waste - refers to waste produced by demolition and building activities, including road and rail construction and maintenance and excavation of land associated with construction activities (DEWHA and EPHC, 2010). Classification: • Masonry materials: Asphalt, bricks, concrete, rubble, plasterboard and cement sheeting (DEWHA and EPHC, 2010) • Metals: Steel, aluminum, non-ferrous metals • Other: Leather and textiles, rubber • Hazardous: asbestos

Disaster Waste (DW) in Asia and the Pacific

Disasters such as earthquakes, tsunamis, flood, and cyclones occur frequently in Asia and the Pacific. These generate a large amount of waste due to their strong destructive force. The amount of DW can equal tens-hundred years' worth of regular municipal waste, such as 239 municipalities in 13 prefectures, Japan, approximately generated 20 million tons of disaster waste and 11 million tons of tsunami deposits because of Great Eastern Japan Earthquake (Asari et al., 2015).DW is also difficult to treat due to its different characteristics (**Table 3.2.4-3**).

Table 3.2.4-3: Estimated amount of DW in the past disasters (Kim, 2021)

Date	Name of the Disaster	Estimated Amount of DWs
Earthquake and Tsunami		
Dec 2004	Sumatra – Andaman Earthquate (Indonesia)	**7 million – 10 million m^3**
May 2008	Sichuan Earthquake (PR China)	20 million tons
January 2010	Haiti Earthquake (Haiti)	23 million – 60 million tons
March 2011	The Great East Japan Earthquake (Japan)	31 million tons
April 2015	Nepal Earthquake (Nepal)	14 million tons
Cyclone and Typhoon and Hurricane and Flooding		
August 2005	Hurricane Katrina (USA)	26.8 million tons
October 2011	Thailand Floods (Thailand)	100,000 tons
November 2013	Super Typhoon Haiyan (Yolanda) (Philippines)	19 million tons
February 2016	Tropical Cyclone Winston (Fiji)	23,525 tons

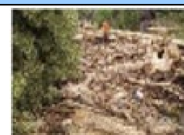
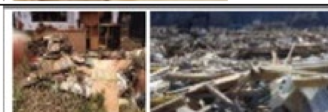
In the event of a disaster, in addition to regular municipal waste generation, wastes from evacuation centers, excreta from temporary toilets, and DW are generated (**Table 3.2.4-4**). These must be treated promptly and appropriately, while preparations and countermeasures need to be considered in advance life-threatening risk, public health risk, environment risk, impact on regular waste management services in place, economic impact (resource efficiency and cost effectiveness and benefit) and resilience (community, communication, gender, training, etc.).

Table 3.2.4-4: Types of Disaster Waste (Kim, 2021)

Household Waste	Wastes Generated from Household in Daily Life
Evacuation	Wastes generated from evacuation centers such as containers and packaging, cardboard, clothing, relief goods and so on.
Excreta	Excreta from temporary toilets, and Wastewater from sewage flowing into the toilet bowl due to the disaster.
Disaster Wastes	Wastes when the residents clean up damaged objects in and around their homes Wastes generated due to removal of damaged houses (dismantling as necessary), and All types of wastes listed in table 3.2.4-5

DW may consist of destroyed buildings and the objects they held inside, destroyed pavements or other infrastructure, wood, sands, and other natural derivatives. Not only waste directly generated from disasters, activities in recovery and reconstruction in the post-disaster phase also generate waste. The identification of materials is essential to promote proper waste management. **Table 3.2.4-5** shows the categorization of DW generated by type of disaster.

Table 3.2.4-5: Category of waste generated by disasters (Kim, 2021)

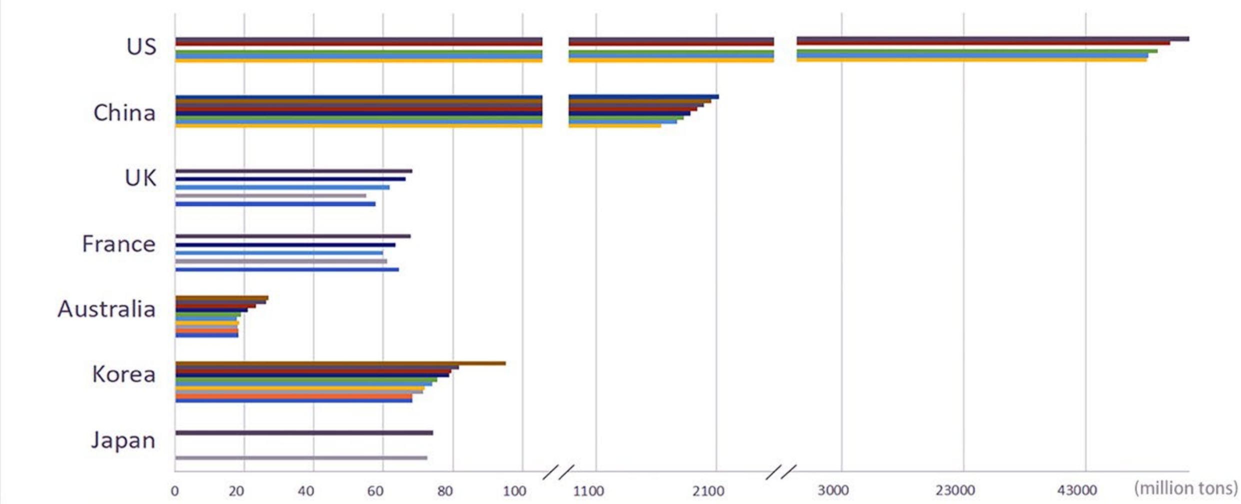
Category	Characteristics of DW	Image	Type of Disaster (□□; frequently generated, □; generated)			
			Earthquake	Tsunami	Flook	Cyclone
Green Wastes	Vegetation such as fallen trees, glasses and timbers		□	□□	□	□□
Building rubble	Timber, wood chips, waste wood (such as column, beam wall-material), bulky items, cables		□□	□	□	□
Household materials	Food wastes, tatami mats, wastes mixed with fibers, paper, wood chips, packaging materials, household furnishing and belongings, other wastes (such as plastics, cardboard, paper)		□□	□□	□□	□
Mixed wastes	Mixed wastes consisting of a small amounts of concrete, wood chips, plastics, glass, soil and sand, etc.		□	□□	□□	□
Electrical appliances	Televisions, washing machines, and air conditioners discharged from affected houses, which are damaged by disasters and become unusable		□	□□	□□	□
Automobiles	Vehicles, motorcycles, and bicycles that are damaged by disasters and cannot be used		□	□□	□□	□
Vessels	An unusable ship damaged by a disaster			□□		□
Wastes difficult to treat properly	Dangerous goods, such as fire extinguishers, cylinders and items which are difficult to treat at local government facilities, such as planes and mattresses (including radiation sources for nondestructive inspection), fishing nets, gypsum boards, etc.		□□	□□	□□	□
Hazardous wastes	Hydrocarbons, such as oil and fuel; paint; varnishes and solvents; pesticides and fertilizers; medical waste and debris; waste posing healthcare risks; asbestos containing waste; PCB; infectious waste; chemical substances; toxic substances, such as chlorofluorocarbons, CCA (waste using chromium, copper, arsenic wood preservative), and tetrachloroethylene; pharmaceuticals; pesticides hazardous		□□	□□	□□	□

Category	Characteristics of DW	Image	Type of Disaster (□□; frequently generated, □; generated)			
			Earthquake	Tsunami	Flook	Cyclone
	waste; solar panels and accumulators. etc.					
Mementos, Valuables	Albums, photos, Ihai tablets, cash, passbooks, precious metals		□□	□□	□□	□□
Industrial wastes, Commercial wastes	Bulk wastes, hazardous wastes, food wastes, marine products and foodstuffs discharged from refrigerators, raw materials and products generated from fishery processing plants and fertilizer factories, machinery, equipment.		□□	□□	□□	□
Tsunami Sediment	Sand and sludge sediments launched to land from the bottom of the sea as well as farmland soils by tsunami			□□	□□	
Sand and stone	Sand and stone launched to land from mountains, rivers and other areas		□	□	□	□
Household Wastes	General and bulky wastes discharged from households		□	□	□	□
Wasters from evacuation centers	Waste discharged from evacuation centers, waste from relief supplies		□	□	□	□

Construction and Demolition Waste Management (CDM) and Disaster Waste (DW)
There are several points to consider in the relationship between CDM and DW. Construction (infrastructure) might become disaster waste at large scale disaster time. For example, "building rubble" and "mixed waste" as described in Table 3.2.4-5 are typical categories like CDW. So, the resilience and design of construction (infrastructure) is crucial from the viewpoint of DW. Also "built back better" concept is important to think both about DW and CDM. However, not enough discussion has been done at disaster management sector and waste management sector.

ii. Quantification and Generation

CDW Quantification and Generation
The availability and reliability of data on CDW generation is very limited. Countries of Asia and the Pacific regions have not developed proper inventories of CDW. Among those countries where CDW data is available, some of them collect data every few years therefore very limited data is available.



	Japan	Korea	Australia	France	UK	China	US
2020	—	—	—	—	—	2,119.98	—
2019	—	95.11	27.03	—	—	2,058.23	—
2018	74.40	81.67	26.32	67.75	68.27	1,998.29	60,030.00
2017	—	79.70	23.35	—	—	1,940.08	56,940.00
2016	—	78.80	20.90	63.42	66.46	1,883.58	—
2015	—	75.39	19.08	—	—	1,828.72	54,780.00
2014	—	74.13	17.77	59.96	61.70	1,775.45	53,400.00
2013	—	71.98	18.60	—	—	1,645.00	53,030.00
2012	72.69	71.31	18.10	61.20	55.06	—	—
2011	—	68.22	18.32	—	—	—	—
2010	—	68.27	18.36	64.42	57.68	—	—

Figure 3.2.4-2: CDW Quantification and generation annual amount of some countries in Asia and the Pacific (ABD, 2016; DCCEEW Australia, 2020; Deloitte, 2015a; EPA US, 2018; MOEJ, 2018; Research and Markets Globe Newswire, 2021)**.**

CDW data of some countries are limited, such as France and the United Kingdom, which are both collected by the government once every two years, and Japan is collected every 4 to 6 years by Ministry of Land, Infrastructure, Transport and Tourism. Regarding PR China's data, the absence of yearly statistics on CDW makes it difficult to estimate how much CDW will be generated based on historical data. Instead, the generation of CDW could be estimated by looking back at areas that have been constructed and demolished. This estimation and predictions are based on unit production.

DW Quantification and Generation

DW composition differs widely according to the type and scale of disaster. In the DW the ratio of inorganic waste is high. Case studies from different countries have been presented to explain the DW Quantification and generation.

Case of Japan

In earthquakes and tsunamis, as many buildings and infrastructure are damaged, much waste is composed of inorganic material like cement. The data from the Kumamoto Earthquake, indicates that waste composition depends on the source of DW generation. **Table 3.2.4-6** shows that shortly after the time, disaster breaks out, the ratio of mixed and combustible waste ratio is high, as the waste is mainly generated by household clean-up. Also, it’s clear that the amount of waste like CDW is large.

Table 3.2.4-6: Amount of disaster waste generation classified by material type (OECD, 2017)

	*1,000 ton	Waste disposal and estimated generation amount	Waste concrete	Waste wood	Waste metal	Other (remaining materials)			
						Mixed waste (landfill)	Combustible material	Tiles	Other
Waste generated mainly by household cleanup	Apr - Aug 2016 Disposal Amount	471	137	45	4	153	68	45	18
	Ratio (%)	100%	29.1%	9.6%	0.9%	32.4%	14.5%	9.6%	3.8%
Waste generated mainly by building demolitions	Sep 2016 - Mar 2018 Estimated generation amount*	2,422	1,233	411	9	263	63	252	190
	Ratio (%)	100%	50.9%	17.0%	0.4%	10.9%	2.6%	10.4%	7.9%
	Total*	2,893	1,371	456	14	416	131	297	208
	Ratio (%)	100%	47.4%	15.7%	0.5%	14.4%	4.5%	10.3%	7.2%

Note: Some totals do not match due to calculations after decimal point rounding.

Case of Fiji

Category Five Severe Tropical Cyclone (TC) Winston left a path of destruction across Fiji from 20th to 21st of February 2016, claiming 43 lives with 160 people injured. 35,000 evacuees found shelter in 424 evacuation centers. 97 schools were damaged while 100 percent of crops were destroyed in the affected areas. A 30-day state of disaster was declared. An estimated 9410 loads (23,525 tons) of waste were generated from urban centers alone, excluding rural and maritime areas.in Fiji is still recovering from these disastrous impacts, even two years later (housing, schools, agriculture, etc.).

Lautoka City Council has a 3R Promotional Plan which targets recycling of green waste from wood chipping (for mulching in gardens, fuel for sugar mill, and as a component for composting). Estimated 575 tons of green waste were chipped after tropical cyclone Winston. Lautoka City Council has allocated a separate site within a landfill for the reception of DW (though it requires improvements). Resource recovery is also promoted (biofuel, reuse, and recycling). 127 tons of DW was recovered from landfills by waste pickers and an estimated 1,800 tons of green waste was recovered for biofuel by residents after TC Winston.

Case of Thailand

Bangkok witnessed unprecedented flood waste in 2011. Flood waste included: MSW, infectious waste (from medical treatment, research, etc.), and industrial waste, all of which were generated both during and after flood events. Among these, the main types of floods waste the Bangkok Metropolitan Administration (BMA) dealt with were MSW (including household hazardous waste) and infectious waste. The exact amount and composition of flood waste depends on each flood event. For example, according to the waste composition survey by the Department of Environment (DoE) of the BMA, the composition of waste during flooding in 2011 was as listed in Figure below. Here you can see that the amount of waste like CDW is small.

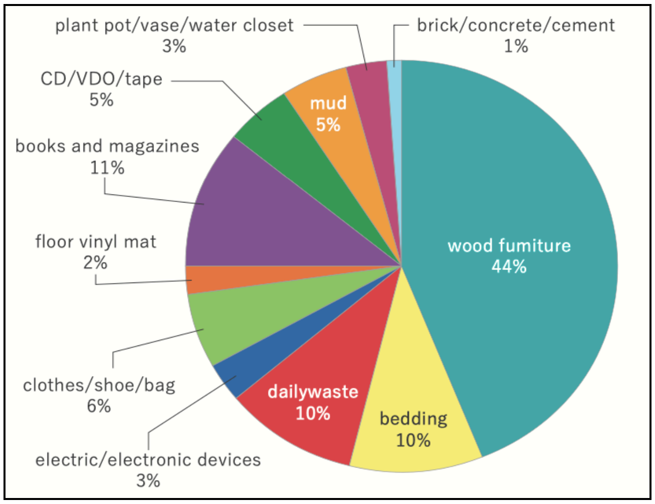


Figure 3.2.4-3: Composition of flood waste during 2011 flooding. Source: OECD (2017)

iii. Urban development and regional demographic outlook and its possible impact

The most recent United Nations projections show an increase in urban population of 1.35 billion, and more than 5.87 million km^2 of land have been converted to urban areas Worldwide by 2030. Among that, nearly half of the increase in high-probability urban expansion globally is forecasted to occur in Asia, with PR China and India absorbing 55 percent of the region total.

The demographic shift will change the country's social fabric but also its urban and rural landscape dramatically. Rural and remote areas have constantly lost their populations and the local culture and customs unique to a region are gradually dying out. In particular, vernacular architecture, the highly indigenous traditional housing cultivated by the natural features of a region is quickly being replaced with buildings incorporating large amounts of new materials such as concrete blocks, galvanized iron sheets, and cement slates.

The global construction and demolition waste market size is estimated to grow from USD 26.6 billion in 2021 to USD 34.4 billion by 2026, at a CAGR (compound average growth rate) of 5.3 percent during the forecast period. The global market is primarily driven by increasing construction activities and inclination of governments toward sustainability in various regions across the globe. Rising demand for sustainable and recycled construction materials for commercial construction projects will further drive the construction and demolition waste market.

Figure 3.2.4-4: Global Construction and Demolition Waste Market Trends. Source: (UNCRD, 2016d)

iv. Change in land-use pattern and impact on climate change

(Include Status of filling of lands in coastal periphery)

Since the beginning of the 21st century, urbanization, industrialization, and population density in the Asia and the Pacific gulf region have increased significantly. Throughout the world, most of the gulf region have become poles of growth that drive regional economic development (Xu et al., 2018). Under such a background, reclamation activities become an important means to expand land resources and develop the marine economy in the gulf region. With a rapid development of social economy and a rapid progress of urbanization, conflicts between humans and land in various countries have become increasingly prominent (Dietz and Engels, 2020). The implementation of a wetland reclamation project is one of the many ways to alleviate the contradiction between humans and land in coastal areas (Van Maren et al., 2016). Large-scale reclamation projects will change the living environment of the original terrestrial plants and the composition and structure of species and cause their species diversity to decline (Wang et al., 2010). It will also encroach on intertidal beaches and salt marsh wetland, destroying fish and benthic habitats. Changes in the structure of wetland resources and the environmental system and reduced biodiversity will ultimately affect the productivity and ecological service functions of the ecosystem, resulting in the degradation of ecological functions.

Changes in land cover continue to impact local to global scale weather and climate by altering the flow of energy, water, and greenhouse gases between the land and the atmosphere. Reforestation can foster localized cooling, while in urban areas, continued warming is expected to exacerbate urban heat island （UHI） effects. Urban regions include several characteristics that can influence climate, including construction materials that absorb more heat than vegetation and soils do, impervious cover that minimizes the cooling effect of evapotranspiration, the canyon-like architecture of buildings that tends to trap heat, and heat generation from vehicle and building emissions. These factors make urban areas warmer than their surroundings, a phenomenon referred to as the urban heat island effect. Further, climate change may act synergistically with future urbanization, resulting in increased likelihoods and magnitudes of flood events (Hamdi et al., 2011).

At the same time, climate change affects land use and ecosystems. Climate change is expected to impact land use and cover directly and indirectly by altering disturbance patterns, species distributions, and the suitability of land for specific uses. The composition of the natural and human landscapes, and how society uses the land, affects the ability of the Nation’s ecosystems to provide essential goods and services. Climate can drive changes in land cover and land use in several ways, including changes in the suitability of agriculture, increases in fire frequency and extent, the loss or migration of coastal wetlands, and the spatial relocation of natural vegetation (Hamdi et al., 2011).

3.2.4.2 Overall assessment of national policies, regulations, and standards in the region

i. National policies, regulations and standards including policy and institutional gaps

In the Asia and the Pacific nations, CDW regulations vary significantly. Some countries have fully implemented CDW regulations while some Pacific Island countries have no CDW regulations. **Table 3.2.4-7** summarizes the state of CDW regulations in the region from 3 aspects policies: Policy on land development plan, Policy on utilization of recycled products from CDW Wastes and green building material and Policy on use of subsidy on recycled material of CDW waste.

Table 3.2.4-7: Status of CDW Policy and Regulations. Source: (MOEJ, 2018; UNCRD, 2016d)

Policy status	Country and Policy
Full implementation of CDW regulations and laws	**PR China** **(1) Policy on land development plan** • Land Requisition for State Construction (MLRSC)1953 • The Regulations on Land Requisition for State Construction (RLRSC)1982 • Land Administration Law (LAL)1987 • Land Management Law 1999 • Property Law， 2007 **(2) Policy on utilization of recycled products from CDW Wastes and green building material** • Material efficiency and a circular economy 2005 • Development Strategy and Immediate Action Plan of Circular Economy 2013 **Japan** **(1) Policy on land development plan** • National Spatial Strategy (National Plan) • National Land Use Plans (National Plan) • National Spatial Planning Act • National Land Use Planning Act

<table>
<tr><th>Policy status</th><th>Country and Policy</th></tr>
<tr><td></td><td>

City Planning Act
Building Standards Act
Soil Contamination Countermeasures Act
Water Pollution Prevention Act
Erosion Prevention Act

(2) Policy on utilization of recycled products from CDW Wastes and green building material

Waste Management and Public Cleansing Law (1970)
Law for Promotion of Effective Utilization of Resources 1991
Act on promoting Green Procurement 2000
Construction Materials Recycling Act

<u>The Republic of Korea</u>
(1) Policy on land development plan

4th National Comprehensive Plan (2011-2020)
Provincial Comprehensive Plans
Regional Development Plan
National Transport Network Plan
Water Environment Management Master Plan National Land Planning and Utilization Act
Building Act
Industrial Sites and Development Act
Urban Traffic Readjustment Promotion Act

(2) Policy on utilization of recycled products from CDW Wastes and green building material

Waste Control Act 1986
Act on the Promotion of Saving and Recycling of Resources 1992
Promotion of Installation of Waste Disposal Facilities and Assistance to Adjacent Areas Act 1995
Construction Waste Recycling Promotion Act
Framework Act on Resource Circulation 2016

<u>Australia</u>
(1) Policy on land development plan

Metropolitan Strategies and Plans
land-use planning and environmental laws，1970s
Australian Capital Territory (Planning and Land Management) Act 1988
Planning and Development Act 2007

(2) Policy on utilization of recycled products from CDW Wastes and green building material

Product Stewardship Act 2011
Green Building Council of Australia’s Green Star building rating tools 2022
Australian Green Infrastructure Council rating tool 2008

(3) Policy on use of subsidy on recycled material of CDW waste

Environmental Protection Act 1970

</td></tr>
<tr><td>Limited implementation or draft stage development of CDW regulations</td><td>
<u>Solomon Islands</u>

National Waste Management and Pollution Control Strategy 2017-2026

<u>Vanuatu</u>

National Waste Management, Pollution Control Strategy and Implementation Plan 2016-2020

</td></tr>
<tr><td>No CDW regulations but managed by existing environmental regulations or</td><td>
<u>Fiji</u>

Environmental Management Act 2005
2007 Environmental Management

<u>Wallis and Futuna</u>

INTEGRE Project

<u>Tuvalu</u>
</td></tr>
</table>

Policy status	Country and Policy
strategies	• Waste Operations and Services Act • Environment Protection Litter and Waste Control Regulation • Tuvalu Integrated Waste Policy and Action Plan 2017-2026 **Samoa** • Development of National Solid Waste Management Strategy (J-PRISM II) • Development of Waste Management Regulations **Palau** • National Solid Waste Management Plan, • Integrated Solid Waste Management Plan **Marshall Islands** • National Solid Waste Strategy and Action Plan **Kiribati** • Special Fund (Waste Materials Recovery) Act 2004 • NZ funded Urban development program • EU funded regional pacific hazardous waste management project (PACWASTE) • secretariat of the pacific regional environment program(SPREP)

ii. 3R Management of Disaster Waste – Policy, Institutional and Data Issues

Frequent disasters in Asia and the Pacific region relating to geophysical activities are earthquakes, tsunamis, and volcanic eruptions, while those relating to climate are floods, tropical cyclones, and cloudbursts. Preparing for these disasters is considered one of the most important actions in climate change adaptation and disaster risk reduction. Disasters are increasing year by year. Social factors, such as urbanization, exert a large influence on disasters. From the viewpoint of DW, greater attention must be given to high functionalized building materials as well as to the increase of the amount of furniture in each household.

The basic principles of DW management are listed as the preservation of the living environment and the promotion of the 3Rs. It is necessary to examine circumstances from various angles and proceed to treatment. In general, the goal is to make use of existing facilities and equipment for appropriate management to the greatest limits. For this, waste management system during normal times is critical. Here we confirm the basic principles of DW management (DWM), excluding the preparation during normal times. To decide the process and flow of treatment, we need to examine the conditions of both hard and soft aspects and from various angles (**Figure 3.2.4-5**).

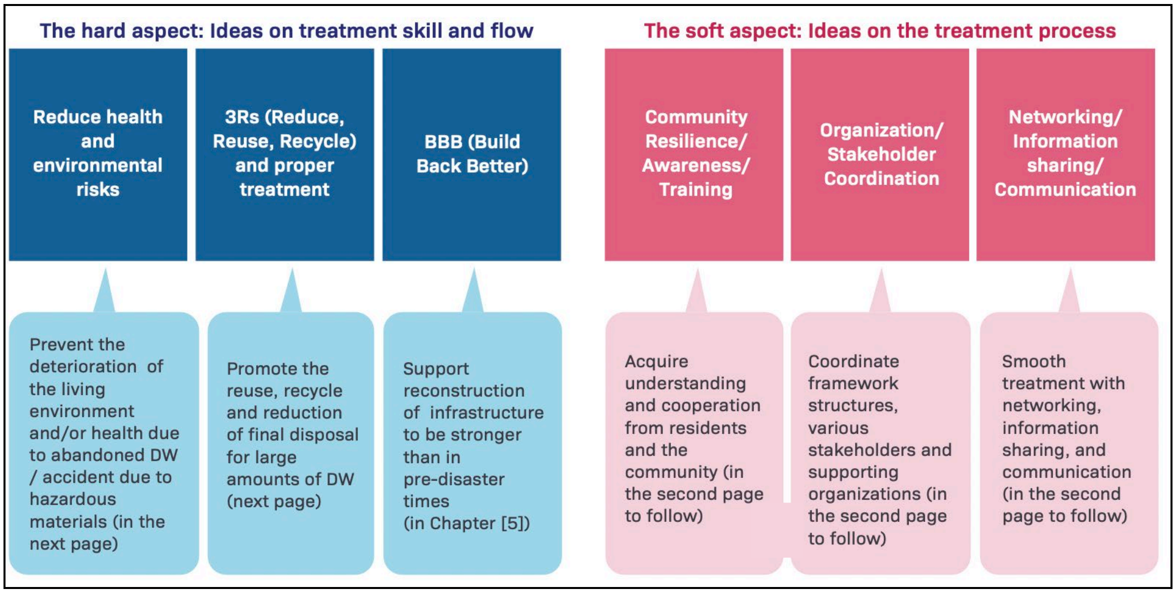


Figure 3.2.4-5: Hard and soft aspects of DWM process and flow of treatment. Source: (ABD, 2018)

DW management requires much know-how, systems, and techniques. As such, sharing experiences, developing human resources and organizations are important. It requires too the following ways of thinking: Completing preparations in normal times; Coordinating with actors in the private sector; Setting policies toward better recovery.

Evolution of DWM into Ordinary 3R Policies and Stakeholders

People are apt to pay less attention to DW before a disaster occurs. However, once disasters break out, inadequate DWM causes adverse effects on living environments and sanitary conditions instantly. Moreover, it could impede disaster recovery. This situation causes serious damage for society. Thus, we need to focus on not only acting as an effective and useful guideline at the time of disaster, but also during post-disaster recovery by preparing DW disposal in advance and making it a smooth process.

Incorporating DWM in ordinary waste management is important to improve community resilience, ordinary waste management skills, capacity, and technology, as well as to keep motivation for DWM preparedness. We expect to achieve this, as pre-disaster preparation enables progress in regular WM systems, reduces disaster risks, and encourages continuous progress during normal times. Persons in charge must deepen their understanding of DWM first and clarify the importance of preparation to policymakers and citizens, while at the same time drawing up contingency plans by starting with plans for disasters which directly affect the capacity of regular WM and, thus, developing it strategically.

Though the exact structure of government may differ in each country and municipality in Asia and the Pacific area, it is essential to determine which division will be responsible for DWM and how to cooperate with other divisions. Other stakeholders who may be involved in DWM, such as humanitarian agencies and NGOs, are also targeted.

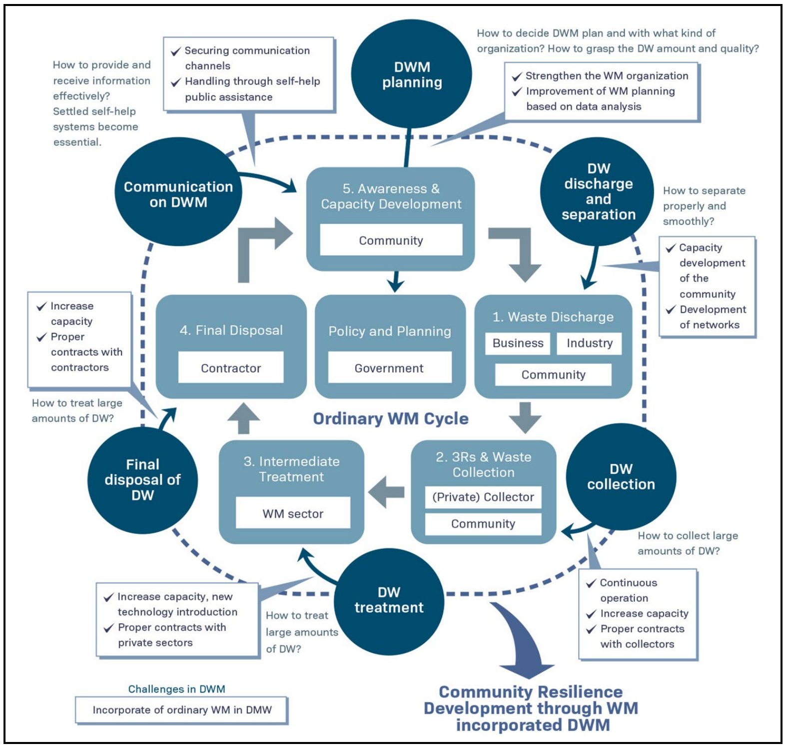


Figure 3.2.4-6: Incorporation of ordinary waste management in DWM. Source (MLIT, 2019a)

According to **Figure 3.2.4-6**, the processes of the ordinary WM cycle can be treated as the fundamental base of conducting the detailed preparations to meet the new challenges of the DWM cycle. Six problem-driving categories aspects can be found during each transaction between the 5 steps of ordinary WM cycle, which directly tackle the operational issues regarding a large amount of DW and network building. With the specific targets of difficulties, suggestions and improvements will be much easier to set up in a systematic way for DWM. Along with the properly organized process, community resilience development through WM incorporated DWM can be found realistically and practically to contribute to the modernization of DW management.

DWM Networking and Stakeholders

Many stakeholders are getting involved in DWM. As the examples shown in **Figure 3.2.4-7**, it is effective to build up face-to-face relationships considering characteristics and the actual situations of countries and regions.

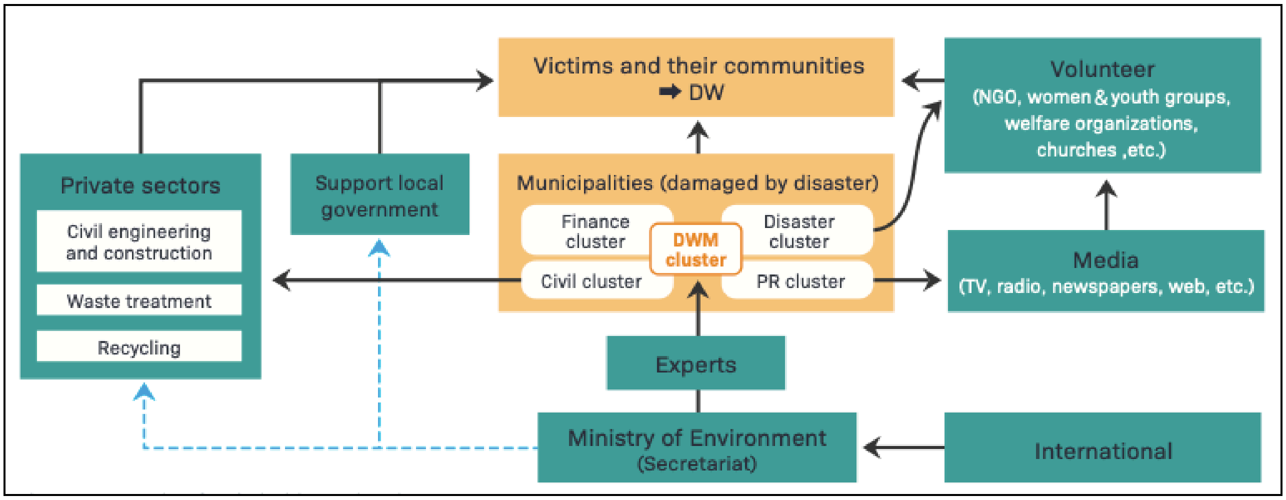


Figure 3.2.4-7: Example of stakeholders related to DWM. Source: (OECD, 2016)

Recording, data analysis, and accumulation of lessons learned

Recording, analyzing, and sharing facts and experiences from disaster are important for other countries. As for the content of records, an overview of the disaster and damage, damage situation of the waste treatment facility, quantity of DW generation (by composition), the flow of DW (qualitative and quantitative), temporary storage sites, sorting and processing methods, frameworks, budgets, and the related information are useful.

Networking and Information Sharing

Considering the countermeasures in large-scale disasters or small nations with few material possessions, as in the Pacific, networking of DWM over local or national government framework is important. In normal times, sharing information, plans, and experiences through face-to-face relationships enables building of support and the smooth acceptance of frameworks using such networks. It allows networking support groups to operate more efficiently and effectively.

Box 3.2.4-1: Example of regional networks for DWM (MLIT, 2019a)

In the Pacific, SPREP establishes the platform and educates persons responsible in waste management to be experts of DWM. They promote networking to respond to disaster over nations or local areas. Concretely, their activities include promoting:

- Disaster Waste Management Guide in the Pacific (DWMGP)
- Knowledge-sharing and Information Hub
- Capacity Development
- Database of experts on DWM
- Funding mechanisms to respond DWM in the Pacific
- Development of the pilot project

In Japan, experts of DWM (societies and industry groups) are networked as D.Waste-Net. In normal times, they share information and make the framework, e.g., after outbreak they go in the affected area and support the investigation, planning, and coordination. Actually, D.Waste-Net participated actively in recent disasters.

iii. Overall data issues on construction and demolition waste

There is a significant amount of waste generated during construction and demolition activities, but few data to understand the sources, age, spatial origin, and its fate following entry into the waste management system.

In some Asia and the Pacific countries, such as PR China, Korea, there is limited up-to-date and publicly accessible data on waste quantity and composition. Furthermore, there is no standard practice for reporting CDW data. In US, Environmental Protection Agency (EPA) estimated that 170 million tons of CDW was generated in the United States in 2003 (United States Environmental Protection Agency US EPA, 2009). This aggregate figure accounts for all waste generated by construction and demolition activities in the United States; few, if any, data exist at regional or municipal levels. Same situation could be seen in PR China. Generally, the data that are reported tend not to follow a standardized protocol, which leads to inconsistent public datasets (Marcellus et al., 2012b; NEWMOA, 2017). Little information is shared with the public on the size and composition of CDW volumes, which makes it difficult to understand trends in CDW reuse over time. In order to better understand landfill diversion rates and waste material flows deposited in end-of-life (EOL) facilities such as construction and demolition landfills, more precise reporting of waste material composition and quantity is needed. Because public data are scarce, approximation methods are necessary for determining CDW flow volumes.

Additionally, the acquisition of construction and demolition data and management practices through consultation with private industry is possibly the only way to derive reliable estimates of CDW recycling and reuse patterns. However, working with private industry to collect data presents challenges because their data tends to be proprietary, and they may not want to divulge precise material accounts.

3.2.4.3. Management and Circular Economic opportunities of construction and demolition waste (including disaster waste)

i. 3R economic opportunities in construction and demolition waste.

CDW is the largest waste stream worldwide (30 to 40 percent of total solid waste). While in the United States this proportion was close to 67 percent (534 million tons, (EPA US, 2015a), and in PR China it was 30 - 40 percent (2.36 billion tons, (Huang et al., 2018; Zheng et al., 2017).

Because of the negative impacts of CDW on the environment and the high rates of waste produced, the management of CDW has become a priority for sustainable development programs worldwide. Even though there is increasing interest in implementing recovery practices such as reuse and recycling, in most cases the waste management process is inefficient, resulting in large volumes of waste disposed off in landfills or even illegally dumped without environmental protection measures. This situation is evident: only 20 to 30 percent of CDW is recovered globally (World Economic Forum, 2016). In the United States it stands at around 70 percent (Zheng et al., 2017), while in PR China the recovery rate remains limited at less than 5 percent (Huang et al., 2018).

In the light of environmental challenges derived from the current linear economy model of "take-make-consume-dispose", the construction industry requires the implementation of new, enhanced building strategies focused on the problem of CDW. In this context, the transition to a Circular Economy (CE) is considered a solution as it would reduce environmental impacts while contributing to economic growth (Lieder and Rashid, 2016). The notion of CE is also based on ideas from scientific and semi-scientific concepts that include industrial symbioses, cleaner production, and the concept of zero emissions (Korhonen et al., 2018). Furthermore, the 3R principle (Reduction, Reuse and Recycle) is considered the basis of CE. Thus, CE constitutes a novel regenerative system to optimize the use of materials and their value throughout their lifecycle phases, and to minimize waste (Bocken et al., 2016)

The CE concept has gained academic, government and organizational recognition. At global level, Germany, Japan, PR China, and Europe are recognized for having developed legislation on the implementation of CE principles. According to the CE at CDW sector, there are several points to be discussed. In developed countries including Japan, buildings and infrastructure built during the period of high economic growth are aging, and it is important to manage them appropriately. Safe long-term use has merits in terms of both CE and resource reduction. However, it is required to judge the level of aging (safety) and apply appropriate life-prolonging technology. In all Asia and the Pacific countries, including developing countries, designing with long life and ease of maintenance will be important in future construction. It is also important to improve resource productivity. It is possible to improve the efficiency of human resources as well as construction materials, and it is expected that DW will be used. Regarding the reuse and recycling of CDW, it is urgent to share knowledge and technology internationally and expand it.

ii. 3R plans, practices, and stakeholders' engagement

Ha Noi 3R Declaration- Sustainable 3R Goals for Asia and the Pacific for 2013-2023-
Representatives from the Governments of 30 countries (Australia, Bangladesh, Bhutan, Brunei Darussalam, Cambodia, PR China, Fiji, India, Indonesia, Japan, Kiribati, Republic of Korea, Lao PDR, Malaysia, Maldives, Marshall Islands, Federated States of Micronesia, Mongolia, Myanmar, Palau, Papua New Guinea, the Philippines, Samoa, Singapore, Solomon Islands, Thailand, Timor-Leste, Tonga, Tuvalu, and Viet Nam) from Asia and the Pacific, international organizations, bilateral and multilateral agencies, research organizations, and professionals on waste management, who have met at the 4th Regional 3R Forum in Asia, held in Ha Noi, Viet Nam, from 18 to 20 March 2013, to demonstrate renewed commitment to realizing a promising decade (2013-2023) of sustainable actions and measures for achieving resource efficient society and a green economy in the Asia and the Pacific region through the implementation of the 3Rs.

Ha Noi 3R Declaration, reaffirming as noted in the Johannesburg Plan of Implementation, the need for consolidated efforts to prevent and minimize waste and to maximize reuse, recycling, and use of environmentally friendly alternative materials, with the participation of government authorities and all stakeholders, in order to minimize adverse effects on the environment and improve resource efficiency. Reaffirming and building upon the Tokyo 3R Statement announced by the participants at the Inaugural Meeting of the Regional 3R Forum in Asia, held in Tokyo, Japan, on 11 and 12 November 2009, which endorsed the establishment of the Forum and set the regional priorities in the area of the 3Rs, and subsequently on the outcome of the IInd Regional 3R

Forum held in Kuala Lumpur, Malaysia from 4 to 6 October 2010, which addressed the 3Rs for Green Economy and Sound Material-Cycle Society. Acknowledging the unique and effective roles the 3Rs can play by offering a complementary and integrated package of measures and tools to harness recyclable resources, energy, and economic benefits from waste. Recognizing that the 3R approach, which is fundamentally an approach that requires efficient use of resources from the point of extraction up to their final disposal, could make a significant contribution in reducing greenhouse gas (GHG) emissions from the entire life cycle of resources and products.

Furthermore, Ha Noi 3R Declaration outlines a reference list of indicators that the countries may use for monitoring specific progress made on 3Rs and resource efficiency. Among that, Hà Noi 3R Goal No. 22: Integrate the 3R concept in relevant policies and programmes, of key ministries and agencies such as Ministry of Environment, Ministry of Agriculture, Forestry and Fisheries, Ministry of Industry, Ministry of Trade and Commerce, Ministry of Energy, Ministry of Water Resources, Ministry of Transport, Ministry of Health, Ministry of Construction, Ministry of Finance, Ministry of Labour, Ministry of Land and Urban Development, Ministry of Education, and other relevant ministries towards transitioning to a resource efficient and zero waste society.
The Monitoring Indicators:
(a) Existence of a national 3R task force.
(b) Number of sectoral policies and programmes that have integrated 3R concepts.
(c) Number of cities introducing state-of-the-art 3R technologies in various sectors
A summary of indicators is given in **Table 3.2.4-8.**

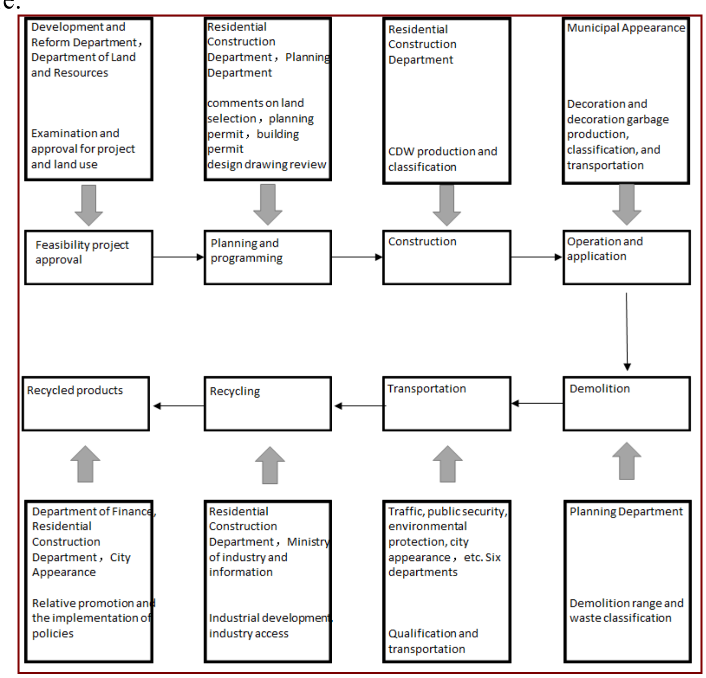
Table 3.2.4-8: Asia and the Pacific countries 3R progress reports in Ha Noi 3R Declaration (2013~2023). Source: (Shooshtarian et al., 2020)

Country	Existence of a national 3R task force	Number of sectoral policiesand programmes that have integrated 3R concepts		Number of cities introducing state-of-the-art 3R technologies in various sectors
		Policies	Programmes	
The Republic of Korea	Yes	5	-	1
Japan	Yes	4	9	3
Bangladesh	Yes	>2	>20	>19
PR China	Yes	1	1	-
Solomon Islands	Yes	6	4	-
Kiribati	Yes	-	1	-
Marshall Islands	Yes	-	1	-
Palau	Yes	-	1	-
Samoa	Yes	-	-	-
Tuvalu	Yes	2	3	-
Vanuatu	Yes	1	-	-

Note: "-" means no data source.

According to the above data in **Table 3.2.4-8**, it can be seen that most countries in the Asia and the Pacific region have 3R task forces at the national level, but from the perspective of specific policies and plans, many Pacific Island countries still do not have specific national policies or holistic policies. Furthermore, there is no relevant data on the number of cities citing related 3R technologies, or the data is not made public.

Table 3.2.4-9: Case studies of CDW Management in PR China and Japan

Country	3R plans, practices, and stakeholders' engagement
PR China	<u>**3Rplans and Practices:**</u> **CDW recycling:** The State adopts policies and measures in terms of fiscal assistance, taxation, prices, and government procurement to encourage and support the environmental industries such as environmental protection equipment, comprehensive utilization of resources techniques, environmental services etc. **CDW reduction:** People's Governments at all levels should give priority to purchase energy-saving, water conservation, waste reuse, environmental protection, and resource conservation products. **CDW-Circular Economy Promotion:** The government shall implement procurement policies in favor of circular economic development. Procurement using Government funds should give priority to purchase energy, water and materials and environmentally friendly products and recycled products. <u>**Stakeholders' engagement:**</u> The CDW recycling management of local governments involves different government administration departments (including development and reform commission, land resources, housing and construction, planning, municipal administration and landscape, transport, environmental protection, industry and information technology and finance) with their respective administration privileges and responsibilities, in which the management procedures on CDW of the whole construction process are shown in the figure:  **PR China Local administration of CDW Recycling**

Japan	<u>**3Rplans and Practices:**</u> **Construction Materials Recycling Law:** Under the Construction Materials Recycling Law, construction contractors of a certain scale or morewere required to sort and recycle specific CDW.  **(1) Applicable construction works:** • demolition work of building : total floor space ≧ 80 ㎡ • construction work or enlargement work : total floor space ≧ 500 ㎡ • civil engineering work: contract fee ≧ 5 million yen • repair work or remodeling: contract fee ≧ 100 million yen **(2) Specific construction materials** • concrete, construction material from concrete and iron, wood asphalt concrete **(3) Obligation to implementconstruction contractor:** • Sorting CDW: Sorting specific CDW by type at the construction anddemolition site. • Recycling CDW: Recycling sorted specific CDW

iii. Facilities and technologies for the resource efficiency

Growth is one of the major driving forces of the world's development. But to improve the well-being of citizens in an environmentally friendly manner, we need a greener and more inclusive model of growth. Prosperity and well-being need not be achieved by increasing the "weight of nations" in terms of the resources they consume. The problem is not growth per se, but the composition of that growth. By improving resource efficiency, we can decrease the amount of virgin materials that are extracted and used, as well as the associated environmental impacts. (Policy Guidance on Resource Efficiency, OECD 2016)

Against this background, G7 Leaders launched an Alliance on Resource Efficiency at their Summit in Schloss Elmau on 7-8 June 2015. This initiative builds on the commitments laid out within the 2008 Kobe 3R Action Plan and broadens them in several ways, including through a stronger involvement of the private sector. In their declaration at Schloss Elmau, G7 Leaders also called upon the UNEP International Resource Panel (IRP) and the OECD to develop a synthesis report and policy guidance on resource efficiency, respectively. (Policy Guidance on Resource Efficiency, OECD 2016)

Going for green growth and establishing a resource efficient economy is a major environmental, development and economic challenge today. In this context, improving resource productivity and putting in place policies that implement the principles of reduce, reuse, recycle (the 3Rs) is crucial. Although resource efficiency is first and foremost matter of national policy decisions, only collective action and coordinated efforts will ensure widespread benefits amongst countries.

The key trends and outlooks related to resource efficiency in the Japan, United Kingdom, and United States have been summarized in **Table 3.2.4-10**., The Asia and the Pacific region shows the same trends with an advanced CDW resource recycling facilities and technologies in Japan (Box1).

Table 3.2.4-10: The key trends and outlooks on resource efficiency in Japan, United Kingdom, and United States.

Country	The key trends and outlooks on resource efficiency
Japan	**National policy framework** • 2001 Fundamental law for a sound material-cycle society: this is supported by laws on waste management and efficient use of resources, as well as regulations applying to specific waste streams and resources. • 2000 Green purchasing act. **Resources covered** • Materials used in the economy. **Range of activities covered** • Comprehensive range of activities throughout the product lifecycle. Priority also given to international co-operation, particularly in the Asian region. **Targets (to be achieved by 2015 using 2000 as the base year)** • Resource productivity: 60 percent improvement; equivalent to JPY 420 000 per ton. • Cyclical rate (the proportion of the total material input to the economy that remains in productive use): 40-50 percent increase; equivalent to about 14-15 percent of the total material input. • Final disposal volume: 60 percent reduction; equivalent to 23 million tons. **Priorities** • As specified by the Cabinet in the 3rd Fundamental law for a sound material-cycle society: promoting 2Rs (reduce and reuse); recovery and recycling of useful metals; recycled waste and biomass to energy; integration of initiatives for low carbon society, harmony with nature and upgrading local recycling networks; co-operation and technology transfer, particularly in the Asian region; treatment and reuse of waste from the Great East Japan earthquake; safe treatment of radioactive-contaminated waste from the earthquake. **Main programmes** • As defined by the main bodies of legislation: containers and packaging; home appliances; construction materials; food waste; end-of-life vehicles; small home appliances; and green purchasing.

In Japan, the Promotion Council for Recycling Construction Materials and Wastes has pushed forward various activities, such as preparation of this "Case Studies", etc. With these activities, the academic, business, and government will deliver jointly the information on advanced CDW recycling initiatives and technologies in Japan from Tokyo to all sections of Japan and further to the world. **Table 3.2.4-10** showed several advanced CDW resource recycling facilities and technologies in Japan.

Box 3.2.4-2: Case studies of Advanced CDW Recycling facilities and technologies in JAPAN

ACRAC Quality audit system

- **ACRAC Quality audit system** belongs to Affairs Council of Recycled-Aggregate Concrete (ACRAC), which is a Quality audit system on recycled aggregate for concrete. As the quality audit system on recycled aggregate for concrete using concrete waste as the raw material, it is the first of its kind in Japan. This audit system for ACRAC members is a system to objectively audit the quality of recycled aggregate for concrete from 2013.

Tokyo brand 'Cool eco-Stone'

- New quality management codes for low quality recycled aggregate named "**Tokyo brand 'Cool eco-Stone'**", extending applicability for several soil and ground materials. This code is a quality standard of recycled aggregate established by the cooperative committee among industries, local governments and academia for branding recycled aggregates which have much attached mortar. This quality standard aims to be widely used not only for roadbed materials but also general geo materials (ground materials). The characteristic of this code is to design the grades of concrete wastes for applying embarkment, pervious foundations, and drainage systems as well as conventional road baseandsub base. As a result, the quality of concrete wastes become improved and connect into manufacturing high quality recycled materials applied to several soil structure.

Effective utilization technology of fly ash and coal ash

- **Effective utilization technology of fly ash and coal ash,** as a technology that can effectively utilize coal ash powder discharged from a coal-fired power plant in large quantities, an "ash- Crete" having a formulation that minimizes unit water content without using aggregate were developed. This technology has made effective use of over 1 million tons of coal ash, due to the development of "ash-Crete" technology using coal ash powder.

Non-fired eco bricks

- **Non-fired eco bricks** are utilized, Sewer sludge, burned ash, coal ash, ceramics abolished soil, molten slag, glass waste and many other unused resources and are regenerated to form a revolutionary brick style block, without baking, using special solidification technology (Patent process). Non-fired eco bricks has a texture of pottery and abundant color, yet it is non-baked, realizing low price and good workability. In addition, it meets strict criteria for safety such as strength slip resistance, elution of harmful substances and can be used with confidence. A newly developed Eco brick, friendly to the earth, which does not burn fossil fuels that cause global warming at least 80 percent of the recycled material ratio, non-fired eco bricks is a product born of the demands of the era.

Construction project of temporary exhibition hall on the eastern side of Tokyo Big Site

- **Construction project of temporary exhibition hall on the eastern side of Tokyo Big Site** is an Olympic-Paralympic-related facility. It was ordered with the design build method of design and construction bulk order including technical proposal considering to be removed and used for about 10 years after construction. The facility built eco-friendly buildings that can be recycled, minimizing environmental impacts in new construction work and future demolition work. At this site, a pile head ring socket was adopted which eliminated the underground beam for all foundations. The upper structure adopts a pure steel structure, double folded roof, and outer wall ALC, both of which can be recycled. Efforts to 3R, especially waste prevention of large-scale buildings from the planning stage are the first in Japan.

iv. Business models for recycled products made of CDW Wastes

Since the increasing rate of urbanization is a critical concern for socio-environmental reasons, this also leads to more extraction of natural raw materials and the generation of significant quantities of construction and demolition (CDW) waste. Although the use of recycled CDW waste products is technically feasible and regulated, and positive application examples are evident, it is still unclear how to engage key stakeholders to leverage this opportunity in construction projects. Shooshtarian et al. (2020) present an emergent enablers and barriers for recycled CDW waste products model and provide commentary on how stakeholders' perceptions, decision and behavior influence the use of recycled CDW waste products.

Figure 3.2.4-8 indicates the seven key barriers that influences the key stakeholder's ability to utilize CDW waste and the application of recycled products in the construction industry. These barriers include increase in energy and transport costs; lack knowledge on recycled products;

limited of technologies for waste recovery; low quality and reduced performance; lack of market availability of the products; limitations caused by specifications, standards and permits; and limited acceptability and negative perceptions.

The right-hand side of the model presents five enablers that would help stakeholders to improve applications of recycled products. These enablers cover increase community awareness and education on recycled products; develop supportive regulations, policies, and specifications; facilitate sustainability programs; promote product certification and advocate targeted technologies and innovative practice. The model conceptually indicates how successfully addressing the barriers and amplifying the enablers can enhance the application of recycled products in the construction industry.

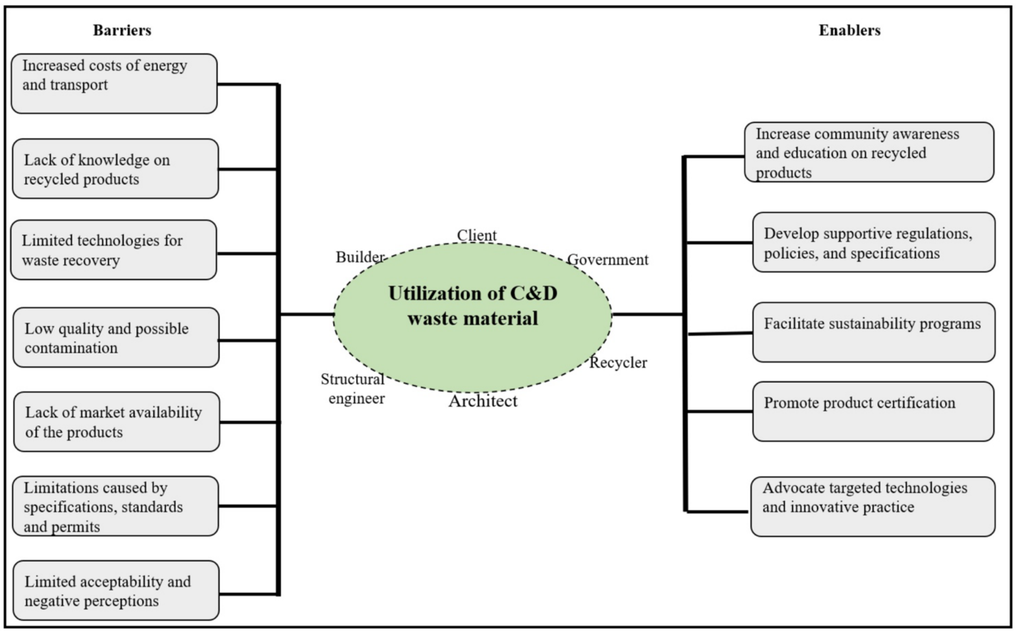


Figure 3.2.4-8: Emergent model on barriers and enablers for using recycled CDW waste products. Source: (Shooshtarian et al., 2020)

v. Alternative material to reduce pressure on raw material

Aggregates Replacement

There are various benefits to the properties of concrete when adding waste as an aggregate. Glass is one material which can increase the properties of concretes. Glass can be crushed into three different forms: Coarse Glass Aggregate (CGA), Fine Glass Aggregate (FGA), and Glass Powder (GP). When glass is mixed with cement, it creates a pozzolanic reaction, which reduces GHGs produced in concrete. Additionally, glass has a high thermal conductivity compared to general aggregate; therefore, it can be used on buildings that require thermal stability. Combining both coarse and fine glass together allows for improved water absorption, therefore reducing shrinkage.

PET is a plastic which can be used in concrete, with many believing it benefits the environment. Adding this plastic to concrete can increase its ductility and reduce shrinkage cracks which occur due to moisture changes in the concrete. Another added benefit is that the concrete is lightweight while still maintaining a high quality. Light weight concrete is often used to reduce the dead weight of a structure, whilst lowering the workability, density, modulus of elasticity, tensile strength, and slump. Overall, this aggregate is good for lightweight and corrosion resistant concrete.

Supplementary Cementitious Materials (SCMs)
It was found that adding fly ash to the mix helped to prevent shrinkage that was due to the addition of the concrete waste. Another study found that the use of clay brick powder as cement compensated for the decrease in compressive strength due to the waste aggregate. The research indicates concrete waste is a viable recycle material to be used as an aggregate; however, caution should be taken when using it as different projects require different concrete properties, and the specific amount of waste can greatly affect the concrete performance.

3.2.4.4. Conclusion and Way Forward

Most Asia and the Pacific countries have limited up to date and publicly accessible data on CDW and DW quantity and composition, which makes it difficult to understand trends in CDW and DW management over time. Therefore, the first important step needs to obtain quantitative and qualitative data.

Due to the development of urbanization and climate change, the CDW and DW have the big influence in the environment, which need the proper planning and management. In particular, the coexistence of developed and developing counties in this region, effective knowledge sharing is particularly important.

Governments and authorities in urban areas have attempted to meet the demand for housing and services through increased construction. However, lack of awareness of resource-efficient construction practices has resulted in excessive use of natural resources and generation of large amounts of construction waste that is rarely recycled. In developing countries, construction buildings should therefore take into account the requirements of circular economy, 3Rs, and SDGs, as well as medium and long-term decarbonization. On the other hand, developed countries may find that a challenge to circulate the large amounts of CDW in the future.

The circular economy (CE) in CDW sector, there are several points to be discussed. In developed countries including Japan, buildings and infrastructure built during the period of high economic growth are aging, and it is important to manage them appropriately. Safe long-term use has merits in terms of both CE and resource reduction. However, it is required to judge the level of aging (safety) and apply appropriate life-prolonging technology. In all Asia and the Pacific countries, including developing countries, designing with long life and ease of maintenance will be important in future construction. It is also important to improve resource productivity. It is possible to improve the efficiency of human resources as well as construction materials, and it is expected that DW will be used. Regarding the reuse and recycling of CDW, it is urgent to share knowledge and technology internationally and expand it.

Decarbonization of housing is attracting attention as transition toward decarbonization society. As new materials and construction methods are developed, it is necessary to pay close attention to trends in CDW and DW, and at the same time, from the perspective of CE, it is necessary to emphasize the importance of design with post-use management in mind.

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3.2.5 Agriculture Biomass Waste and Livestock Waste

3.2.5.1 Regional overview of biomass waste and livestock waste

3R (reduce, reuse and recycle) is at the core of Ha Noi 3R declaration for achieving resource efficiency at national level and becoming green economy in Asia and the Pacific in the period of 10 years (2013 – 2023).Since, agricultural biomass has the potential of simultaneously tackling several economic, social and environmental issues currently facing the Asia and the Pacific countries, Ha Noi3R declaration had set a dedicated goal (Goal 11) for maximum utilization of agricultural biomass and livestock waste in the region. Through achieving goal 11, energy security, reduction in greenhouse gases (GHG), reduction in poverty, sustainable livelihoods in rural areas, reutilization of organic resources could be ensured. Thus, indicators such as annual generation and utilization of agricultural biomass, annual reduction in greenhouse gas (GHG) emissions, electricity production from agricultural biomass, and bio-energy capacity installed annually can reveal the progress made in improving socioeconomic and environmental situation of the region. These indicators can also manifest the progress made in achieving sustainable development goals (SDGs). For example, target 2 of SDG 7 (Affordable and Clean Energy) requires significant increment of renewable energy in the share of energy mix worldwide by 2030. Moreover, the target 4 of SDG 12 (Responsible Consumption and Production) encourages environmentally sound management of waste throughout their life-span, which would also cover agriculture biomass waste and target 5 sets the goal of waste reduction through resource circulation. Indirectly, SDG 11 (Sustainable Cities and Communities) has target 11.6 which aims towards reducing per capita negative environment impacts through air quality and waste management which could include agriculture biomass waste.

i. Definition of agricultural biomass waste and livestock waste

Agricultural biomass waste conceptually represents organic material deemed as waste or by-product that may originate from potentially any source such as agriculture, fishery, industry (food manufacturing and processing industries), municipalities (food waste from municipal solid waste (MSW)) and others. However, it does not include biomass from fossil resources. For instance, United Nations Framework Convention on Climate Change (UNFCCC) describes biomass as 'non-fossilised and biodegradable material originating from animals, plants and microorganisms.' While there are other definitions of biomass and agricultural biomass waste as reported in UNCRD's previous report, Table 3.2.5.-1 lists down the definitions of agricultural biomass waste used in national regulations in some countries of Asia and the Pacific. In this document, biomass arising from potentially all sources is described as 'Agricultural biomass waste', unless mentioned otherwise.

Table 3.2.5-1: Definition of Agricultural Biomass Waste in Asia and the Pacific Countries

Countries	Definition	Source
PR China	'Organic material discarded during agricultural production process. Agriculture process includes plantation, forestry, animal husbandry,	

Countries	Definition	Source
	fishery, and other industries.'	
Japan	'Organic substances derived from animals and plants that can be used as a source of energy (excluding crude oil, petroleum gas, combustible natural gas, coal, and products manufactured there from.'	Article 3, Act No. 81 (2013)
Malaysia	'Compromises of non-fossilised and biodegradable organic material, including products and by-products and residues from agriculture, industrial or municipal wastes originating from Malaysia.'	
The Philippines	'Non-fossilized, biodegradable organic material originating from naturally occurring or cultured plants, animals and micro-organisms, including agricultural products, by-products and residues such as, but not limited to, biofuels except corn, soya beans and rice but including sugarcane and coconut, rice hulls, rice straws, coconut husks and shells, corn cobs, corn stovers, bagasse, biodegradable organic fractions of industrial and municipal wastes that can be used in bioconversion process and other processes, as well as gases and liquids recovered from the decomposition and extraction of non-fossilized and biodegradable organic materials.'	

ii. Sources of agricultural biomass waste and livestock waste

As described above, agricultural biomass waste can originate from several sources, **Table 3.2.5-2** enlists major crops and the respective residues, as well as livestock and livestock waste found in Asia and the Pacific countries. In addition to these crops, plantation of vegetables and fruits is also common in Asia and the Pacific countries and Agricultural Biomass Waste is generated from these sources as well. The indicator of annual generation of agricultural biomass waste in several Asia and the Pacific countries is tabulated in **Table 3.2.5-3** below.

Table 3.2.5-2: Major Crops and Livestock in Asia and the Pacific Countries

Biomass			
Crop	**Scientific Name**	**Waste**	**Origin**
Rice	*Oryza sativa*	Straws, Husks, Bran	Bangladesh, Cambodia, India, Indonesia, Japan, Lao PDR, Malaysia, Myanmar, Pakistan, Sri Lanka, Thailand, PR China, The Philippines, The Republic of Korea, Viet Nam
Sugarcane	*Saccharum officinarum*	Bagasse, Leaves andTops, Molasses, Press mud	Bangladesh, Cambodia, India, Indonesia, Japan, Lao PDR, Malaysia, Myanmar, Pakistan, Sri Lanka, Thailand, The Philippines, Viet Nam
Corn and Maize	*Zea mays*	Stalks, Husks, Cobs	Bangladesh, Cambodia, India, Indonesia, Japan, Lao PDR, Malaysia, Myanmar, Pakistan, Sri Lanka, Thailand, PR China, The Philippines, The Republic of Korea, Viet Nam
Cassava	*Manihot esculenta*	Leaves, Stems, Stalks, Pulp, Peels, Starch bagasse	Cambodia, India, Indonesia, Lao PDR, Malaysia, Myanmar, Sri Lanka, Thailand, PR China, The Philippines, Viet Nam
Oil Palm Fruit	*Arecaceae*	Empty fruit bunches, Oil palm trunks, Oil palm shells, Palm pressed fibres	Cambodia, Indonesia, Malaysia, Thailand, PR China, The Philippines
Rubber	*Hevea brasiliensis*	Leaves, Bark, Seed, Wood	Bangladesh, Cambodia, India, Indonesia, Malaysia, Myanmar, Sri Lanka, Thailand, PR China, The Philippines, Viet Nam
Soybean	*Glycine max*	Stems, Leaves, Branches, Shells	Bangladesh, Cambodia, India, Indonesia, Japan, Lao PDR, Myanmar, Pakistan, Sri Lanka, Thailand, PR China, The Philippines, The Republic of Korea, Viet Nam
Peanut and Groundnut	*Arachis hypogaea*	Straw, Husk	Bangladesh, Cambodia, India, Indonesia, Japan, Lao PDR, Malaysia, Myanmar, Pakistan, Sri Lanka, Thailand, PR China, The Philippines, The Republic of Korea, Viet Nam
Wheat	*Triticum*	Straw	Bangladesh, India, Japan, Myanmar, Pakistan, Thailand, PR China, The Republic of Korea
Cotton	*Gossypium*	Stalk, Side branches, Leaves, Bolls,Seeds	Bangladesh, Cambodia, India, Indonesia, Lao PDR, Myanmar, Pakistan, Thailand, PR China, The Philippines, Viet Nam
Coconut	*Cocos nucifera*	Shell, Husk, Fibre	Bangladesh, Cambodia, PR China, India, Indonesia, Malaysia, Myanmar, Pakistan, Sri Lanka, Thailand, The Philippines, Viet Nam
Pineapple	*Ananas comosus*	Residual skin, Peel, Pulps, Stem and leaves	Bangladesh, Cambodia, India, Indonesia, Japan, Lao PDR, Malaysia, Sri Lanka, Thailand, PR China, The Philippines, The Republic of Korea, Viet Nam
Jute	*Corchorus capsularis*	Stalk	Bangladesh, Cambodia, India, Myanmar, Pakistan, Thailand, PR China, Viet Nam
Tea	*Camellia sinensis*		Bangladesh, India, Indonesia, Japan, Lao PDR, Malaysia, Myanmar, Sri Lanka, Thailand, PR China, The Republic of Korea, Viet Nam
Barley	*Hordeum vulgare*	Barley straw, Malt waste, Spent grain	Bangladesh, India, Japan, Pakistan, PR China, The Republic of Korea, Thailand
Coffee	*Coffea*	Coffee stems, leaves, branches, Husks, Coffee	Cambodia, India, Indonesia, Lao PDR, Malaysia, Myanmar, Sri Lanka, Thailand, PR China, The Philippines, Viet Nam

Biomass			
Crop	**Scientific Name**	**Waste**	**Origin**
		ground	
Livestock			
Livestock	**Scientific Name**	**Waste Generated**	**Origin**
Cattles	*Bos taurus*	Manure	Bangladesh, Cambodia, India, Indonesia, Japan, Lao PDR, Malaysia, Myanmar, Pakistan, Sri Lanka, Thailand, PR China, The Philippines, The Republic of Korea, Viet Nam
Buffalo	*Bubalus bubalis*	Manure	Bangladesh, Cambodia, India, Indonesia, Lao PDR, Malaysia, Myanmar, Pakistan, Sri Lanka, Thailand, PR China, The Philippines, Viet Nam
Pig	*Sus*	Manure	Cambodia, Hong Kong SAR, India, Indonesia, Japan, Lao PDR, Malaysia, Myanmar, Sri Lanka, Thailand, PR China, The Philippines, The Republic of Korea, Viet Nam
Goat	*Capra aegagrus hircus*	Manure	Bangladesh, India, Indonesia, Japan, Lao PDR, Malaysia, Myanmar, Pakistan, Sri Lanka, Thailand, PR China, The Philippines, The Republic of Korea, Viet Nam
Poultry	*Gallus gallusdomesticus*	Manure	Bangladesh, Cambodia, India, Indonesia, Japan, Lao PDR, Malaysia, Myanmar, Pakistan, Sri Lanka, PR China, Thailand, The Philippines, The Republic of Korea, Viet Nam
Sheep	*Ovis*	Manure	Bangladesh, India, Indonesia, Japan, Malaysia, Myanmar, Pakistan, Sri Lanka, Thailand, PR China, The Philippines, The Republic of Korea
Duck	*Anas*	Manure	Bangladesh, Cambodia, India, Indonesia, Lao PDR, Malaysia, Myanmar, Pakistan, Sri Lanka, Thailand, PR China, The Philippines, The Republic of Korea, Viet Nam
Turkey	*Meleagris gallopavo*	Manure	Japan, Myanmar, The Philippines

(Source: FAO, n.d.; Son *et al*., 2021)

Table 3.2.5-3: Annual Generation of Biomass in Asia and the Pacific Countries

Countries	Quantity of Biomass Type (Million Tonnes)					Comments	References
	Agriculture	**Livestock**	**MSW**	**Forest**	**Total**		
Bangladesh	94.10	88.89	13.38	17.44	213.81		HilBaky*et al.*, 2017
India	500	1,095	21.67	59.68	1,676.35		Agamuthu *et al.*, 2020; Bisht and Thakur, 2018
Japan	4.38	4.86	11.55	4.2	34	MSW biomass includes paper waste, food waste and sewage sludge (which are separately reported as biomass in Japan) and total biomass also includesblack liquor (4.03 million tonnes), waste materials from sawmill factories (3.2 million tonnes) and wood chips derived from construction (2.2 million tonnes)	MAFF, 2021
Myanmar	19	N.A.	5.62	N.A.	24.62		Agamuthu *et al.*, 2020
Pakistan	113.896	417.3	12.36	N.A.	543.556	Agriculture waste is based on 5 major crops (cotton, wheat, rice, sugarcane, maize)	World Bank, 2016; Khan *et al.*, 2021
Singapore	0.313	N.A.	0.665	N.A	0.978		NEA, 2021
Sri Lanka	6.86	N.A.	1.58	N.A.	8.44		Agamuthu *et al.*, 2020
Thailand	174.1	N.A.	N.A.	N.A.	174.1		Jusakulvijit*et al.*, 2021
PR China	900	3,900	127,183	406.76	132,389.7		Guo *et al.*, 2017;CICC, n.d
The Republic of Korea	1.584	2.05	1.625	N.A.	5.259		Statistics Korea, 2015
Viet Nam	94.71	86.92	13.23	N.A.	194.86		Son *et al.*, 2021

3.2.5.2 National policies and legislations for utilization of agricultural biomass waste and livestock waste

i. Energy related policies and legislations- Renewable energy and bioenergy

Majority of national legislations, policies, plans and strategies of related to agricultural biomass waste are related to energy in Asia and the Pacific countries. Since most of the countries either face electricity shortages or have pledged to reduce greenhouse gas (GHG) emissions, energy recovery from Agricultural Biomass Waste appears more alluring. Energy related laws and policies are given in Table 3.2.5.-4 below.

The Act No. 81of Japan not only promotes rejuvenation of rural areas through sustainable growth of agriculture, forestry and fisheries but also encourages integration of electricity generation from the abovementioned sources of renewable sources, as well as alleviating global warming from these measures as per national plans. On the other hand, in addition to promoting the application of renewable energy sources for the generation of electricity in Japan, Act No. 108 also modulates prices and period for achieving its targets. Thus, these legislations not only provide sustainable sources of electricity and sustainable income for rural inhabitants, but also reduces GHG emissions. Interestingly, under Renewable Portfolio Standard (RPS) Policy, the government of the Republic of Korea is currently favoring biomass-based energy over other renewable sources such as solar and wind to a point that it has sparked controversy in the country. The Republic of Korea imports around 98 percent of wood pellets for energy generation by cogeneration of forest wood with coal under RPS Policy. The countries exporting this wood biomass include Viet Nam, Malaysia, Indonesia, and Thailand (Gaworecki, 2020). In contrast to developed countries mentioned above, several laws in Bangladesh namely Electricity Act (2018), Rural Electrification Board Act (2013) are focused on the production, transmission and use of electricity without any mention to the sources of electricity. Thus, they exclude the utilization of biomass and other renewable energy sources for electricity generation (Karim et al., 2019). On the other hand, the regulation on biofuel in Indonesia has formed Special Biofuel Zones (SBZ) which are allotted for biofuel crop plantation and transformation outside Java (10,000 hectares). This regulation also created special initiatives for villages in SBZ such as to receive regional funding for setting up the renewable energy development plans according to local renewable potential. These villages are known as Energy Self-Sufficient Villages (ESSV). Through this policy, energy sufficiency, job creation, poverty reduction and productivity can be achieved.

The common theme between policies, plans and regulations of Asia and the Pacific countries are summarized below:

1. Clearly stating the share of renewable energy sources in national electricity generation by a certain year. The renewable energy sources include solar, wind, biomass, geothermal and hydropower.
2. Special focus on use of renewable energy sources for electricity and power in rural areas to make rural areas self-sustaining and also improve the socio-economic situation of villages.
3. Incorporating and implementation of feed-in-tariff scheme. Similarly, other initiatives such as government subsidies and loans (although at lower percentage) are also offered through national legislations.

4. Blending of biofuel and biodiesel by a certain year. Most of the countries with specific regulations, plans and strategies on biofuel and biodiesel blending clearly state the use of agricultural waste as the feedstock.
5. Inclusion and implementation of bio-gasification for power and energy.

The challenges or issues arisen in implemented energy relation regulations and other initiatives in Asia and the Pacific countries are listed below:

1. Some countries such as Indonesia legally allow plantation of energy crops for biofuel and biodiesel production, whereas The Republic of Korea allows plantation of energy crops for bioenergy.
2. The use of term 'renewable energy sources' in national legislations and initiatives creates unnecessary biased as seen in The Republic of Korea. Similarly, in most developing countries, solar energy seems to be leading source of renewable energy source.
3. In developing countries of Asia and the Pacific, the implementation of national legislations and other initiatives on use of agriculture biomass waste as renewable energy source is still less.

ii. Agricultural biomass waste and livestock waste related policies and legislations

In comparison to energy related policies and legislations, waste related regulatory framework is less common, especially in developing countries of Asia and the Pacific. Table 3.2.5.-4 complies the waste related regulatory framework agricultural biomass waste. In Japan's Basic Plan for the Promotion of Biomass Utilization was formulated under the Act No. 52, which aims to rejuvenate the rural areas, and reduce GHG emissions like Act No. 81, and also focuses on resource circulation of Biomass. On the other hand, article 65 of Agricultural Law of PR China, despite encouraging the use of agricultural waste, does not highlight the utilization for energy production or recycling or both.

Table 3.2.5-4: Regulations, Policies and Plans for Energy Generation from Agricultural Biomass and Livestock Waste

Countries	Law and Policy and Plan	Description
Bangladesh	The Sustainable and Renewable Energy Development Authority Act (2012)	Unlike other energy related laws in Bangladesh, this act includes renewable sources for energy generation. An authority, Sustainable and Renewable Energy Development Authority (SREDA) formulated under this act aims to increase 1.5 percent renewable energy share to 50 percent for the supply in grid.
	Renewable Energy Policy (2008)	A total of 11 objectives were set and among those, a few are as followed: Utilize renewable energy sources (including biomass) for generation of renewable energy for the entire country and encourage private and public sector's investment in renewable projects and phase out non-renewable energy sources. A target of 5 percent and 10 percent electricity generation from utilization of renewable sources was set for 2015 and 2020, respectively.
Cambodia	Cambodia Basic Energy Plan (2019)	By 2030, 10 percent of total energy mix should be from renewable energy sources such as biomass and solar and photovoltaic.
	National Strategic Plan on Green Growth 2013 – 2030 (2013)	This plan promotes activities such as promotion of renewable energy utilisation in rural areas, implementation of 3R and resource extraction from waste and making renewable energy competitive.
PR China	Medium- and Long-Term Development Plan of Renewable Energies (2007)	National Development and Reform Commission formulated this plan to increase renewable energy utilization to 10 percent in 2010 and 15 percent in 2020. According to the goals set, 30,000 MW of biomass energy, 24,000 MW of energy from agriculture and forestry wastes and energy crops plantation, 3,000 MW of biogas plants (10,000 large scale plants on livestock farms and 6,000 biogas plants for industrial organic effluent), 50 million tonnes of biomass pellet fuels for rural areas, and 10 million tonnes of bio-ethanol and 2 million tonnes of biodiesel were tobe met by 2020.
	Animal Husbandry Law of PR China (2005)	Article 39 requires livestock related facilities to have 'methane conversion pits' for the treatment of all kinds of waste related to livestock such as faeces, waste water, and other solids waste.
India	Integrated Energy Policy (2006); Draft National Energy Policy (2019); India 175 GW Renewable Energy Target for 2022 (2015)	Draft National Energy Policy augments the success of Integrated Energy Policy (that also validated the use of biomass for energy extraction) by aiming to increase the renewable energy capacity by 175 GW by 2022 and achieve 40 percent non-fossilised electricity mix by 2030 (which indirectly or directly includes biomass).The target of 175 GW by 2022 includes 10 GW energy from biomass.
	National Policy on Biofuels (2018)	It aims at utilization, development and promotion of biomass feedstock (including agricultural waste and residues, forestry residues, tree based or other non-edible oils, plastics, MSW, waste gases and others) for the production of biofuels and sets the target of 20 percent blending of ethanol in petroland 5 percent blending of biodiesel in diesel by 2030. It enlists the feedstock to be used for biofuel production.
	National Biogas and Manure Management Programme (2014); Biogas Power (off-grid) Programme (2013)	These are the programmes that are dedicated to promotion of bio-gasification technology for livestock and agriculture waste. As a result, they provide bioenergy and biofertilizers for public use.
Indonesia	Government Regulation No. 50 of	GR No. 50 mandates PT Perusahaan Listrik Negara (PT PLN) to purchase produced renewable energy which

Countries	Law and Policy and Plan	Description
	2017 on Utilization of Renewable Energy Sources for Power Supply; Medium-Scale Power Generation using Renewable Energy (Ministerial Regulation No. 2and2006); Electricity Purchase from Small and Medium Scale Renewable Energy and Excess Power (No. 4and2012); Feed-in-Tariffs for Biomass and Municipal Waste (Ministerial Regulation No. 27and2014 and No. 44and2015)	also includes biomass, biogas and MSW as renewable energy sources. MR No. 2and2006 also obliges PT PLN to deploy renewable energy power plants up to 10 MW capacity on a must-run basis. MR No. 4and2012 provides feed-in-tariff scheme for renewable energy including from biomass, biogas, MSW and others. MR No. 27and2014 and 44and2015offer feed-in-tariff scheme for projects of bioenergy from biogas and biomass.
	National Team for Biofuel Development and Biofuel Roadmap (Decree No. 10and2006) (2006)	Under this, the biofuel production targets require 'biodiesel utilisation 20 percent of diesel fuel consumption (10.22 mlnkL), bioethanol utilisation 15 percent of gasoline consumption (6.28 mlnkL), biokerosene utilisation (4.07 mlnkL), pure plantation oil for power plant use (1.69 mlnkL), biofuel utilisation 5 percent of energy mix (22.26 mlnkL).'
	Provision and Utilization of Biofuel (Presidential Instruction No. 1and2006); Biofuel Blending (Ministry Regulation No. 25and2013)	PI No. 1and2006 promotes the supply and utilization of biofuel. Moreover, ministries are responsible for formulation and implementation of policies on tariffs and trading systems, incentives, and others. It also encourages use of unutilized (23.2 million hectors) and deserted (14.9 million hectors) land for bioenergy crops. MR No. 25and2013 has a goal of diversifying the domestic biofuel consumption. It has set targets of blending for certain industries to be achieved by 2025.
	Blueprint of National Energy Management 2005 – 2025 (2005)	A total of 15 percent of national electricity demand must be met by renewable energy sources where biomass must provide 810 MW pf energy.
Japan	Act No. 108 – Act on Special Measures Concerning Procurement of Electricity from Renewable Energy Sources by Electricity Utilities (2011)	Encourages utilization of renewable energy sources for generation of electricity (including biomass).
	Act No. 81 – Act on Promoting the Generation of Electricity from Renewable Energy Sources Harmonized with Sound Development of Agriculture, Forestry and Fisheries (2013)	Promotes revitalisation of rural areas and expansion of the sources of energy for electricity generation from renewable sources such as from land, water, biomass and other resources

Countries	Law and Policy and Plan	Description
	Basic Energy Plan (2014)	Encourages the continuation of the implementation of biofuel. It has set the target of 3.7 – 4.6 percent (6.02 – 7.28 million kW) of power generation mix from biomass by 2030
	Feed-in Tariff Scheme (2012)	It offers feed-in-tariff strategy for renewable energy which also includes biomass
Lao People's Democratic Republic (PDR)	Law on Electricity (2017 Ed.)	This law on electricity acknowledges renewable sources such as biomass for the generation of electricity for the country and favours renewable energy sources in rural and remote areas for electricity generation.
	Renewable Energy Development Strategy in Lao PDR (2011)	This strategy has overarching objectives from utilizing energy crops to socioeconomic benefits and achieving sustainability. It targets contribution of renewable energy sources to 30 percent of total national energy consumption by 2025. However, renewable energy sources also include biomass and biogas among others.
Malaysia	Renewable Energy Act (2011)	Includes Feed-in-Tariff scheme to sell electricity generated from renewable energy to distribution licensees.
	National Renewable Energy Policy (2018)	Set a target of mixing 20 percent of renewable energy in the national energy capacity by 2025. It also aims to implement renewable energy projects other than solar.
	Renewable Energy (Criteria for Renewable Resources) Regulations (2011)	Defines the renewable sources explicitly where biomass is any solid, organic, non-fossilized originating from agriculture, industry or municipal waste.
	Green Technology Master Plan Malaysia 2017 – 2030 (2017)	Targets establishment of 250 biogas plants in palm oil mills for providing electricity to national grid by 2020.
	The National Biofuel Policy (2006)	Provides a detailed framework with clear initiatives of blending of biodiesel with diesel. It aims at reducing the dependence on fossil fuels.
Myanmar	Myanmar Climate Change Strategy and Action Plan 2016–2030 (2017)	In addition to other strategies, large portion of energy generation must come from renewable energy sources by 2030.
	Myanmar Sustainable Development Plan 2018 – 2030 (2018)	Goal 5 'Natural Resources and the Environment for Posterity of the Nation' has a target of mixing of energy production from renewable and non-renewable energy sources. It plans to utilize bioenergy.
	National Energy Policy (2014)	Incorporates nine policies. Policy 1 among other potential sources, also focuses on renewable energy with the aim of scientifically exploring the potential of renewable energy sources, replacing fossil fuels with energy crops, and producing energy from biomass. It also encourages blending of fuel with biodiesel and biofuel for transport sector, bio-gasification of livestock waste, and agricultural waste. Policy 4 targets at utilizing local energy sources in rural areas for social and economic development under the Ministry of Livestock, Fishery and Rural Development. Policy 5 promotes exploiting renewable energy sources at a bigger scale and aims at increasing utilization to meet commercial and industrial energy demand.
Pakistan	Alternative Energy Development Board Act (2010); Alternative and Renewable Energy Policy (Medium term policy) (2011)	Alternative Energy Development Board (AEDB) Act gives authority to AEDB to formulate policies, strategies and plans for exploitation of alternative and renewable (ARE) resources, to implement ARE projects and to examine, monitor and certify ARE projects.

Countries	Law and Policy and Plan	Description
		According to the policy, alternative fuel includes biogas, bio fuel and RDF from agriculture and industrial waste, whereas renewable energy sources include energy from waste (biomass, MSW, sewerage) and others. This policy targets minimum 5 percent of gross commercial energy supplies from ARE.
	Framework for Power Cogeneration 2013 Bagasse and Biomass (2013)	It acts as an addendum to Renewable Energy Policy and offers upfront tariff for cogeneration of bagasse and biomass in sugar mills or in separate entities (to be determined by National Electric Power Regulatory Authority). It also requires power purchasers to consume all energy purchased.
The Philippines	Renewable Energy Act (2008)	Aims to explore and develop renewable energy sources (including biomass) to become autonomous for energy. Further policies and strategies are encouraged to be formulated under this act for utilizing and promoting use of renewable energy sources.
	Biofuels Act (2007); Mandatory Use of Biofuel Blend (2011)	Directs a minimum percentage of biodiesel (2 percent) and bioethanol (10 percent) to be mixed with liquid fuels for motors and engines after the four years of adoption.
	Rules and Regulations for Implementing the Renewable Energy Act (2009)	Intends to support the execution of renewable energy by promoting incentives and mechanisms such as Feed-in-Tariff, Net metering, Renewable Energy Portfolio Standards (RPS) and others.
The Republic of Korea	Renewable Portfolio Standard (RPS) Policy (2012)	Implemented to increase the market share of renewable energy. Thereby generation electricity from renewable sources including biomass, biogas, waste-to-energy and landfill gas
	Framework Act on Agriculture, Rural Community and Food Industry (2015)	Article 47 advises formulation of policies for generation of bio-energy from 'crop and forest resources.'
	Act on the Promotion of the Development, Use and Diffusion of New and Renewable Energy (2004)	Aims to diversify the sources of energy including the use of 'bio-energy' from biological resources as well as from waste.
Thailand	Alternative Energy Development Plan: AEDP2015 (2014)	This plan is part of the framework 'Thailand Integrated Energy Blueprint (TIEB)' which includes a total of 5 master plans. According to this plan, by 2036, approximately 20 percent of total power requirement must be met by renewable energy sources (including MSW 500 MW, biomass 5,570 MW and biogas 1,280 MW).
Viet Nam	Vietnam Renewable Energy Development Strategy 2016-2030 with outlook until 2050 (REDS) (2015)	This Strategy directs the development of renewable energy by setting explicit medium- and long-term goals. The execution of biogas technologies is targeted from 4 million m^3 in 2015 to 8 million m^3 in 2020, 60 million m^3 in 2030 and 100 million m^3 in 2050. Similarly, it aims at increasing generation of biofuels by 5 percent in 2020, 13 percent in 2030, and 25 percent in 2050 for transport sector and incorporating biomass energy by 1 percent in 2020, 1.2 percent in 2025 and 2.1 percent in 2030.
	National Power Development Plan 7 (PDPD7 – revised) (2016)	PDPD7 was revised based on REDS to incorporate renewable energy sources in the national energy mix. According to the revision under REDS, 7 percent of total production of electricity should be from renewable energy sources by 2020 and 10 percent by 2030.
	Decision on support mechanisms for the development of biomass power project in Vietnam (biomass feed-in tariff) (2014)	This mechanism is utilizing feed-in-tariff for combined heat and power plants using biomass and aims to encourage investment.

Table 3.2.5-5: Waste Related Regulations, Policies and Plans for Agricultural Biomass Waste

Countries	Legislation	Description
PR China	Agriculture Law of PR China (1993)	Article 58 encourages use of 'organic fertilizers.' Article 65 mentions utilization of agricultural wastes including 'straw and other residual materials' as well as waste from livestock and poultry.
	Cleaner Production Promotion Law (2002)	Article 22 enlists agriculture, among the departments, responsible for the implementation of this law for 'resource utilization'. Agriculture mentioned in above law includes agricultural activities, fisheries, livestock and husbandries.
Japan	Basic Plan for Promotion of Biomass Utilization (2010)	Established to implement Act No. 52. Among others aims to reduce GHG emissions, improve resource circulation, diversify energy sources and implement multi-stage utilisation of biomass to maximize the utilization by 2025
	Strategy of Biomass Commercialization (2012)	To achieve the goal of basic plan for promotion of biomass utilization by commercialising the technologies and biomass through selection and concentration
	Food Recycling Act (2001)	Encourages reducing and recycling food waste into feed and fertilizer.
	Act No. 110 – Basic Act on Establishing a Sound Material-Cycle Society (2000)	The management of biomass in line with Act No. 110 including reduction, reuse, recycle and energy recovery
The Republic of Korea	Framework Act on Agriculture, Rural Community and Food Industry (2015)	Article 38 mentioned conversion of 'livestock waste into resources.'
	Act on the Management and Use of Livestock Excreta	Dedicated to resource circulation of livestock waste (in addition to proper disposal) via conversion of livestock waste into manure or liquid manure.

3.2.5.3 Management of agricultural biomass waste and livestock waste

i. Amount of agricultural biomass waste recycled (HNG 11-1)

Goal 11-1 (Amount of agricultural biomass waste and livestock waste recycled) of Ha Noi3R Declaration encourages 'full-scale' utilization of Agricultural Biomass Waste which has not been realized throughout the region yet, as can be seen in Figure 3.2.5.-1. The utilization in Figure 3.2.5.-1 represents reuse, composting, energy recovery, bio-methanation and other techniques carried out in Asia and the Pacific region. The availability of data for utilization of agriculture biomass waste is missing in most of the Asia and the Pacific countries, thus Figure 3.2.5.-1 shows utilization of countries where data was available. Resource circulation of agricultural biomass waste through 3R (reuse, recycle, recover) depends on the type of agricultural biomass waste and other characteristics such as moisture content, energy content, and others. Reusing of Agricultural Biomass Waste includes livestock fodder, mulching, mushroom cultivation, incorporating into the field and others. It is also used as fuel for domestic and industrial sectors and recycling includes aerobic and anaerobic digestion of agricultural biomass waste. While the technologies used to utilize agricultural biomass waste are discussed in the next subsection, this section gives quantitative and overall picture of biomass utilization in Asia and the Pacific countries. It must be noted that recycling of horticulture waste is higher in Singapore (83 percent) as compared to food waste (19 percent) in 2021 (NEA, 2022a).

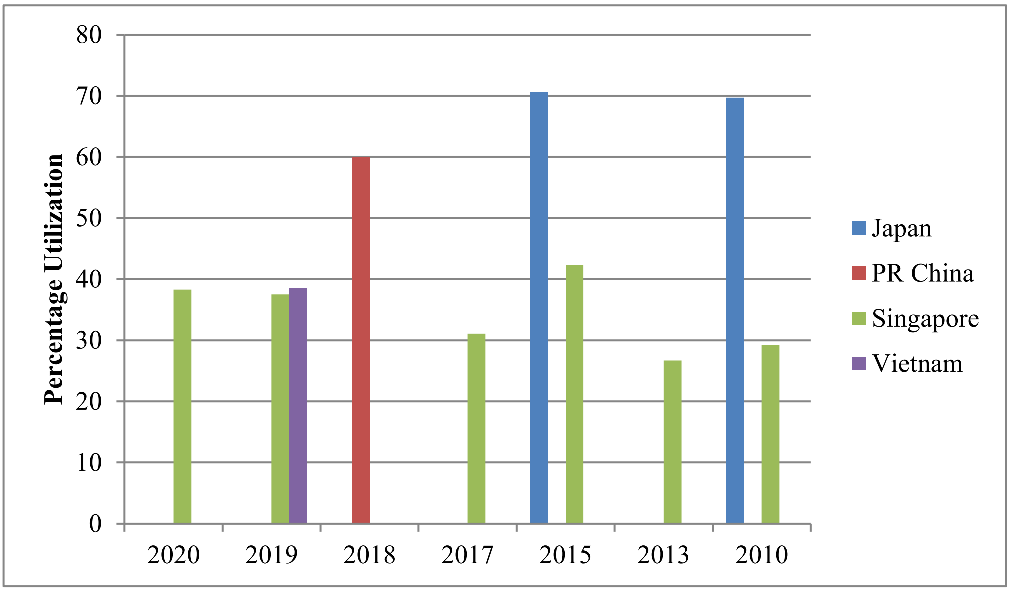


Figure 3.2.5-1: Percentage of Utilization of Agricultural Biomass Waste in Asia and the Pacific. Source: (Pariatamby et al., 2021)

ii. Number of new projects initiated that use agricultural biomass waste as material inputs (HNG 11-2)

Ha Noi3R Declaration Goal 11-2 (Number of new projects initiated that use agricultural biomass waste and livestock waste as material inputs) aims at implementing new projects for the management of agricultural biomass waste. There are several new programs that are being implemented in India for utilization of agricultural biomass waste. Some of the projects related to those programs are described here. The Indian Ministry of New and Renewable

Energy (MNRE) is implementing Programme on Energy from Urban, Industrial and Agricultural Wastes and Residues for utilizing a wide range of wastes including agricultural residues, slaughterhouse waste, MSW, industrial wastes, vegetable and other market wastes and effluent in order to generate biogas, Bio-CNG and power (MNRE, 2021). This program started in 2017-18 calendar year until 2020-21 (Prateek, 2018) and is expected to be extended to 2025-26 as the extension approval is under review (MNRE, 2021). Under this program, MNRE has been providing incentives, subsidies and grants to achieve its objectives and in 2020, 2 biogas plants with capacity of 35,000 m^3andday, Bio-CNG and CBG plants with capacity of 12,440 kg/day and 3 power plants with capacity of 22.20 MW has been added. Thus, by the end of 2020 the total capacity of these waste-to-energy projects had reached 743,508 m^3andday (biogas), 97,199 kg/day (Bio-CNG-CBG) and 291.34 MW (power including grid and off-grid) (MNRE, 2021).

Another program MNRE is executing is 'Biogas Power (Off-Grid) Generation and Thermal Application Program (BPGTP)'which was initiated in 2006 and have been encouraging the applications for biogas generation for off-grid and decentralized renewable power with the capacity range of 3 kW – 250 kW and for thermal energy with the capacity of 30 m^3 – 2,500 m^3andday. As of 31 December 2020, 4 projects have been authorised for power generation capacity of 300 kW and biogas generation of 2,500 m^3andday, bringing the total projects' tally to 325 biogas-based projects. The cumulative power generation of these 325 projects amounts to 7.587 MW and cumulative biogas generation gets to 72,351 m^3andday (MNRE, 2021). Moreover, under Biomass Power and Bagasse Co-generation Programme (which started in 2018), 200 non-bagasse-based biomass cogeneration plants with the capacity of 772 MW have been installed by the end of 2020 (MNRE, 2021).

Another program that was launched in 2018 was the New National Biogas and Organic Manure Programme (NNBOMP) in India, with the aim of establishing small scale biogas plants with the capacity of 1 m^3 – 25 m^3. The target of this program is to provide renewable fuel to the inhabitants in the rural area. The biogas plants will utilize cattle manure with optional linking of sanitary toilets. The biogas generated will be used for lighting, cooking, and to meet other small power needs of cattle farmers, farmers and other people, whereas biofertilizer will be utilized fertilizer. A target of establishing 60,000 small biogas plants has been set for 2020 – 21 under NNBOMP. As of 21 January 2021, 8,483 small biogas plants have been installed (MNRE, 2021).

About 781 biogas plants have been installed in Bangladesh as of June 2020 under the initiative of Bangladesh Council of Science and Industry Research (BCSIR), GIZ, Ministry of Disaster Management and Relief, and Department of Local Government Engineering. A target of 31.06 MW of power generation from biomass and biogas is set for 2021 (SREDA, 2021b). Infrastructure Development Company Limited (IDCOL) has also been executing biogas programme in Bangladesh since 2006 and has funded for more than fifty thousand biogas plants.

Lastly, there are several examples of developed countries collaborating with developing countries for establishing resource recovery plants in developing countries. For instance, in Ayeyarwady region of Myanmar, a rice husk-based biomass power plant is planned to be built with the capacity of 1.8 MW with the help of Japanese Fujita Corporation (Bioenergy News, 2017). Fujita Corporation is collaborating with Myanmar Agribusiness Public Corporation. It is expected to be operational by 2023 (Fujita Corporation 2019). Similarly, an energy company from Finland, St1, had signed a MoU (memorandum of understanding) in 2017 with Ubon Bio Ethanol, Thailand to produce bioethanol from cassava waste. The pilot plant had been constructed in 2018 and, if its execution is successful then a commercial plant will be established (Goodnewsfromfinland, 2018).

Since, Ha Noi3R Declaration in 2013, the installed capacity of bioenergy in Asia and the Pacific for the period of 2013 to 2019 is shown in the Figure 3.2.5.-2 below. The People's Republic of PR China, India, Thailand and Japan are leading in bioenergy capacity installation. An overall increase in installed capacity for bioenergy is observed in most countries of Asia and the Pacific since the start of Ha Noi3R declaration. In 2019, Japan had installed capacity of 3,197 MW (Asia and the Pacific Energy Portal, n.d.).

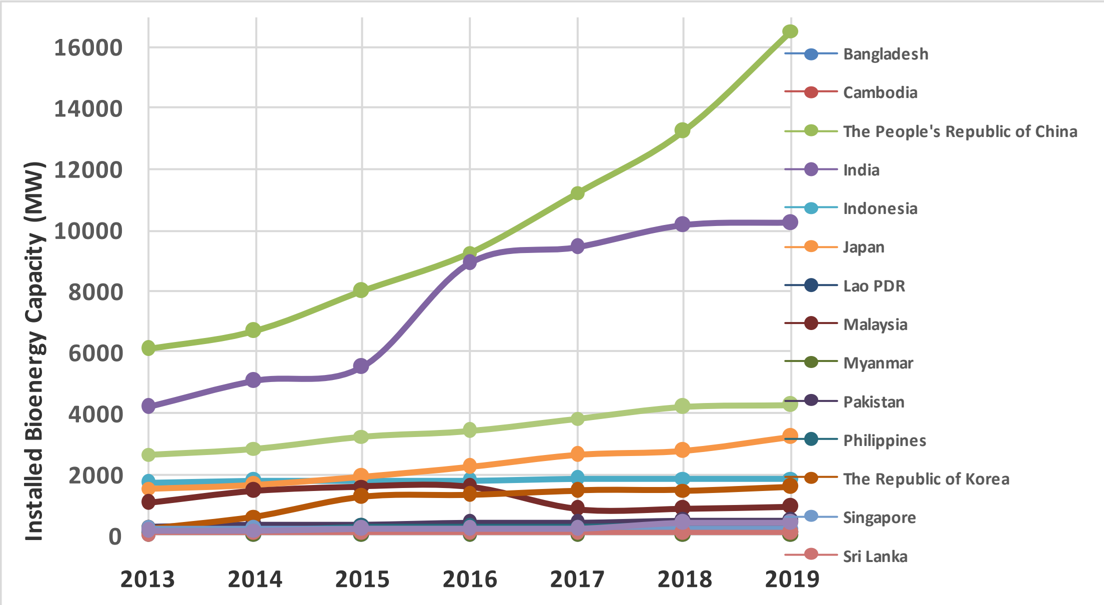


Figure 3.2.5-2: The trend of installed bioenergy capacity in Asia and the Pacific since Ha Noi 3R Declaration. Source: (Asia Pacific Energy Portal, 2018)

iii. Best cases and practices on CE utilization of agricultural biomass waste and livestock waste

Among the countries of Asia and the Pacific, Japan has relatively higher resource circulation of agricultural biomass waste where about 70 percent of waste is utilized as fertilizer, feed, fuel and generation of heat and energy. Several initiatives have been taken and schemes have been formulated that have circular economy at its core. For instance, a biogas plant and composting facility was built near sludge treatment facility in Shikaoi Town, Tokachi District, Hokkaido, in 2007, which is known as 'Hokkaido Shikaoi Environmental Preservation Centre'. The sewage sludge from sludge treatment facility, livestock waste and food waste are treated in Hokkaido Shikaoi Environmental Preservation Centre. Biogas plants generates power which is used within the facility and remaining power is sold to Hokkaido Electric Power Corporation under FIT (Feed-in-Tariff) scheme. Additionally, digested liquid is used as biofertilizer and heat is utilized by aquaculture and fruit culture, thereby creating a local-level recycling-based society. In 2016, one more biogas plant, Urimaku Biogas Plant, was also established in Shikaoi-cho. Lastly, biogas-based hydrogen generating projects have also commence with the support of Ministry of Environment (MAFF, n.d.). Similar other cases of advanced utilization of agricultural waste are present in Japan (see MAFF, n.d.). Japan is also aiming towards establishing Biomass Industrial Areas that will build an integrated system of economy and development of village and town centred biomass industry. Several sectors of the village and town will be exchanging waste and by-products of biomass treatment such as utilizing food waste, livestock waste, agricultural waste and generating and providing electricity, heat, and biofertilizers (MAFF, 2017).

While this second case study is not big scale utilization of agricultural biomass waste but if its scale is increased, the benefits could become several folds. In the village Pirangut of Pune, Maharashtra, India, an anaerobic digestor of 100 kg/day capacity was installed in 2016 for the production of 2nd generation Bio-CNG and bio-manure by utilizing local agriculture waste. The characteristic of required feedstock is low moisture (10 percent) agriculture waste such as maize straw, rice straw, cotton straw, sugarcane trash, coconut frond, soya trash, bamboo, organic solid waste, napier grass and others. The capacity of this plant can be increased to 5 tonnes/day to 50 tonnes/day or more. This biogas plant has been operational since 14 August 2016 and can provide power to 13 cars (8 kg/fill) or 25 auto rickshaws (4 kg/fill) or combination of these two. One of the several benefits this project brings is that it offers opportunity to local (and potentially poor) farmers to sell their agriculture waste instead of openly burning their agriculture waste. Thus, it will be an additional source of income and the air pollution from open burning will also be avoided. Moreover, it generates ready to use Bio-CNG for vehicles and hence, has the potential to replace imported CNG or LNG and other transportation fuels. In conclusion, this project can reduce GHG emissions, bring sustainability to rural areas, save the cost of importing fuel and improve resource circulation.

3.2.5.4 Common technologies deployed for agricultural biomass waste and livestock waste management.

i. Reuse

The reuse practice of agricultural biomass waste includes use as fodder, incorporating into the field as fertilizer (sometimes without processing), as cooking fuel and others. These practices are more common in developing countries of Asia and the Pacific. For instance, firewood, leaves, branches, twigs, cow dung, rice straw and husks are utilized as cooking fuels in villages of Bangladesh. Similarly, dung and poultry droppings are used for agriculture lands in Sri Lanka. Viet Nam has multiple uses of agricultural biomass waste which includes use as fertilizer (direct incorporating into the field), as animal feed, in mushroom cultivation and others (Agamuthu, 2020) (Table 3.2.5.-6). PR China has a RMB 70 billion market for fodder and others, thus in 2017, 160 million tonnes of agricultural biomass waste was utilized this way. Similarly, agricultural biomass waste equal to RMB 90 billion worth (1.9 billion tonnes) were returned to field (CICC, n.d.).The use of agricultural biomass waste as fodder also occurs in India (Agamuthu, 2020).

Table 3.2.5-6: Reuse of Agriculture Waste in Viet Nam in 2017

Biomass Type	Incorporation in the Field	Animal Feed	Barn Padding	Mulching	Fuel for Cooking
Rice Straw	25 percent	4.1 percent	2.1 percent	3.9 percent	3.6 percent
Rice Husk	-	-	8.9 percent	3 percent	20.3 percent
Corn Leaves	7.1 percent	34.4 percent	-	4.1 percent	17.6 percent

Biomass Type	Incorporation in the Field	Animal Feed	Barn Padding	Mulching	Fuel for Cooking
Corn Stubble	7.2 percent	30.4 percent	-	2.1 percent	16.1 percent
Cassava Leaves	16.9 percent	8.1 percent	-	-	-
Cassava Stubble	-	-	-	-	5.6 percent
Cassava Pulp	-	-	-	5.6 percent	-
Sugarcane Leaves	-	22 – 55 percent	-	15 percent	-
Coffee Stems, Leaves, Branches	82 percent	-	-	-	-
Coffee Pulp	-	-	-	-	40 percent

ii. Composting

Composting is the most deployed technology for the treatment of organic waste (including agricultural biomass waste). The advantage of composting is that it provides biofertilizer as a by-product can be used in the agriculture land again. There are about 279 composting plants and 138 vermi composting facilities present in India that treat organic waste originating from MSW, agriculture activities and others. Similarly, composting is also carried out in Singapore for the treatment of horticulture waste. The market size of composting in PR China was RMB 230 billion and approximately 700 million tonnes of Agricultural Biomass Waste was composted in 2018.

iii. Anaerobic Digestion

Anaerobic digestion or Bio-gasification is another commonly utilized technology for treatment of organic waste as it offers generation of bioenergy and biofertilizer. PR China and India are two countries in the world with the highest number of anaerobic digestors (IRENA, 2018). Bangladesh generated 1.09 MW of electricity from biomass (0.4 MW) and biogas (0.69 MW) in 2021 (SREDA, 2021). The sources for generation of biogas in Bangladesh include as agricultural waste, organic fertilizer, municipal waste, plant materials, sewage waste, green waste or food waste. Out of these, biogas plants utilizing poultry waste have been the most successful in Bangladesh. In 2014, about 65,317 biogas plants were installed in Bangladesh (Halder et al., 2014) and as of June 2021, the capital for the construction of 58,900 biogas plants in Bangladesh has been provided IDCOL. In Malaysia, about 92 palm oil mills had biogas plants in 2016 and it is expected that around 250 palm oil mills will provide electricity to national grid and 233 mills will provide electricity to their boilers by 2020. On the other hand, under Viet Nam Biogas Program, 170,000 biogas plants were established by March 2017 in Viet Nam. This national biogas program had started in 2003 with the support of The Netherlands SNV (Netherlands Development Organization). The biogas plants utilized animal manure and human excreta for biogas generation (SNV, n.d.). As for Pakistan, according to the latest figures,8,000 biogas plants have been established in Pakistan with a range of production capacity of 3 to 15 m^3 per day (Khan et al., 2021). It must be noted that the treatment capacity and methane generation capacity of bio-digestors may vary in each country and hence the number of bio-digestor may not directly be comparable in terms of capacity or scale. For example, in India about 5,058,054 bio-digestors have been established under NNBOMP which are all small scaled biogas plants and the remaining 325 biogas plants are relatively large scaled as mentioned in previous section (3.2.5-3 – number of new projects initiated that use agricultural biomass waste as material inputs).Similarly, in Viet Nam the total biogas plants, 465,370, includes small scale (450,000), medium scale (14,370) and large-scale biogas plants (1,000). In PR China, about 42 million biogas plants are small scale (household digestors), whereas remaining are small-medium, medium-large and other biogas plants (Giwa et al., 2020).

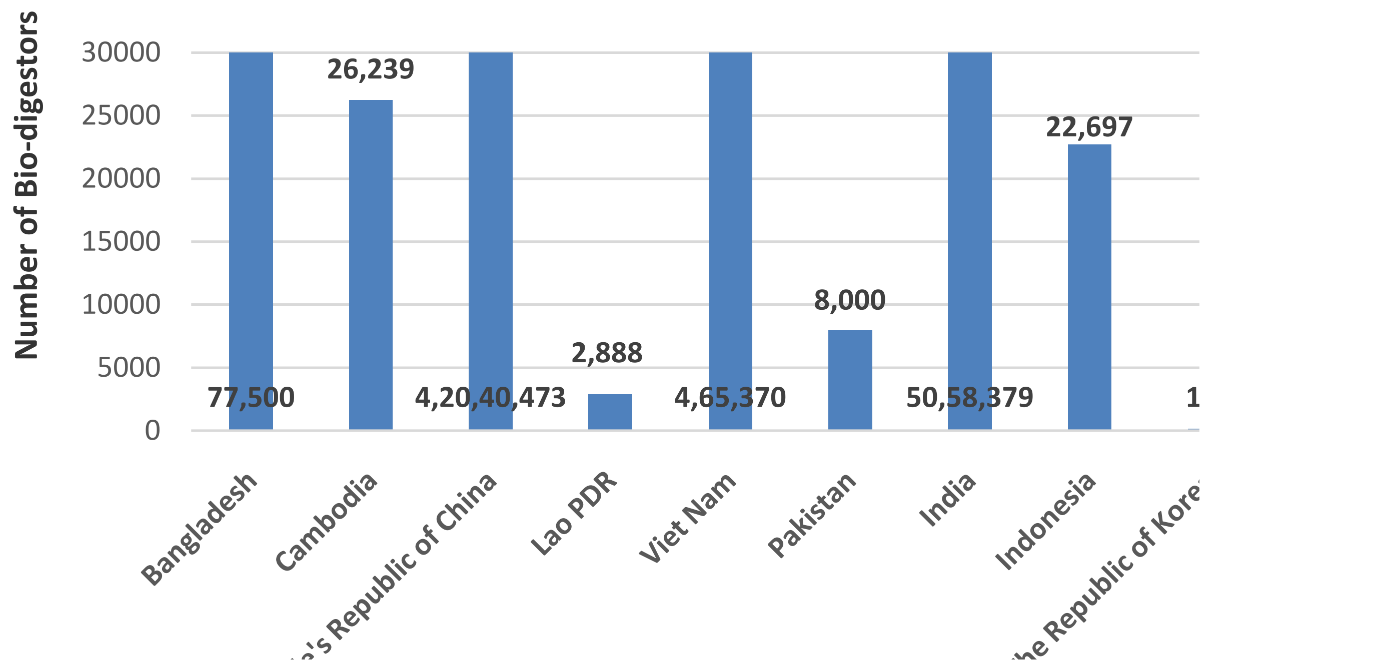
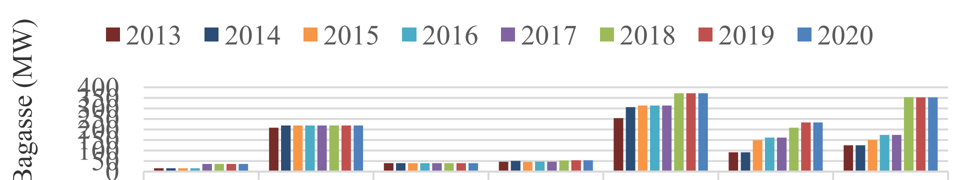


Figure 3.2.5-3: Number of bio-digestors present in selected Asia and the Pacific countries. Source: MNRE, 2021; Khan et al., 2021; Giwaet al., 2020; Zheng et al., 2020; Tun and Juchelkova, 2019; GDE, 2019;Pirelli and Rossi, 2018; Kang, 2013

iv. Cogeneration

Cogeneration of agricultural biomass waste can provide heat and electricity as by-product. Electricity output from bagasse treatment is shown in Figure 3.2.5.-4. A total of eight companies have been approved for cogeneration of bagasse and biomass under the policy framework for power cogeneration (2013) in Pakistan (AEDB, n.d.). Overall, about 15.4 million tonnes of bagasse is cogenerated in 84 sugar mills and electricity and low-pressure steam is generated for utilization of sugar mills. The estimated total installed capacity of 84 sugar mills for energy is 830 MW (World Bank, 2016). In comparison, more than 550 projects of installing biomass power and cogeneration have been completed by 2020 in India. The total capacity of these projects is 9,373 MW. Sugar industry in India, just like Pakistan, has been utilizing bagasse for heat and energy for the operation of sugar mills. There are over 540 sugar mills in India and 360 of these possess established cogeneration power plant capacity of 7,547 MW where excess power is provided to the main grid under the Biomass Power and Bagasse Co-generation Programme (MNRE, 2021).



	Camdodia	Indonesia	Lao PDR	Myanmar	Pakistan	The Philippines	Viet Nam
2013	16	208	40	47	254	92	125
2014	16	219	40	51	306	92	125
2015	16	219	40	46	314	149	150
2016	16	219	40	48	314	161	174
2017	36	219	40	47	314	161	174
2018	36	219	40	52	372	208	353
2019	36	219	40	54	372	233	352
2020	36	219	40	54	372	233	352

Figure 3.2.5-4: The trend of utilization of bagasse for electricity output in Asia and the Pacific since Ha Noi 3R Declaration. Source: (IRENA, 2021)

v. Incineration

Incineration is usually deployed for Agricultural Biomass Waste that has low moisture content such as woody biomass, paper waste, palm oil residues and others. Aerobic combustion of waste can also produce electricity and heat as a by-product. Thus, electricity generated by combustion of Agricultural Biomass Waste may be called bioelectricity as it is produced from renewable source. There are three main generators of bioelectricity in Asia and the Pacific and PR China has become the largest producer of bioelectricity in the world. In 2017, the bio-power generation and capacity of PR China rose by 23 percent respectively. The feedstock for the generation of bioelectricity was Agricultural Biomass Waste and MSW (Renewables, 2018). The market for energy treatment in PR China was approximately RMB 80 billion and the Agricultural Biomass Waste treated in 2018 was 140 million tonnes (CICC, n.d.). On the other hand, Japan's capacity for treating Agricultural Biomass Waste for bioelectricity generation increased by 14 percent and the generation of bioelectricity rose by 16 percent. In Japan, agricultural biomass waste with low moisture content is incinerated. Lastly, the increase in total capacity of bioelectricity and generation in India was 10 percent and 8 percent, respectively (Renewables, 2018). Figure 3.2.5.-5 presents the generation and capacity values for bioelectricity.

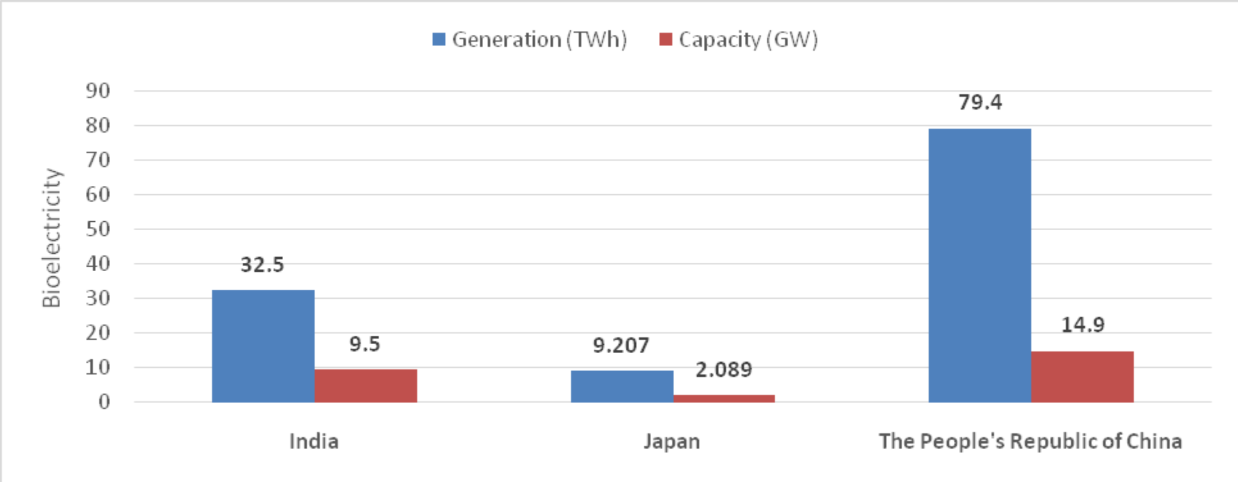


Figure 3.2.5-5: The generation and capacity of bioelectricity in 2017. Source: (Renewables, 2018)

vi. Gasification

There are about 272 operational gasification plants in the world which mainly utilize coal as feedstock and a few uses agricultural biomass waste and other waste as feedstock (Lee et al., 2020). Currently, two gasification plants are operational in Bangladesh for processing rice husk (Baky et al., 2017). One of these gasification plants is Downdraft (250 kW) located in Kapasia, Bangladesh (Das and Hoque, 2014). Additionally, Sinobioway Group of PR China partnered with Enerkem Inc. in 2018 to bring gasification technology to Chinese market. Similarly, small scale biomass gasifier has been used for generating electricity in South and Southeast Asia (Renewables, 2018). Myanmar has about 1,105 gasification plants which produce electricity from rice husk and wood chip (Tun and Juchelková, 2019).

3.2.5.5 Innovative technologies for agricultural biomass waste and livestock waste management

i. Fermentation

The fermentation is not a new technique as such (as it has been used in fermenting food), however it can also be used on sugary agricultural biomass waste to produce bioethanol. Crops such as sugarcane and corn have primary value of food and feed, thus their use as feedstock will be competing with their use as feed. In addition to sugary feedstock, starch-based feedstock can also be used for fermentation. Nevertheless, the focus is utilization of agricultural biomass waste in feedstock. This is where lignocellulosic agricultural biomass waste including wood residue, straw waste and crop residues can be used to produce bioethanol (see Figure 3.2.5-6). Bioethanol is a biofuel which can be blended with fossil fuel at 5, 10 and 85 percent. Approximately 98.4 billion litres of bioethanol were produced globally in 2018 and Asia produced 6.87 billion litres (WBA, 2020). In United States and Brazil, bioethanol is mainly produced from starch-based or sugary feedstock. But such practice may not be feasible in developing countries where poverty, food insecurity and agriculture intensity are high. The trend of production of biofuels in Asia and the Pacific countries since Ha Noi3R Declaration are revealed in Figures 3.2.5-6 and 3.2.5-7, respectively. PR China, Indonesia, Thailand and the Republic of Korea are major producers of biofuels in the region. However, Indonesia allows growing the energy crops, hence total biofuels produced may not be solely from agricultural biomass waste. Nevertheless, in order to fully utilize Agricultural Biomass Waste in Asia and the Pacific region, several challenges must be overcome such as relatively high cost, transportation of biomass, steady supply of required agricultural biomass waste and others. Table 3.2.5-7 tabulates the types of feedstocks from agricultural biomass waste that can be utilized for production of bioethanol via fermentation.

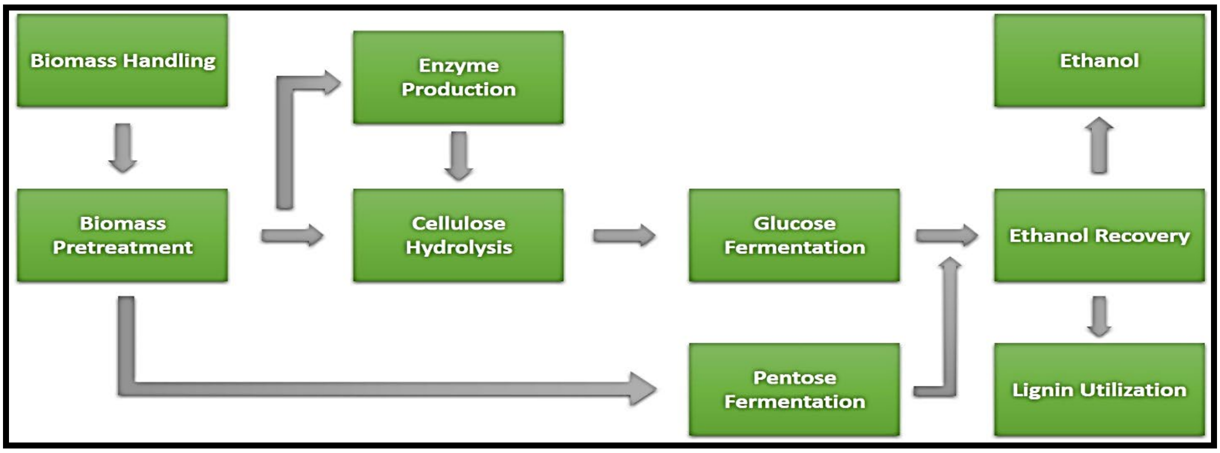
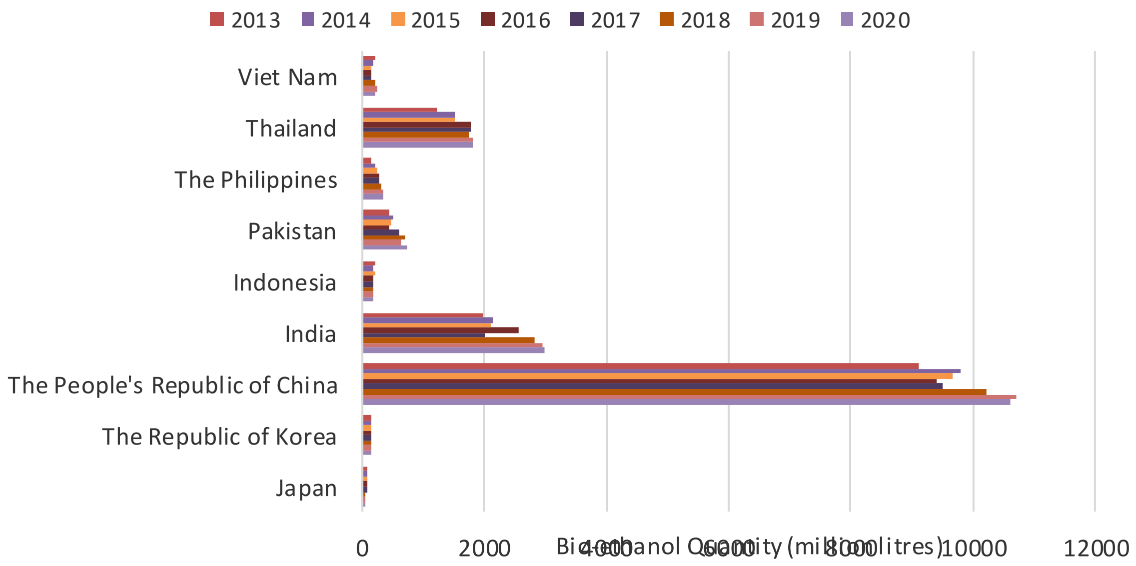
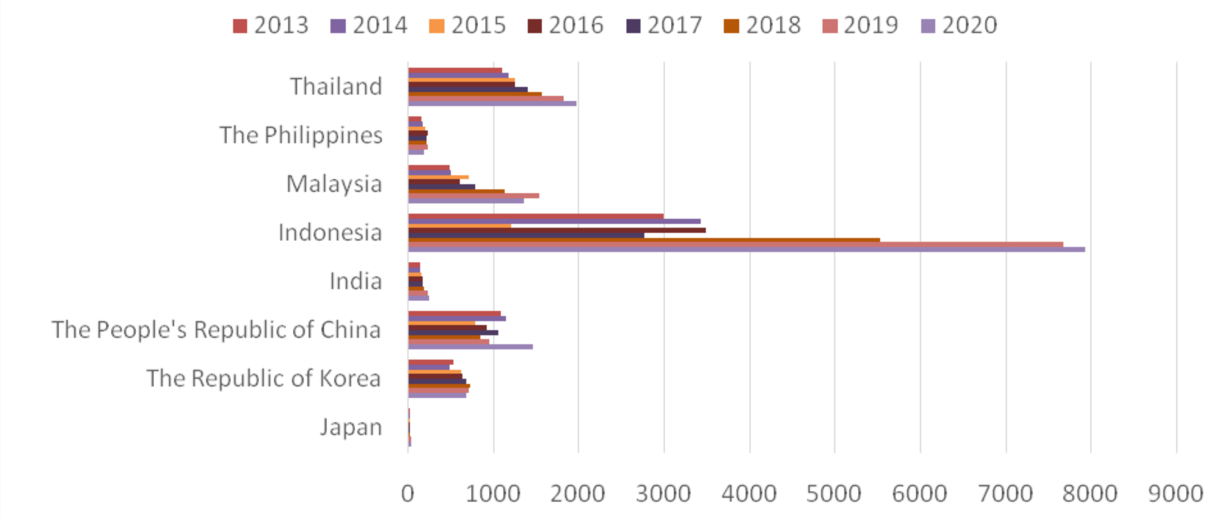


Figure 3.2.5-6: Flow diagram of fermentation process for ethanol production. Source: (RFA, 2021)



	Japan	The Republic of Korea	The People's Republic of China	India	Indonesia	Pakistan	The Philippines	Thailand	Viet Nam
2013	97	165	9115	1975.533	208.408	459.508	168.954	1248.712	229.691
2014	85	160	9800	2157.748	193.853	526.362	223.839	1535.821	207.311
2015	80	168	9665	2120.684	209.322	475.175	270.902	1522.802	167.272
2016	79.25	160	9400	2557.094	206.743	468.669	300	1777.07	151.375
2017	78.5	150	9500	2000.042	197.416	615.187	284	1782.782	169.284
2018	77.75	150	10200	2824.899	190.064	705.368	326	1739.707	226.63
2019	77	150	10700	2949.275	189.806	652.514	350	1834.39	242.938
2020	77.001	160	10590.816	2982.096	177.074	737.383	350	1827.093	212.238

Figure 3.2.5-7: The trend of production of bio-ethanol in Selected Asia and the Pacific countries since Ha Noi3R Declaration. Source: (Busicet al., 2018)



	Japan	The Republic of Korea	The People's Republic of China	India	Indonesia	Malaysia	The Philippines	Thailand
2013	14	526.465	1079	131.6	2989.999	474.999	153	1093
2014	15	484.007	1133	141.8	3413.999	494.999	163	1172
2015	15	621.989	787	150.3	1202.999	708.999	201	1244
2016	16	633.706	909	158	3483.999	600.999	218	1244
2017	16	670.515	1043	165.5	2758.999	773.999	204	1397
2018	17	726.466	834	177.9	5521.999	1129.999	208.999	1567
2019	23	702.528	939	232	7663.999	1531.999	219.999	1812
2020	23	676.811	1455	241	7926.999	1356.999	185	1970

Figure 3.2.5-8: The trend of production of biodiesel in Selected Asia and the Pacific countries since Ha Noi3R Declaration. Source: (Busicet al., 2018)

Table 3.2.5-7: Types of Feedstocks for Fermentation of Agricultural Biomass Waste. Source: (Gollakota et al., 2018)

Feedstock Type	**Bioprocess Mode**	**Microbe Used**
Sugarcane Bagasse	Batch simultaneous saccharification and fermentation (SSF)	Recombinant*Saccharomyces cerevisiae* containingthe β-glucosidase gene from*Humicola grisea*
Bagasse	Separate hydrolysis and fermentation (SHF) and SSF	*Z. mobilis* ATCC 29191immobilized inCa-alginate(CA) and polyvinylalcohol (PVA) gel beads
Eucalyptus globulus wood	SSF	*S.cerevisiae* IR2T9-a
Rice Straw	Batch Simultaneous saccharification and co-fermentation (SSCF)	*S. cerevisiae,Candidatropicalis,S. stipitis*
Corn Stover	SHF	Genetically engineered*S. cerevisiae* Y35

ii. Hydrothermal Liquefaction

Crudely, Hydrothermal Liquefaction (HTL) involves three steps of depolymerisation, degradation and repolymerisation (Gollakota et al., 2018). Figure 3.2.5.-9 depicts the reaction and process of HTL for treating agricultural biomass waste. Academic research studies of several agricultural biomass waste have been carried out which are tabulated in Table 3.2.5.-8 below. The by-products of HTL include biogas, bio-oil and bio-char. One of the main disadvantages of this technology is the probable high cost as it requires high pressure condition. On the other hand, biofuel obtained from HTL process does not require treatment or upgrading as such. A small pilot scale HTL reactor was set up to process food waste which resulted in better yield than at laboratory level. Nevertheless, HTL requires further research, especially in scaling up the HTL process to make it commercially feasible as majority of the studies have been in laboratory (Gollakota et al., 2018).

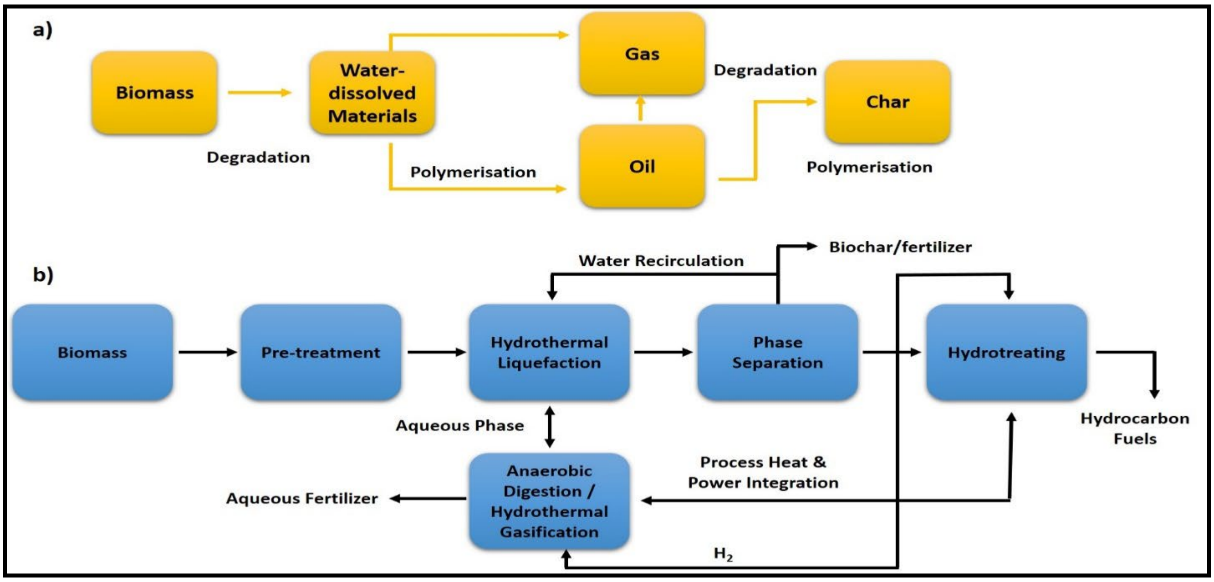


Figure 3.2.5-9: (a) Flow diagram of hydrothermal liquefaction reaction (b) Flow diagram of hydrothermal liquefaction process of agricultural biomass waste. Source: (Gollakota et al., 2018)

Table 3.2.5-8: Hydrothermal Liquefaction of Agricultural Biomass Waste. Source: (Gollakota et al., 2018)

Type of Feedstock	Conditions	By-products
Oil Palm; raw fruit bunch, palm mesocarp fibre and palm kernel shell	Temperature 330 – 390°C, Pressure 25 – 35 MPa	Optimum bio-oil yieldobtained at 390 °C and 25 MPa
Beech wood	Temperature 300°C, Pressure 1 MPa, Batch Reactor	High Iodine value bio-oil
Landscape waste leaves	Temperature 300°C, Pressure 2 MPa, Batch Reactor	Bio-oil (with value-added chemicals; ketones, phenolics, esters, alcohols and acids)
Rice straw	Temperature 300°C, Pressure 12 MPa, Batch Reactor	High value chemicals; monophenols, sugar concentrates, acid-acids, cyclopentanones
Kenaf and wheat straw biomass	Temperature 200 – 350°C, Pressure 5 MPa, Batch Reactor	Biofuel
Birch wood saw dust	Temperature 300°C, Pressure 90	Bio-crude oils with phenolic

Type of Feedstock	Conditions	By-products
	bar, Stirred Reactor	derivatives and aliphatic compounds
Wheat Straw	Temperature 350ºC, Pressure 200 bar, Tubular Reactor	Maximum of 28 Mjandkg Higher Heating Value (HHV)
Malaysian oil palm	Temperature 390ºC, Pressure 25 MPa, Batch Reactor	Bio-oil containing ketones, phenols, and aromatic carboxylic acids

iii. Industrial Insect Farming

Industrial insect farming is one of the technologies that appears valuable. Insect farms at a large scale can process hundreds of tonnes of organic waste in a day and will provide by-products such as insect oil, frass product and high-quality organic fertilizer (fine fertilizer which can easily be absorbed by plants.By deploying this technology, landfilling of organic waste can be avoided and a biofertilizer can be produced. Hence conceptually it can bring the circular economy in agriculture. Less preparation of feed will be required if waste streams are single-sourced. Another challenge is that this technology will have to compete for Agricultural Biomass Waste that may be used in bio-gasification, composting or for animal feeding (Ragossnig and Ragossnig, 2021).

3.2.5.6. Life-cycle assessment and performance of advanced technologies of agricultural biomass waste and livestock waste management

Life-cycle assessment (LCA) of agricultural biomass waste management is not uncommon. A generic system boundary of LCA for agricultural biomass waste treatment is shown in Figure 3.2.5-10. It must be noted that the system boundary of LCA will change depending on the type of agricultural biomass waste such as agricultural residue, energy crops etc. Different technologies that were mentioned in previous sections and different types of agricultural biomass waste are evaluated using LCA (see Table 3.2.5-9). While the type of agricultural biomass waste and the technologies deployed for their treatment will most certainly reduce the GHG emissions to a varying extent, however from a policy and operational perspective, choosing a technology for a certain type of agricultural biomass waste with the highest possible GHG emission reductions should be aimed. Hence, it requires a level of sophistication and attention to implement such practice.

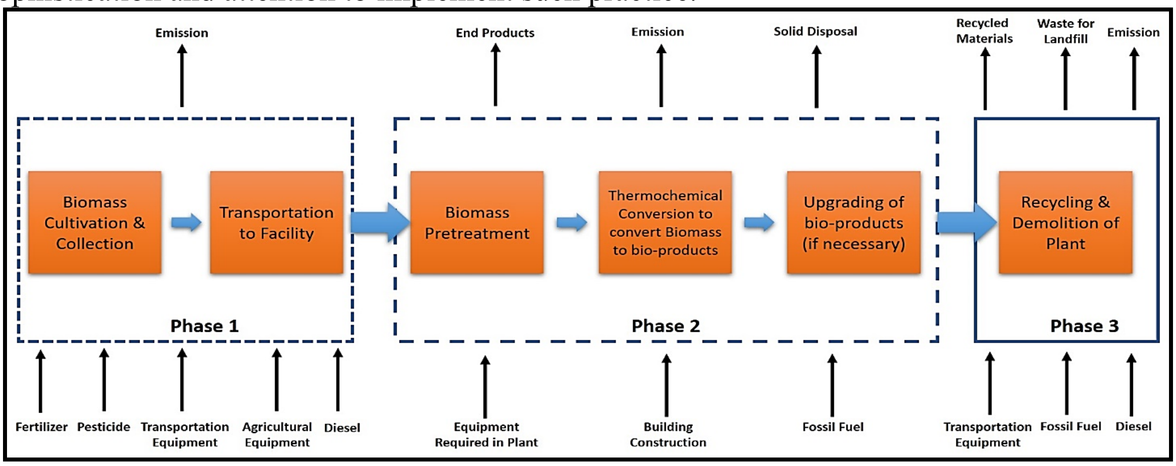


Figure 3.2.5-10: General system boundary of LCA analysis for biomass. Source: (Patel et al., 2016)

Table 3.2.5.-9 Selected LCA Analysis of Treatment Technologies for Agricultural Biomass Waste

Agricultural Biomass Waste	Technology	Benefits	References
Sewage Sludge, Woody biomass	Proposed: Gasification Current: Incineration	Annual GHG emission savings 138.9 – 165.9 million kg CO_2-eq, better electricity recovery and by-product biochar	(Ramachandran et al., 2017)
Food waste, pig slurry, cattle slurry, maize	Anaerobic digestionwith different combination of biomass	Reductions of 128.6 – 634.2 kg CO_2-eqandMWh heat	(Welfle et al., 2017)
Pigandcow manure	Anaerobic digestion for bioelectricity	-128 – -395 g CO_2-eq	(Tonini et al., 2016)
Manure	Anaerobic digestion for biogas (bio-methanation)	44 – 104 g CO_2-eq MJ^{-1}	
Strawandstover		20 – 50 g CO_2-eq MJ^{-1}	

3.2.5.7 Conclusion and Way Forward

Agricultural biomass waste is generated more in agriculture intensive countries of Asia and the Pacific than the industrial intensive ones. Based on the national legislations, plans, and strategies, as well as management practices, agricultural biomass waste is seen more as a commodity for energy extraction than a resource to be reused and recycled. Partly, it is influenced by the shortages of energy in developing countries of Asia and the Pacific and by the willingness to shift from non-renewable energy to renewable energy in developed countries of Asia and the Pacific. Therefore, technologies such as bio-gasification, co-generation, co-firing and fermentation for biofuels are commonly deployed in Asia and the Pacific.

The trend of energy generation from solid agricultural biomass waste and the trend of energy generation from biogases in selected Asia and the Pacific countries since the start of Ha Noi3R Declaration is shown in Figure 3.2.5.-11 and Figure 3.2.5.-12, respectively. Both figures demonstrate a general increasing trend of electricity output from agricultural biomass waste and highlight that progress has been made according to Ha Noi3R declaration goal 11 as well as SDG 7.2. Ha Noi3R Goal 11-2, launching new projects for the management of agricultural biomass waste, is relatively achieved as compared to Goal 11-1;amount of agricultural biomass waste and livestock waste recycled. While anaerobic digestion is the most commonly deployed technology for the treatment of agricultural biomass waste, the use of cogeneration, gasification, composting, and incineration may still contribute to the generation of GHG emissions, albeit less.

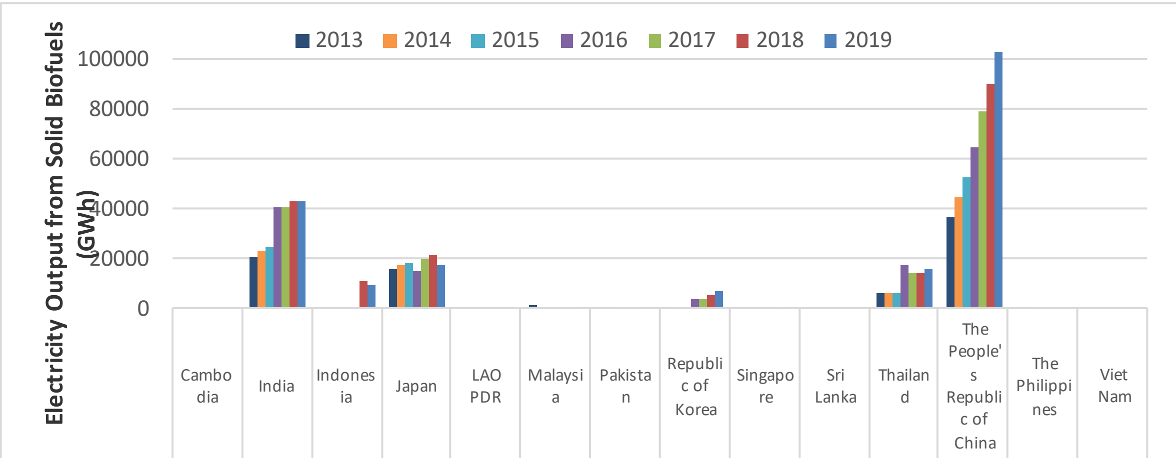
Box 3.2.5.-1 – Case Study of Japan's Progress after Ha Noi 3R Declaration (MAFF, 2017, 2021)

Before Ha Noi 3R Declaration, 69.7 percent of agriculture biomass waste was utilized for resource circulation and the utilization rate has increased to 70.6 percent in 2015. It is expected that 81.25 percent of agriculture biomass waste will be utilized by 2025 (MAFF, 2021). The table below shows the agriculture biomass waste utilization in Japan.

Type of Waste	2009 – Before Ha Noi 3R Declaration		2015 – After Ha Noi 3R Declaration	
	Generated (million tonnes)	Recycled Percent (million tonnes)	Generated (million tonnes)	Recycled Percent (million tonnes)
Animal waste	3.3	69.7 percent (2.3)	4.86	87 percent (4.19)

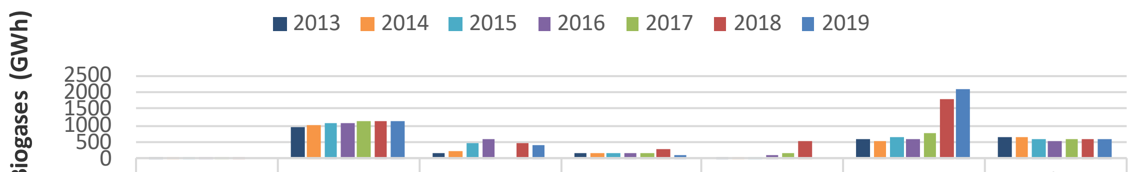
Sewage sludge			0.9	68 percent (0.61)
Black liquor			4.03	100 percent (4.03)
Waste paper			10	81 percent (8.14)
Food waste			0.65	29 percent (0.19)
Timber offcuts			3.2	97 percent (3.1)
Wood			2.2	94 percent (2.07)
Agriculture residues			4.38	32 percent (1.39)
Forestry residues			4.2	13 percent (0.56)

The management of agriculture biomass in Japan includes composting, reuse and energy recovery. As shown in Figure 3.2.5.-2, the installed capacity for bioenergy in Japan has been increasing and as of latest data, 4,287 MW of capacity has been installed for bioenergy. Japan's biomass power capacity is expected to rise to 7,230 MW in 2030, where national goal was to establish 6,020 – 7,280 MW of biomass capacity. The probable sources of biomass power would be woody biomass (4,254 MW) such as palm kernel shell, methane fermentation gas (176 MW), general wastes and others (429 MW) and other capacities (2,300 MW) that were launched before July 2012 (before FIT system). FIT program has enabled the approval of biomass power capacity of up to 8,215 MW by September 2020. However, the investment in biomass power might decline due to the challenges pertaining to feedstock availability and sustainability of fuel (Argus Media, 2021). Nevertheless, an overall increasing trend of electricity generation from agriculture biomass waste and biogases is also observed since Ha Noi 3R Declaration (see Figures 3.2.5.-11 and 12 below). Compared with other countries in Asia and the Pacific, Japan has achieved goal 11 of Ha Noi Declaration to a greater extent.



	Cambodia	India	Indonesia	Japan	LAO PDR	Malaysia	Pakistan	Republic of Korea	Singapore	Sri Lanka	Thailand	The People's Republic of China	The Philippines	Viet Nam
2013	11	21063		16173	5	1108		500	93	26	6141	37000	152	57
2014	17	23059		17073	5	649		266	155	41	6593	44400	130	58
2015	38	24348		18449	4	686	556	666	221	57	6568	52700	329	70

Figure 3.2.5-11: The trend of electricity generation from solid agricultural biomass in Asia and the Pacific countries since Ha Noi 3R Declaration. Source: (IEA, 2021b)



	Hong Kong SAR	India	Indonesia	Japan	Malaysia	Thailand	The Republic of Korea
2013	36	948	144	123	23	539	609
2014	43	992	205	151	52	551	659
2015	43	1034	461	177	65	643	588
2016	40	1081	584	186	74	595	519
2017	41	1094		140	147	789	568
2018	43	1112	478	276	512	1791	578
2019		1112	398	135		2086	568

Figure 3.2.5-12: The trend of electricity generation from biogases in Asia and the Pacific countries since Ha Noi Declaration. Source: (IEA, 2021b)

Nevertheless, majority of agricultural biomass waste in developing countries of Asia and the Pacific such as Cambodia, Viet Nam, India, Pakistan and others is openly burnt or is openly disposed of. Moreover, the value of agricultural biomass waste is observed throughout the region as its reuse and recycling is also practice in form of mulching, fodder, and other practices. Overall, some form of utilization of agricultural biomass waste occurs in Asia and the Pacific but it is not as extensive as it should be. Thus, SDGs 11.6, 12.4 and 12.6 have not been partially or fully achieved.

Several countries such as Cambodia, Myanmar, Malaysia, Viet Nam, Thailand, Indonesia, India, Japan, The Republic of Korea have formulated plans and policies for utilization of agriculture biomass waste for energy recovery after the Ha Noi3R Declaration (as shown in Table 3.2.5.-4). Moreover, several countries in the Asia and the Pacific region have been putting efforts into improving the socioeconomic and environmental situation of rural areas which are also supported by national legislations and policies in the respective countries such as Japan's Act No. 81, Cambodia's National Strategic Plan on Green Growth 2013 – 2030, Myanmar's National Energy Policy, and Lao PDR's Law on Electricity.

Nonetheless, it is expected that the utilization of agricultural biomass waste will continue to increase in coming years but there are several challenges that must be overcome to achieve circular economy in agricultural biomass waste management.

1. Majority of national legislations and plans are focused on renewable energy and under this big umbrella of renewable energy, several renewable sources have to compete with each other. Perhaps that is why hydro or solar energy (in addition to its mature technology and other positives) capacity and projects are greater in number than agricultural biomass waste related capacity and projects. Thus, a holistic approach is required by renewable energy sector to achieve the common goal.
2. Efforts from all stakeholders are required to realize the maturation of technologies for maximum extraction of resources from agricultural biomass waste. Similar attempts must be made to scale up the new technologies to increase their capacity, advancing from laboratory scale to pilot scale to commercialisation.

3. There is an urgent requirement for dedicated legislations for the management of agricultural biomass waste. Only developed countries of Asia and the Pacific have specific waste laws for agricultural biomass waste. Lack of regulations hinder the sustainable utilization of agricultural biomass waste. Currently, having only energy related policies and laws in developing countries of Asia and the Pacific does not translate into resource circulation of agricultural biomass waste as tapping into this renewable energy source is not mandatory.
4. Post Ha Noi 3R Declaration, several clear goals or targets could be set related to agriculture biomass waste including data collection, quantitative targets of utilization, quantitative targets of increase in installed capacity for bioenergy, quantitative targets of reducing GHG emissions, and encouraging technology sharing and capacity building between developed and developing countries of Asia and the Pacific.

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3.2.6 Food Waste

3.2.6.1 Introduction and Background

An estimated one-third of food is either lost or wasted globally, amounting to about US$940 billion in economic losses in 2012 (FAO, 2015b). This annual loss of about 1.3 billion tons of food waste corresponds to roughly 21 to 37 percent of greenhouse gas emissions globally (IPCC, 2019). These economic costs and environmental impacts of food loss and waste translate to social concerns especially for those employed in the agriculture sector who are likely to be in low-income households. Improving the efficiency of the food supply chain could help bring down the cost of food to the consumers and increase food security and supply, thus, it could deliver immediate and significant impacts to the farmers (FAO, 2011).

Food loss and waste also represent lost opportunities for sustainable consumption and production, food security and proper nutrition, and they happen in every stage of the food supply chain. Food loss occurs from the production stage to pre-retail due to some practices and limitations in harvesting, storage, transportation and infrastructure systems. Food waste, on the other hand, mostly occurs in retail and consumption stages due to erratic product demand patterns, confusing date labels, and poor storage management in households (FAO, 2019). Worldwide, food continues to be lost or wasted primarily due to producers deciding to maximize their profits and consumers protecting their well-being and their families resulting to losses along the way.

Food loss and waste presents a vital challenge to combat hunger, raise income, improve food security, and spur economic and environmental development especially in the poorest countries. Various measures have been put forward to address food loss and waste in food supply chains from farm to fork. At the global level, Goal 12 (Ensure sustainable consumption and production patterns) of the Sustainable Development Goals (SDGs) identified Target 12.3 as halving the per capita global food waste at the retail and consumer levels (Indicator 12.3.1b – Food waste index) and reducing food losses along production and supply chains, including post-harvest losses (Indicator 12.3.1a – Food loss index). This goal is closely related to Goal 2 that is about reducing food loss and zero hunger.

In Asia and the Pacific, the commitment towards sustainable development and achieving resource efficient society was reaffirmed through the development of Ha Noi 3R Declaration held at Ha Noi, Vietnam in 2013. One of the priorities in the Declaration is the Goal 10 which aims to reduce losses in the overall food supply chain while increasing the quality and quantity of products reaching consumers (FAO, 2019; UNCRD, 2013e). Among the priority measures in Asia and the Pacific to curb losses in pre-retail level include the improvement of agricultural knowledge and research, strengthening of technological and personnel capability, and provision of financial assistance. Meanwhile, redistribution of excess foods, repurposing of food waste to animal feeds, and awareness campaigns are the common strategies and initiatives to reduce food waste in the region.

Efforts by both public and private sectors involve the application of technology and encouragement of behavioral changes to address food loss and food waste. Technologies employed involve recycling, composting, and waste to energy, where food wastes are converted into fertilizers, feeds, and energy. Technology startups also emerged wherein smartphone applications were developed connecting food services with excess food or food products close to expiry to food banks or (sold to) consumers at a discount. On the other hand, awareness campaigns, education, and food redistribution constitute behavioral change initiatives implemented in the region.

The increasing awareness of the SDGs and food loss and food waste reduction targets led to initiatives from both private and public sector and collaborative work throughout the Asia and the Pacific. However, rapid urbanization and rising population magnifies the challenge of reducing food loss and waste. Efforts at measuring food loss and waste remain limited, and most of the region have yet to establish food loss and waste reduction targets aligned with the SDG and Ha Noi 3R Declaration. Only Japan and Australia monitor food loss and waste and establish reduction targets throughout the food supply chain (Lipinski, 2020). Data on food loss and waste are important in crafting strategies and policies to adequately address these challenges where they occur in the food supply chain. Research and cooperation need to be encouraged particularly in developing countries to help conduct food loss and waste assessment throughout the food production cycle, and support evidence-based policy and decision making. Likewise, there is a need for a holistic approach and stakeholder engagement to address these issues in a sustainable and inclusive manner towards achieving SDG Target 12.3 and Ha Noi 3R Declaration Goal 10.

3.2.6.2 Regional overview of food waste in Asia and the Pacific

Definition of food loss and food waste

Food loss and food waste are key factors in the decrease in quality and quantity of food products along the food supply chain. **Food loss** occurs at the "production stage of the food supply chain up to, but not including, the retail level." This includes losses in harvest, slaughter, catch, storage, processing, transport, and distribution. **Food waste**, on the other hand, "occurs in the retail and consumption level, including wastes from household and food services" (FAO, 2019).

Food loss and food waste challenge food systems in ensuring food security and nutrition. The social, economic, and environmental impacts associated with food loss can further deepen the impacts of agricultural intensification, resource consumption, land conversion and climate change among those involved in the food production sector. Food waste likewise increases the demand on food systems and contributes to the growing pollution problems resulting from agriculture.

Causes of increasing food loss and waste

The Asia and the Pacific region, home to 60 percent of the world's population or 4.3 billion people, experienced one of the most rapid growth in population and economic progress among all the major regions in the world in the past decades. The region faces a challenge in nutrition as 479 million of the population are undernourished, while in case of overweight and obesity in the adult population are increasing. Consequently, there is a massive increase in the demand for food in the region and changes in the type of food demanded, which may contribute to the increasing food loss and waste (FAO, 2020).

Food loss and waste throughout the food supply chain can potentially be due to direct causes or indirect drivers (**Figure 3.2.6-1**). Direct causes are associated with actions (or lack thereof) of some sectors in the supply chain such as harvest and post-harvest practices and technologies. Indirect drivers refer to economic, cultural, and political environment of the food supply chain on which the actors operate that may influence the food supply chain such as market prices, legal framework, and public infrastructure. From production to pre-retail, the causes of food loss include lack of storage and transportation facilities, poor scheduling and machinery, substandard quality, and inadequate processing capacity and management. From the retail to consumption stage, erratic demand patterns, confusion of date labels, poor storage and stock management, and oversized portions are the common causes for food waste. In developed nations, food loss and waste can be attributed to consumer behavior patterns as well as poor coordination between different sectors in the food supply chain (FAO, 2019). On the other hand, the causes of food losses and wastes in developing nations are mainly connected to financial, managerial, and technological limitations in harvesting, storage and transportation, manufacturing, infrastructure, and marketing systems (FAO, 2011).

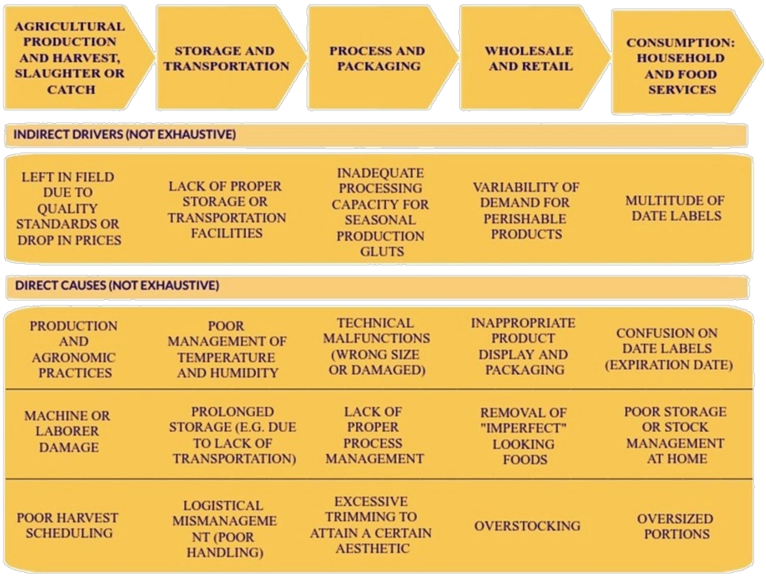

Figure 3.2.6-1: Potential direct causes and indirect drivers of food loss and waste, globally. Source: (FAO, 2019)

In Asia and the Pacific, similar causes for food losses and wastes are observed as with the global causes (**Table 3.2.6-1**). For instance, the lack of infrastructure in storage, transportation and processing, and inefficiencies in agricultural practices in India, Bangladesh, Pakistan and Indonesia are among the commonly cited causes of food loss. The technological, managerial, and technical limitations faced by many developing countries add to the challenge in addressing these problems. In addition, the geographical location of Asia and the Pacific, with its vast coastlines, islands and coastal communities, makes it among the most vulnerable to climate change impacts, such as rising sea levels, stronger typhoons and unpredictable weather that contribute to losses in the production side (agriculture) of the food supply chain.

On the consumption side of the food supply chain, many developed countries in the region like Japan, the Republic of Korea, Australia, and New Zealand) experience food waste due to over production and excess stocks, and spoilage of food going beyond expiry date. Some consumer practices contribute to food waste like choosing products with later expiration date even when product is to be consumed right away, buying in bulk for discounts, and preferring blemish-free produce. On a macro scale, cultural practices, societal norms, community habits and increasing incomes in the region are some of the factors that also impact food waste. Comparing global data on where food loss and waste happens, industrialized economies and developed countries appear to have less food loss at the production stage having more advanced technologies and systems to mitigate losses in production, storage, and transportation compared to developing nations (Lipinski, 2020). **Appendix 3.11** provides more details on the causes of food loss and food waste along with references.

Table 3.2.6-1: Causes of food loss and waste in Asia and the Pacific

Country	Cause of Food Loss	Cause of Food Waste
East and Northeast Asia (ENEA)		
PR China (Liu et al., 2013; Liu et al., 2016; Ma et al., 2015)	• Lack of sowing technologies, drying equipment, and other technologies needed for production • Inadequate storage facilities, modern logistics system, food processing technologies, and mechanized bulk handling equipment • Presence of diseases, insects, weeds, and rodents; severe weather during planting and inefficient seeding practices	Rapid urbanization resulting to changes in consumption pattern (more leftovers)
Japan (Ju et al., 2017; Liu et al., 2016; Wakiyama et al., 2019; Watabe et al., 2016)	Oversupply, overproduction, and disposal of agriculture products in the field due to the lack of demand	• Non-standard, excess, damaged, and expired products • Increase in affluence and changes in consumption behavior and traditions for younger generations
The Republic of Korea (Adelodun and Choi, 2020; Kim and Lee, 2020; Lee et al., 2007)		• Consumption culture and behavior of having too many side dishes leading to more waste • Increasing non recyclables in the collected food waste
North and Central Asia (NCA)		
The Russian Federation (Filimonau and Ermolaev, 2021)	Inadequate storage facilities, presence of pests and unpredictable weather	Poor sales leading to disposal of food products
Kazakhstan (Broka et al., 2016; UNDP, 2020)	Lack of transportation methods and processing equipment and lack of climate change adaptation measures	
Pacific		
Australia (Lapidge, 2015; RIRDC, 2017)	• Lack of quality, low demand, labor shortages, and contractual supply agreements • Product damage, contamination, and inefficient handling and manufacturing processes • Presence of pests, diseases, and unpredictable weather	• Confusion over "use-by" and "best before" date labelling • Food products are left too long in the fridge leading to leftovers
New Zealand (Goodman-Smith et al., 2020; Goonan et al., 2014; Mirosa, 2019)	Improper crop management and canceled export orders	Imperfections in appearance and lack of portion control

Country	Cause of Food Loss	Cause of Food Waste
Pacific Islands (FAO, 2015a; UNCRD, 2016c)		• Changing consumption patterns attracting importation of goods which are unregulated leading to substandard quality of products and close to expiration date • Overripening of products, long distance travel of goods, and lack of storage facilities
South and Southwest Asia (SSWA)		
India (Gokarn and Choudhary, 2021; Magalhães et al., 2021)	• Inadequate storage facilities and low packaging efficiency • Lack of market and transportation infrastructure and transportation planning • Presence of pests, natural hazards, and other seasonal factors	Consumption behavior patterns of leaving too many leftovers
Bangladesh (Ananno et al., 2021; Bari, 2015)	Inadequate infrastructure, processing facilities, preservation facilities, modern technologies, and poor handling of agricultural goods	
Pakistan (Aamir et al., 2018; Menhas et al., 2016; Tostivint et al., 2017)	Inefficient production techniques, improper handling, and substandard quality and unpredictable weather	Overproduction, plate waste, and spoilage
Southeast Asia (SEA)		
The Philippines (Doliente and Samsatli, 2021; Limon and Villarino, 2020)	Lack of transportation infrastructure and mechanization and inefficient milling technology	Rapid population growth and lack of recycling facilities
Indonesia (Srivastava, 2019)	• Erratic weather patterns • Lack of machineries, food preservation and processing, packaging, handling, distribution, and marketing infrastructures	
Singapore (Grandhi and Appaiah Singh, 2016; Singapore Environment Council, 2019)	• Improper handling and lack of storage with temperature control • Packaging failures	• Food spoilage, substandard food, and lack of appropriate methods for sorting and recycling facilities • Throwing away unconsumed food due to reasons such as filtering of “ugly foods”, lack of penalties for throwing away food, and improper storage of food, purchasing patterns, and food handling habits of consumers

3.2.6.3 National regulations, standards and guidelines to reduce food loss and waste

National policies and programs to reduce food loss and waste in food supply chains

Policy approaches to food loss in the region is closely tied to the focus on food security in Asia and the Pacific nations as a response to the growing food demand and the need to reduce food losses along the food supply chain. Overall, the policy priorities in the region aim to increase productivity and efficiency of food systems through a variety of measures like improving agricultural knowledge and research, strengthening technological and personnel capability, and providing financial assistance (**Table 3.2.6-2**). Specifically, Asia and the Pacific focuses on pre-production and production stages of food supply chain wherein farmers and farm enterprises are empowered to encourage food security and to address the demand of the growing population in the region. Although many country policies highlight the importance of proper food storage and distribution practices, more investment and support are needed to fully address the challenges in food supply, food loss and related concerns especially among developing countries. The need to reduce food loss may also be considerably emphasized in country policies to relay its importance in food security.

Local policies and programs to reduce food loss and waste in consumption-level

Policies addressing food waste at the consumption level generally involve food waste recycling or repurposing and food rescuing (**Table 3.2.6-2**). Food waste recycling and repurposing converts it to feed, fertilizer or energy. Waste segregation as part of the 3R (reduce, reuse, recycle) measures commonly implemented in solid waste management policies in the region can facilitate in the collection of food waste that will go through recycling or repurposing. This approach can be observed in both industrialized and developing economies in the region wherein food wastes are usually repurposed as animal feeds and and or fertilizers.

Most of the nations in the region also have initiatives focusing on food rescuing and redistributing the excess foods from various sources to those in need addressing the food wastes in the food services consumption stage of the food supply chain. In Auckland, New Zealand, the Kai Ika initiative collects discarded fish parts and distributing them to the communities who value and reuse these parts. Some countries have also been responsive in addressing potential bulk sources of food waste and consumption trends that can result to food waste. For instance, the Disposal of Excess Food Regulation of 2019 in Pakistan rewards restaurant and hotels supporting the initiative of reducing food waste and proper disposal of excess food. Moreover, many Asia and the Pacific nations also include food waste reduction strategies and interventions in the development of their plans and programs primarily targeting household and food services consumption.

Table 3.2.6-2: Policies in Asia and the Pacific region on food loss and food waste

	Food Loss	Food Waste
East and Northeast Asia (ENEA)		
	Improvement of food security by protecting production resources such as arable lands and grasslands, perfecting and improvement of grain distribution, storage, and processing system, strengthening of scientific and technological support to agriculture, and creation of food policies promoting production capability, arable land protection, water resource protection, agricultural and food science development plans, grain saving livestock development plan, and grain logistic, storage, and processing development plan	• Encourage the citizens to eat everything on thei • Banning of binge eating (mukbang) video excessive leftovers in restaurant
	Improvement of the structure of agricultural production by stressing the importance of farm enterprises, identifying the principal farmers who would be the foundation of a stable and efficient farm system, and promotion of new entrants to agriculture	• Obligate national and local government to dev loss reduction • Promote food waste reduction by recycling the f
	Improvement of the agricultural competitiveness, increase of the farmer's safety net income, and enhance the quality of life to the people in rural areas	Limiting the food waste by charging households a fee discarded food wherein the waste is repurposed to eit feed
North and Central Asia (NCA)		
	Development of strategic planning focusing on food security, food independence, balanced food consumption, economic food availability, physical food availability, and framework for development of regulatory legal policies in this area	
	Creation of development plans and strategies to provide financial support to the agriculture sector and diversification of crops to ensure food security	
Pacific		
	Development of a strategy that focuses on capacity development of the workforce by promoting interdependency and cooperation, local empowerment, excellence, and continuous capability development	Development of a framework in four priority areas: p improvement, market development, and behavior cha avoidance, reduction and repurposing, adoption of tec markets to support food waste repurposing, and prom avoiding and reducing food waste
	Development of policies focusing on animal diseases control, natural hazards insurance, and improvement of agricultural knowledge and information system	Provision of technical and financial support to variou government organizations that have initiatives in redu
		Development of strategy and action plans to reduce fo

	Food Loss	Food Waste
		landfill using composting and other recycling technol
South and Southwest Asia (SSWA)		
	• Provision of financial assistance and relief to farmers from losses due to natural hazards • Provision of investment subsidies to businesses involved in agriculture • Enhancement of agricultural productivity focusing on integrated farming, water use efficiency, soil health management, and resource conservation	• Creation of initiatives that minimize the food wa from various places and events and redistributin poor • Provision of strategic regulation and program fo waste and facilitation of massive awareness prog
	Ensure a modern and efficient food production and distribution system that can best contribute towards food security and nutrition, in terms of availability, access, utilization and stability	Development of initiative providing food from the ex hotel that will be given to the people in need
Southeast Asia (SEA)		
	Improve self-sufficiency levels and climate change resiliency through new crop varieties, modernizing agricultural production and post-harvest handling, empowering cooperatives, and collaborations, and educating farmers and fisher folk on modern techniques	Improve organic waste segregation, recycling of orga logistics in food markets, depots, and terminals
	Improve overall land productivity by reusing one-third of degraded land and limiting global cropland	Reduce food loss within the supply chain and during t through the evaluation of consumption and food wast post-harvest loss and value-creation
	Promote sustainable agriculture through water and land resource management, organic farming, produce marketing, research and innovation, and logistics systems and farmer welfare improvement	Address food waste and loss issues by improving foo among communities, reusing agricultural waste, and f
		• Mandate food waste segregation and treatmen industrial premises from 2024 onwards to allo and potential for treatment. • Mandate large developers of new commercial a to allocate and set aside space for on-site food their design plans (e.g., aerobic digestion system

Policies and systems that enable best practices

To build effective circular economies for food, it is important to first recognize that policy systems that enable and support circular economies are often prerequisites. With supportive systems incentivizing and motivating the conception of ideas for reapplication, valorization, and diversion of food waste, ideas can be realized as real-life applications that result in positive environmental impact. **Table 3.2.6-3** lists out policy systems that enable circular economies for food from around the world.

Table 3.2.6-3: Policies that enable food waste circular economics from around the world

Geography	Policy and System
Australia	Circular Economy Policy released in New South Wales (NSW) in Feb 2019 – *Too Good to Waste*. The policy provides direction for circular with seven guiding principles, defines the State Government's role in implementing circular economy principles across NSW and provides principles for implementing circular economy in the Government's processes and decision making(Economics, 2020).
	The State of Victoria has commenced shifting towards a circular economy and is currently developing a circular economy policy and action plan to be released in late 2019 through the Department of Environment, Land Water and Planning (KPMG, 2020).
	In 2019, the Queensland State Government defined its waste vision and strategy towards a zero-waste society that leverages circular economy principles. Earlier this year Queensland became home to Australia's first Circular Economy lab with an aim to help drive the state's transition to a new low-carbon and circular economy, delivering opportunities for industry and more jobs for Queenslanders. A key focus of the Circular Economy Lab is to consolidate industry, research and government partnerships and expertise to identify and deliver circular economy pilot projects, including two focused on the food supply chain.
	In June 2019, the Government of Tasmania released a Draft Waste Action Plan for consultation. The plan proposed, among other targets, the reduction of organic waste sent to landfill by 25 percent by 2025 and 50 percent by 2030 and the introduction of a waste levy by 2021 (Economics, 2020)
	Through circular economy principles the state of South Australia is transforming the way the economy uses and values resources. Top of the agenda is reforming household waste, reducing food waste through developing industry solutions, reforming packaging and single use items, developing the circular economy in business and preparing for waste resulting from natural disasters (KPMG, 2020).
	These initiatives correspond to goal 2's indicators of reduction of organic waste landfilled per capita and reduction of amount of organic waste component of MSW treated by waste-to-energy, and number of jobs in organic waste management (formal and informal) and goal 10's indicator of reduction of percentage of food loss at each stage of food supply chain, as per the Ha Noi 3R Declaration (UNCRD, 2013).
Japan	The Japanese Government enacted the law entitled "Basic Act on Establishing a Circular Society" in 2000 (KPMG, 2020).
	In May 2019, the Government introduced the Food Loss Reduction Promotion Bill which will come into effect by the end of 2019. The Bill includes the establishment of a food loss reduction body in the Cabinet Office that will be responsible for policy development on the issue. The Bill establishes October as the annual Food Loss Reduction month and requires Government to investigate food loss and enable initiatives that support entities such as Food Bank (KPMG, 2020).
	The Japanese concept of "mottainai" refers to regret at allowing a resource to go to waste without using its full value(Economics, 2020).
	The Japanese food industry recycles about 85 per cent of its food waste, which are turned into animal feed, fertilizer or methane (KPMG, 2020).
	These initiatives correspond to goal 2's indicator of reduction of organic waste

Geography	Policy and System
	landfilled per capita and goal 10's indicator of reduction of percentage of food loss at each stage of food supply chain, as per the Ha Noi 3R Declaration(UNCRD, 2013).
Cambodia	The 166-page "Waste Management Strategy and Action Plan of Phnom Penh" was adopted in 2018 with food waste positioned as a key component where the gradual development of resource utilization capacity and phased approach to the introduction of source segregation are planned (Dickella, et al., 2020; Phnom Penh Capital Administration, 2018).
	These initiatives correspond to goal 2's indicators of reduction of organic waste landfilled per capita, amount of organic waste component of MSW treated by anaerobic digestion, reduction of amount of organic waste component of MSW treated by waste-to-energy, number of jobs in organic waste management (formal and informal), and amount of organic waste component of MSW treated by waste-to-energy, and goal 10's indicator of reduction of percentage of food loss at each stage of food supply chain, as per the Ha Noi 3R Declaration (UNCRD, 2013).
Singapore	Singapore introduced the Zero Waste Masterplan in 2019 with aims to achieve a 70 per cent overall recycling rate and to reduce the amount of waste sent to Semakau Landfill by 30 per cent per capita per day by 2030(MSE, 2019). Food waste is one of three priority waste streams identified under the Zero Waste Masterplan (MSE, 2019).
	The Resource Sustainability Act (RSA), which was enacted in 2019,gives legislative effect to the regulatory measures targeting the three key waste streams under the Zero Waste Masterplan. Under the RSA, it is mandatory, from 2021 onwards, for developers of new commercial and industrial developments, where large amounts of food waste are expected to be generated, to allocate and set aside space for on-site food waste treatment systems in their design plans. From 2024 onwards, it will be mandatory for the owners and operators of commercial and industrial developments, where large amounts of food waste are generated, to segregate their food waste for treatment(MSE, 2019).
	In 2021, the National Environment Agency (NEA) launched the Food Resource Valorisation Award to recognise companies in Singapore that engage in food waste valorisation to convert food waste into higher-value products and raise awareness on food waste valorisation(MSE, 2019).
	These initiatives correspond to goal 2's indicator of reduction of organic waste landfilled per capita and goal 10's indicator of reduction of percentage of food loss at each stage of food supply chain, as per the Ha Noi 3R Declaration (UNCRD, 2013f).
Pakistan	The Disposal of Excess Food Regulation of 2019 rewards restaurants and hotels supporting the initiative of reducing food waste and proper disposal of excess food (Sarkar et al., 2022)

3.2.6.4 Food loss and waste status in Asia and the Pacific

Asia and the Pacific faces major challenges in addressing the food loss and waste in every phase of the food supply chain. Although significant efforts have been carried out to manage food waste and the related challenge of food security, the Asia and the Pacific region need to increasingly respond to food loss and food waste considering the socioeconomic realities and sustainability aspirations of the region.

Percentage of food loss at each stage of food supply chain (HNG10-1)
In recognition of the Tokyo 3R Statement and Singapore Forum on the 3Rs in Achieving a Resource Efficient Society in Asia, the Asia and the Pacific countries reaffirm their commitment in realizing sustainable actions and measures for achieving resource efficient society and a green economy in the region through the implementation of 3Rs (reduce, reuse, and recycle) and the development of Ha Noi 3R Declaration during the 4th Regional 3R Forum in Asia held at Ha Noi, Viet Nam in 2013 (UNCRD, 2013e). The Hanoi Declaration contains 33 goals divided into four subsectors, namely, 3R Goals in Urban and Industrial

Areas, 3R Goals in Rural Areas, 3R Goals for New and Emerging Wastes, and 3R Goals for Cross-cutting Issues. One of the goals in the Declaration is to reduce losses in the overall food supply chain (Goal 10), leading to reduction of waste while increasing the quality and quantity of products reaching consumers. The indicator identified for Goal 10 is the percentage of food loss at each stage of food supply chain.

Estimates in 2009 show a noticeable difference as to where food loss and food waste occurs in the food supply chain between regions and subregions globally (**Figure 3.2.6-2**). A larger share of food loss and waste occurs at the consumption stage in developed regions and countries like North America and Oceania (58 percent), Europe (42 percent) and Industrialized Asia (35 percent), whereas much of the food loss and waste happens at the production (farming activities) and handling and storage stage in South and Southeast Asia (total of 65 percent) and Sub-Saharan Africa (total of 72 percent). The total share of food available that is lost and wasted also varies between 26 percent (South and Southeast Asia) to 36 percent (Sub-Saharan Africa; North Africa, West and Central Asia) (Lipinski, 2020). The Food Loss and Waste Database (https:andandwww.fao.organdplatform-food-loss-wasteandflw-dataandenand) of the Food and Agriculture Organization (FAO) gathers data of food loss and waste from literature and reports, but various geographical areas still have unavailable information regarding these indicators.

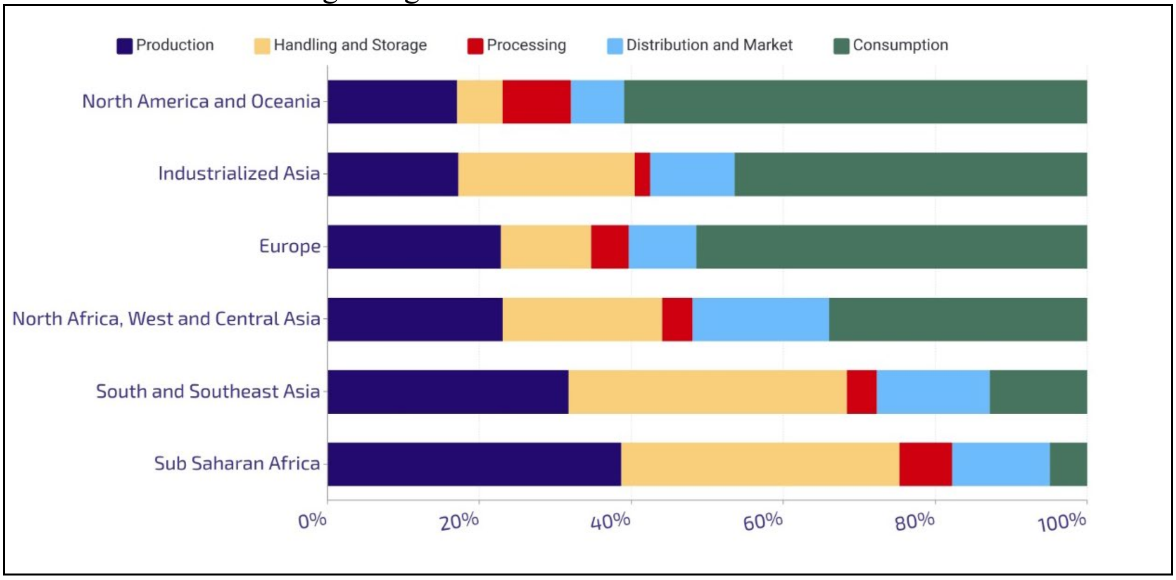

Figure 3.2.6-2: Food loss and waste by region and stage in the food value chain. Source: (Lipinski, 2020)

Reducing food loss and waste is vital in decreasing production costs and increasing efficiency of food system, improving food security and nutrition, and contributing towards environmental sustainability. The call for reduction of food loss and waste is indicated under Target 12.3 of SDG 12, which aims to "halve per capita global food waste at the retail and consumer levels and reducing food loss along production and supply chains including post-harvest losses". To measure and track the progress of SDG Target 12.3, FAO and UNEP developed two indices, Food Loss Index (FLI) and Food Waste Index (FWI), respectively (FAO, 2019). In Asia and the Pacific, most nations have yet to develop reduction targets pursuant to SDG Target 12.3. PR China, Japan, Vietnam, Malaysia, and Australia are the only nations that developed targets aligned with SDG Target 12.3. Meanwhile, only Japan, Australia, and New Zealand measure food loss and waste in the Asia and the Pacific Region (Lipinski, 2020).

Food Loss Index
Food Loss Index measures the percentage of food losses that occur from production level up to, but not including, retail level. The FLI, which is reported by FAO, measures the changes in the percentage of food losses of the top 10 major commodities of the country in comparison with a base period.

Globally, the percentage loss from post-harvest to distribution in 2016 is 13.8 percent. Central and Southern Asia represent the highest loss with more than 20 percent of food loss, while Australia and New Zealand have the lowest with just under 6 percent (**Figure 3.2.6-**). Both subregions are located in the Asia and the Pacific showing a huge gap among the nations in the region.

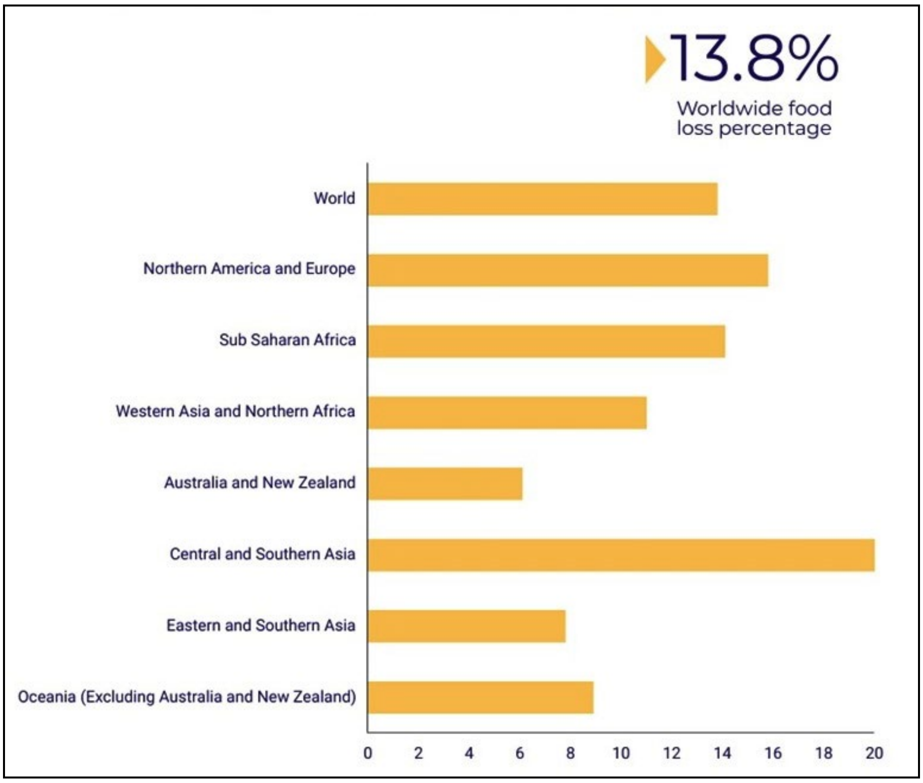

Figure 3.2.6-3: Food loss percentage in selected regions, 2016. Source: (FAO, 2019)

Food Waste Index
Food Waste Index, with UNEP as the point organization, measures food and inedible parts wasted at the retail and consumption levels (household and food service). Unlike the Food Loss Index, the Food Waste Index measures the total food waste rather than calculating the losses of the specific commodities.

A recent report by UNEP (2021) estimated food waste to be 931 million tonnes, where 61 percent came from households, 26 percent from food and restaurant services, and 13 percent from retail sources (**Table 3.2.6-4**). It was also estimated that 17 percent of the total global food production may be wasted with the household sector contributing the most with 11 percent of the total.

Table 3.2.6-4: Food waste statistics, globally and per sector, 2019. Source: (UNEP, 2021)

Sector	Average Food Waste (in kg/capita/yr)	Total weight (in million tonnes)	Food Waste Percentage
Household	74	569	11 percent
Food Service	32	244	5 percent
Retail	15	118	2 percent
Total	121	931	17 percent

In terms of average household food waste per region (**Figure 3.2.6-4**), reported food waste is highest in Sub-Saharan Africa and Western Asia with 108 and 110 kg per capita per year, respectively (UNEP, 2021). In Asia and the Pacific region, Southeast Asia has the highest average household food waste with 82 kg per capita per year.

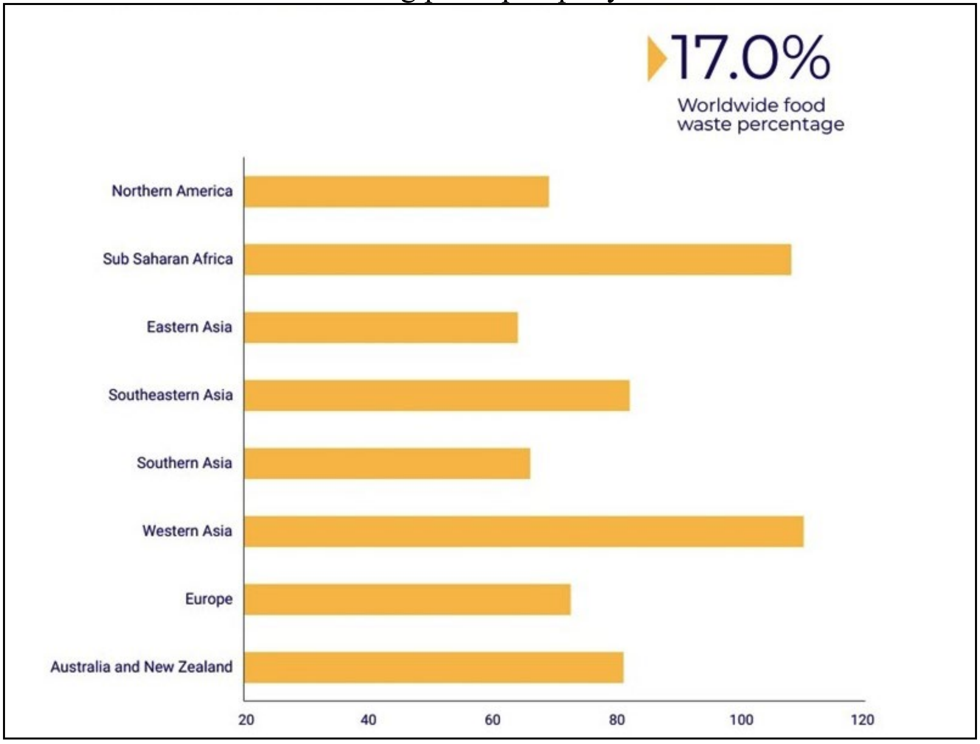

Figure 3.2.6-4: Average household food waste in selected regions. Source: (UNEP, 2021)

Previous estimates suggest that household food waste is a high-income country issue. However, high levels of food waste per capita are already seen in developing regions. While the limited data may be a factor, it should be noted that the Food Waste Index covers both edible and inedible food, thus, household food waste could be a consequence of unavoidable and inedible food scraps. Another contributing factor is the scope of food waste utilized in the calculations and reporting, wherein waste repurposed as animal feeds and processed into energy are not included in the calculation. The lack of recycling and technological capacities in developing nations may have contributed to the high values of food waste reported (UNEP, 2021). Despite the higher food waste generated in developing economies, the food waste percentage in relation with the overall losses in the food supply chain is still higher in developed nations.

3.2.6.5 Stakeholder's engagement to reduce food loss and waste

Various efforts have been done by the nations in Asia and the Pacific to address the issues and challenges surrounding food loss and waste (**Table 3.2.6-4**). As noted by FAO (2011), one of the leading causes of food loss and waste in developing nations is technological and consumption behaviors, and diet patterns for the developed nations.

Technological Innovation and improvement to reduce food loss and waste

Historically, new technologies, research and innovation always happens in the agricultural sector. However, the concept of food supply system has been largely absent as the focus is primarily looking at agriculture as singular activity rather than multi sectoral process that interact within the food supply system. With the growing challenge of interrelated issues on food waste, food loss, food security, and nutrition, a holistic perspective to address these will be needed involving the entire food supply chain (World Bank Group, 2020).

In Asia and the Pacific, efforts have been done to integrate technological innovations in the food supply chain (**Table 3.2.6-4**). Most of the technological initiatives in the region are recycling, composting, and waste to energy technologies where the food wastes are converted to useful products like fertilizers, animal feeds, and energy. Established technologies like biogas digesters and incineration with energy production are widely employed in the region to make use of food waste. On the other hand, Australia provides financial and technical aid to businesses that develop new processes and technologies to address waste management.

Several initiatives also make use of technologies to improve production, storage, and transportation processes, which is where most of the food loss and waste in developing countries occur. These technologies include cold storage systems, cultivating equipment to reduce food loss and improve crop yield and management, respectively. The Philippines also provides technical assistance to farmers to assist in farm management and productivity. Although there are some initiatives to reduce food losses along the pre-retail stages, the bulk of the measures in the region are towards converting and processing food wastes. Only a few measures have been done to address the food losses along the supply chain and improve the efficiency of the logistics from production to retail.

Behavioral Changes

Education and awareness campaigns are the most common means implemented that target behavioral change to address the need for food loss and waste reduction, with some novel initiatives in the Asia and the Pacific (**Table 3.2.6-5**). Regulatory measures like banning certain activities and economic measures like fees have also been observed. In PR China, binge eating (mukbang) videos, competitive eating, and excessive leftovers are banned through the Food Waste Law. The Republic of Korea's "Pay as you Throw" policy imposes a fee to the household food waste based on the weight to encourage households to reduce their food wastes. Initiatives regarding selling of produce that did not pass aesthetic standards at a discounted rate are emerging in Singapore. Similar to the technological innovation initiatives, the approach regarding behavioral change tends to focus on the food waste reduction and limited projects are done towards the losses from production to retail.

Table 3.2.6-5: Technological innovations and behavioral change initiatives in reducing food loss and waste in Asia and the Pacific

Country	Technological Innovation	Behavioral Change
East and Northeast Asia (ENEA)		
Japan	Promotion of recycling technologies that converts food wastes into feed and or fertilizer	• Promotion of the initiative "No-Food loss Project" which aims to reform the behaviors of all actors in food supply chain • Promotion of the initiative "Salvage party" to collect, gather and cook the food surplus of the participating households
PR China	Use of anaerobic digestion technology to convert organic matters into biogas or nutrition rich fertilizers	• Encourage the citizens to eat everything on their plate • Banning of binge eating (mukbang) videos, competitive eating and excessive leftovers in restaurant
The Republic of Korea	Introduction of waste to energy technologies that will convert organic wastes, including food wastes, to useful forms of energy	• Introduction of "Food Table with Less Waste" campaign which aims to educate and raise awareness to reduce food waste • Imposition of a fee to the household's food waste based on weight through "Pay as you throw" policy
North and Central Asia (NCA)		
The Russian Federation		Support of FAO Save Food initiative which creates awareness campaigns and development programs to reduce food waste
Kazakhstan		Integration of waste management and environmental protection to the state educational standards and curricula
Pacific		
Australia	Provision of financial assistance to the businesses to develop new processes and technologies, particularly energy efficient and low emission products	Promotion of "Love Food, Hate Waste" campaign which aims to raise awareness regarding the impacts of food waste
Samoa	• Use of biogas digester technology to convert organic waste to energy and gas • Development of composting facility to divert organic wastes	
Tuvalu	Development of composting technologies to convert food wastes to pig feeds	
South and Southwest Asia (SSWA)		
Bhutan	Establishment of a compost plant facility to manage the organic waste of the capital city Thimphu	
India	• Conversion of wastes from slaughterhouses into food and feed of pets, poultry, and fish using clean technologies • Improvement of transportation sector through technology integration	• Allocation to food banks from food wasted in the restaurants • Restaurant initiatives of installing public fridge outside restaurants to provide leftovers to anyone in need

Country	Technological Innovation	Behavioral Change
Afghanistan	• Introduction of modern agriculture techniques in storage, processing and handling of products • Establishment of local and cold storages to reduce food loss	
Sri Lanka	Introduction of proper packing methodologies and food preservation technologies	
Southeast Asia (SEA)		
The Philippines	• Provision of technical assistance and cultivating equipment to farmers • Provision of postharvest facilities such as freezers, cold storage facilities, and mechanical dryers	Campaign to raise awareness and encourage stakeholders to help improve the Philippines' rice industry
Vietnam	• Provision of harvesting facilities such as harvester and thresher • Conversion of food waste to animal feeds using heat and dehydration technology	
Singapore	• Development of cold chain process to reduce food loss • Valorization of by-products from the food supply chain into higher value products, including food ingredients or animal feed • Conversion of food waste to energy using aerobic and anaerobic digestions • Use of incineration technology to convert organic matters to heat and energy	• Conduct of awareness and advocacy campaigns about economic and environmental impacts of food waste and encourage youth to take action in their food waste • Emergence of initiatives that sell food that didn't pass aesthetic standards at a discount

Food waste management: Linear Economy to Circular Economy

In recent years, global attention has shifted towards the new economic development model circular economy from the linear economy. The linear consumption model assumes unlimited resources and generates wastes. This "take-make-dispose" model sees raw materials collected, transformed into products for consumption and use, and finally disposed. The circular economy, on the other hand, follows a close loop system in which resource use is minimized (reduce), reuse of products and parts is maximized (reuse), and products and raw materials are reused to a high standard (recycle). In this economic system, the value of circular economy is created by focusing on value preservation whereas the value of linear economy only increases by producing and selling as many products as possible (Kuah and Wang, 2020).

Asia and the Pacific experiences rapid urbanization and industrialization, which pose challenges in the management of the natural and ecological resources. Future economic growth needs to be sustainable and resilient to combat and minimize the effects of pollution, natural disasters, and climate change, and effectively manage the finite resources to meet the demand of the growing population. There is also a need to develop strategies and policies to ensure the security of the region's cities, rural communities, natural environment, and ecological assets. Shifting to circular economy is one of the interventions being employed globally and its concepts continue to gain momentum because of the large benefits that it can give. Studies suggests up to 80 percent savings in raw materials, energy use and emissions could be achieved in energy, transport, and food sectors. Recognizing the benefits of circular economy, the Asia and the Pacific region promoted circular economy through the Adelaide 3R Declaration to strengthen collaboration among countries and within countries and develop initiatives and policies that will implement the concepts of circular economy.

The food sector operates in a linear manner, which increasingly stresses the natural resources for food production, and pushes the assimilative capacity of the environment for waste in food manufacturing activities and food loss and waste. In this linear system, food and related products is harvested, manufactured and consumed, and the resulting waste go to landfills for disposal. In applying circular economy in the food sector, the objective is to reduce the waste. Various opportunities exist for sustainability in the food supply chain, such as creating loops in the system through recycling activities that will divert food waste intended for landfills and repurpose it to other products like feed and fertilizer (Hondo, 2021). By recycling food waste, less waste is disposed in landfills, less greenhouse gas is released from decomposing organic matter, and new function is created from waste. Alternately, other potential uses of food waste may be explored to slow down the transformation of resources from raw material to waste. Instead of disposing food waste, energy products like biogas and methane may be produced from certain food waste.

Many initiatives, both by public and private sectors, in Asia and the Pacific resulted to positive impacts in reducing food loss and food waste through the recognition of 3R policies and circular economy concepts. In food storage, the use of simple structures and technologies can lead to significant reductions in food loss (**Box 3.2.6-1**). In many countries of the region, cold storage technologies are still lacking, and its widespread use will greatly reduce spoilage of the agricultural products.

Box 3.2.6-1 Food Storage and Handling Case Studies

Evaporative Coolers in India

In the mid-1990s, the organization Krishi Vagyan Kendra (KVK) constructed 200 Zero Energy Cool Chambers in 10 villages after observing that farmers take their products far more often than they would prefer otherwise the crops would spoil. The project was able to increase shelf life by up to 111 percent.

Metal Silos in Afghanistan

Metal silos were provided to 18,000 households in Afghanistan through a project initiated by FAO and using the funding from German government. Recipients of the silos reported reduction of food loss to 1-2 percent from 15-20 percent before using metal silos.

On the technological side, various startups develop applications to save edible food that are about to be discarded by connecting consumers and food services, wherein consumers can avail the products at a discount or with reward points (**Box 0-23.2..6-2**and **Box 3.2.6.3-3)**. In the Republic of Korea, Smart Bins are scattered all over the capital city of Seoul where residents are charged based on the weight of food waste that they throw. The fees on food waste serve as a means of discouraging people from generating food waste or encouraging to buy and consume sufficiently.

Box 3.2.6-2 Ecobuy App

Ecobuy App awards consumers benefits in the form of reward points who use the app after buying products that are near expiry. The project was launched in Mini Piago Supermarket in partnership with Tokyo Metropolitan Government to reduce food waste in the metropolis. Products with ecobuy sticker are discounted and consumers are also alerted about the best-before dates and consume-by dates of the items that they purchased.

Awareness campaign, education, and food redistribution are the common initiatives implemented by the countries in Asia and the Pacific to spur behavioral change. Social media increasingly becomes a top venue or awareness and education that could potentially reach a broader audience. In PR China, the “Clean Your Plate” Campaign in 2013 sparked awareness using micro blogging sites and contributed to the government’s fight against lavish government-funded food banquets. There are initiatives in Australia and the Russian Federation that save food that are about to be lost or wasted by connecting donors to the needy. In Singapore, the “Love Your Food @ Schools” project raises awareness among primary and secondary school students and help them develop programs and initiatives to reduce food waste.

Box 3.2.6.3-3. Household and Food Services Consumption Case Studies

Food sharing Moscow

Foodsharing Moscow project is a voluntary movement organization wherein volunteers collect food that are mostly near expiry from donors and redistributing it primarily to large families, senior citizens, and the disabled or charity funds. The organization uses an internal platform where the closest volunteer is selected to deliver donated products immediately to avoid using storage systems.

Second Bite

Second Bite is a non-profit organization in Australia that facilitates, rescues, and distribute food by linking farmers, retailers, and donors with the food banks. The rescued edible surplus and unsold food are distributed to over 1,400 charities to feed Australians in need.

Surplus App

Surplus is an Indonesian application which connects food merchants with surplus and near expiry food items with the consumers who can purchase their products at a discount. In total, the app was able to save about 1 ton of food waste and more than 3,000USD of expense was avoided.

Treatsure App

Treatsure is a Singaporean application wherein it allows consumers to pack home leftover food, primarily from buffets and hotels, an hour before closing time for 10SGD per box. In 2019, around 20 boxes of leftover food are saved every single day.

Generally, initiatives by the private sector focus on reducing the food waste in household and food services consumption. Additional food loss and waste interventions in other stages (production to retail) of the supply chain is needed, especially, in developing nations in Asia and the Pacific because bulk of the losses is experienced in these stages.

3.2.6.6 Conclusion and Way Forward

Evolving socioeconomic conditions in the Asia and the Pacific contribute to the challenge of reducing food loss and waste as magnified by the rapid urbanization and growing population happening in the region. Globally, 13.8 percent of food is lost along the food supply chain and 17 percent is wasted. Central and Southern Asia subregion recorded the highest food loss with more than 20 percent, while Australia and New Zealand subregion has the lowest with just under 6 percent. On the other hand, highest food waste was reported in Sub-Saharan Africa and Western Asia with 108 and 110 kg per capita, respectively. In Asia and the Pacific region, Southeast Asia has the highest food waste with 82 kg per capita while Eastern Asia registered the lowest with 64 kg per capita.

The causes of food loss and waste in Asia and the Pacific region vary and may be influenced by a number of factors from culture and consumer behavior to economic capacity. Generally, food loss and waste in developed nations tend to be a result of consumption behavior and poor coordination between different actors in food supply chain. Food losses and wastes in developing nations can be attributed to financial, technological, and managerial inefficiencies. Being in the most disaster-stricken region in the world, natural hazards are also a common reason of food loss in the region.

With the rapid urbanization and rising population in most of the Asia and the Pacific nations, several changes in consumption patterns can be observed throughout the region. Previous estimates indicate that high household food waste is an issue only present in developed nations. However, developing nations also experience high food waste per capita according to latest estimates. This can be attributed to the lack of recycling technologies to convert food waste to more productive resources, and lack of data in developing nations in Asia and the Pacific. Even with ongoing efforts towards SDG12.3 and Hanoi Goal 10, monitoring and reporting of food loss and waste need to be established and strengthened through relevant national agencies.

Various efforts have been developed throughout the region to address the need for food waste management. The development of master plans, strategies and frameworks is the primary focus of the Asia and the Pacific nations to ensure food supply and security. Food rescuing and redistribution of surplus foods are the main programs done to curb food waste in the region. In more developed nations, policies and programs are implemented regarding food recycling and repurposing to other resources. Technological innovation and behavioral change initiatives are developed to combat increasing food loss and waste in the region. Most of the technological initiatives present in the region are food recycling, composting, and conversion of waste to energy and other useful resources. Several startups also emerge throughout the region focusing on reducing the food waste by connecting food services sector with food surplus to the consumers who can avail the products at a discount. Addressing the challenges of food loss and food waste can benefit from cooperation between public and private entities, and north-south and south-south collaboration.

To stimulate behavioral changes, education and awareness campaigns are the most common initiatives done by the Asia and the Pacific nations. Novel strategies and programs such as banning of binge eating (mukbang) videos in PR China and "Pay as you Throw" using Smart Bins in the Republic of Korea have seen positive impacts in reducing food waste. For food waste, approaches may be community-specific, responding to trends, customs, practices and habits of the household or community.

While a significant percentage of food loss happens in the pre-consumption stages for many of Asia and the Pacific nations, much of the measures implemented are geared towards food waste reduction. This response is also observed globally where measures focus mainly on some stages of the food supply chain. Another challenge for the region in addressing food loss and food waste pertains to the lack of data to sufficiently guide policies and programs. The FAO database on food loss and food waste also report unavailable data for some regions, and the recent UNEP report on Food Waste Index also rely on data estimations. Literature and studies also frequently rely on the 2011 FAO report which may not be representative or accurate for some countries and commodities (Xue et al., 2017).

Food that is produced has consumed valuable resources and may have contributed to environmental impacts related to the different phases of the food system. There is a need to develop practical, sustainable, and inclusive strategies and programs, particularly in food loss reduction (production and storage sector) and encourage all actors in the food supply chain to actively participate in crafting solutions against food loss and waste. Working towards reducing food loss through the development of rural communities will also be particularly beneficial to many of the countries in the region where food loss is one of the highest. As noted by the International Resource Panel (IRP), rural development needs to be reinvigorated by investing in rural infrastructure, education, training, technology and knowledge transfer with a specific focus on food loss reduction. Roads, telecommunication facilities, irrigation systems, water supply infrastructure, and other services that enable local production need to be developed to improve the position of the rural stakeholders and enhance the processes during pre-retail stage (UNEP, 2016b).

Adequate data collection, management and analysis need to be encouraged as well since this will provide a clear picture of the problem, and effectively inform policymaking and program development. Such data will also be useful to track the progress of implemented measures on food loss and waste. Every stakeholder in the food supply chain has a key role in addressing the challenges on reducing food loss and waste, and it is vital that they are empowered to help achieve the targets of SDG 12 (SDG Target 12.3) and Ha Noi 3R Declaration Goal 10-1 (HNG10-1).

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3.2.7 Healthcare and Medical Waste

3.2.7.1 Regional Overview in the Region

Globally, safe waste management services for healthcare waste are lacking, especially in least developed countries. The latest available data (from 2019) indicate that 1 in 3 healthcare facilities globally do not safely manage healthcare waste. The COVID-19 pandemic has led to large increases in healthcare waste, straining under-resourced healthcare facilities and exacerbating environmental impacts from solid waste. This report aims to present an overall status of healthcare waste management through the countries in the Asia and the Pacific region describing current healthcare waste management systems and their deficiencies, and summarize emerging best practices and solutions to reduce the impact of waste on human and environmental health with the reference of the Hanoi 3R Declaration and the SDGs. Several definitions have been found in different countries which is discussed below.

i. Definition

The term health-care waste includes all the waste generated within health-care facilities, research centres and laboratories related to medical procedures. In addition, it includes the same types of waste originating from minor and scattered sources, including waste produced in the course of health care undertaken in the home (e. g., home dialysis, self-administration of insulin, recuperative care). Between 75 percent and 90 percent of the waste produced by health-care providers is comparable to domestic waste and usually called “non-hazardous” or “general health-care waste” mostly from the administrative, kitchen and housekeeping functions at health-care facilities and may also include packaging waste and waste generated during maintenance of health-care buildings. The remaining 10–25 percent of health-care waste is regarded as “hazardous” and may pose a variety of environmental and health risks. There are various terms and definitions of Healthcare and Medical Waste used in different countries in the Asia and the Pacific.

India: As per *Biomedical Waste (Management and Handling) Rules, 1998 and* Bio-medical Waste Management Rules 2016, in India, "bio-medical waste" means any waste, which is generated during the diagnosis, treatment or immunisation of human beings or animals or research activities pertaining thereto or in the production or testing of biological or in health camps, including the categories mentioned in Schedule I appended to these rules; The "bio-medical waste treatment and disposal facility" means any facility wherein treatment, disposal of bio-medical waste or processes incidental to such treatment and disposal is carried out, and includes common bio-medical waste treatment facilities. BMW is covered under BMWM (principle) Rules, 2016, BMWM (Amendment) Rules 2018 and 2019; Guidelines for Handling, Treatment and Disposal of Waste generated during Treatment and Diagnosis and Quarantine of COVID-19 patients, CPCB, Version 5, April 2022 and Guidelines on management of BMW in universal immunization programme (UIP), CPCB, 8 Feb 2021.

Japan: Healthcare waste (HCW)in Japan is defined as all the waste generated by healthcare facilities, medical laboratories and biomedical research facilities, as well as waste from minor or scattered sources such as home health care. Another commonly used definition of healthcare waste is: any waste, hazardous or not, generated during the diagnosis, treatment or immunization of humans or animals; or waste generated in research related to the aforementioned activities; or waste generated in the production or testing of biologicals (UNEP, 2012).

Nepal: In Nepal the HCW embraces all the wastes generated through all the medical activities. Medical activities include the activities of, diagnosis, preventive, curative and palliative treatments for human beings, Research pertaining to the above activities and Production or testing of biologicals (Health Care Waste Management Guideline 2014).NSW government, Australia defines the clinical waste as any waste resulting from medical, nursing, dental, pharmaceutical, skin penetration or other related clinical activity that has the potential to cause injury, infection or offense. It includes waste containing: human tissue (other than hair, teeth and nails), body fluids or blood, visibly blood-stained body fluids, materials or equipment, laboratory specimens or cultures and animal tissue, carcasses or other waste from animals used for medical research. Under the Protection of the Environment Operations Act 1997, clinical waste does not include any waste that has been treated by a method approved in writing by the Secretary of NSW Health (NSW Health, 2021).

PR China: As per the Medical Waste Control Act 380 (henceforth, Act 380), PR China, the term “medical waste” is defined as any potentially hazardous solid waste that is generated by medical treatment facilities and laboratory facilities operating in a health center setting (Gao et al., 2018; State Council of China, 2003).

The Republic of Korea: The Republic of Korea MOE promulgated several regulations for definition, segregation, packaging, tracking, and disposal of medical waste. Under the Act, medical waste is defined as any solid waste that is generated by medical treatment facilities and laboratory facilities operating in a hospital setting and is considered to be potentially hazardous to health. The waste includes animal carcasses, human body and animal parts, excretion and secretion from humans or animals, discarded plastic materials contaminated with blood, culture and stocks of infectious agents, discarded medical equipment, and other waste mixed with infectious agents (Jang et al., 2006).

Waste and by-products cover a diverse range of materials, as the following list illustrates:

- Infectious waste: waste contaminated with blood and other bodily fluids (e.g. from discarded diagnostic samples), cultures and stocks of infectious agents from laboratory work (e.g. waste from autopsies and infected animals from laboratories), or waste from patients with infections (e.g. swabs, bandages and disposable medical devices);
- Pathological waste: human tissues, organs or fluids, body parts and contaminated animal carcasses;
- Sharps waste: syringes, needles, disposable scalpels and blades, etc.;
- Chemical waste: for example, solvents and reagents used for laboratory preparations, disinfectants, sterilant and heavy metals contained in medical devices (e.g. mercury in broken thermometers) and batteries;
- Pharmaceutical waste: expired, unused and contaminated drugs and vaccines;
- Cytotoxic waste: waste containing substances with genotoxic properties (i.e. highly hazardous substances that are, mutagenic, teratogenic or carcinogenic), such as cytotoxic drugs used in cancer treatment and their metabolites;
- Radioactive waste: such as products contaminated by radionuclides including radioactive diagnostic material or radiotherapeutic materials; and
- Non-hazardous or general waste**:** waste that does not pose any particular biological, chemical, radioactive or physical hazard.

ii. Types by Sources

Healthcare and Medical Waste are generated at several sources like health care facility where diagnosis, treatment or immunization of human beings or animals is provided irrespective of type and size of health treatment system, and research activity pertaining thereto; accidental release of bio-medical waste in any water body but exclude accidents like needle prick injuries, mercury spills; Health and medical wastes are generated in huge quantities in Hospitals and nursing homes, small health centers, Medical Rehabilitation Clinical center’s, pathological laboratories, research laboratories, etc. The major sources of health-care waste are:

- hospitals and other health facilities
- laboratories and research center’s
- mortuary and autopsy center’s
- animal research and testing laboratories
- blood banks and collection services
- nursing homes for the elderly

High-income countries generate on average up to 0.5 kg of hazardous waste per hospital bed per day; while low-income countries generate on average 0.2 kg. However, health-care waste is often not separated into hazardous or non-hazardous wastes in low-income countries making the real quantity of hazardous waste much higher.

iii. Quantification and Generation (2020-2030) in the region

In many countries, unsafe disposal and mismanagement of medical waste generated in healthcare settings are growing gradually (Minoglou et al., 2017). The global growth rate of healthcare waste management costs is estimated to rise from $11.77 billion in 2018, to $17.89 billion in 2026 at a compound annual growth rate of 5.3 percent. Many countries with economies in transition are expected to witness high growth of healthcare waste due to their strict government regulations, and the current COVID-19 pandemic. In 2020, the already unsustainable increase in the generation and management of medical waste was suddenly exacerbated, leading to an immediate threat that if not safely and properly contained, will spill over into an environmental pollution and public health crisis (Peng et al., 2020; Singh, Tang, and Ogunseitan, 2020; Singh, Tang, Zhang, et al., 2020). During any infectious disease outbreak, the waste generated from healthcare facilities increases exponentially; as a result, special care must be taken by management in order to avoid troubling impacts (Ramteke and Sahu, 2020) which has taken place during this ongoing COVID 19 Pandemic from early 2020 till date continued in March 2022. The WHO Global analysis of health care waste in the context of COVID-19: status, impacts and recommendations base its estimates on the approximately 87,000 tonnes of personal protective equipment (PPE) that was procured between March 2020 - November 2021 and shipped to support countries' urgent COVID-19 response needs through a joint UN emergency initiative. Most of this equipment is expected to have ended up as waste by end of 2022.

The global medical waste management market was estimated to grow from $13.5 billion in 2019 to 14.9 billion in 2020 at a compound annual growth rate (CAGR) of 10.6 percent. The markable growth is mainly due to the COVID-19 outbreak and the measures to contain it. The estimated amount of biomedical waste being generated from COVID-treating hospitals, quarantine centres, healthcare facilities, and self home-quarantine has triggered the need for medical waste management. The market is then expected to stabilize and reach $16.62 billion in 2023 at a CAGR of 3.8 percent. Low awareness among developing countries limits the growth of the medical waste management market. Inadequate knowledge of healthcare professionals and sanitation health workers on biomedical waste regulations and medical waste management protocols is causing improper segregation of waste which is leading to increased hazardous waste, needle prick injuries and infections like hepatitis which is increasing the load on the medical waste management companies. Infectious waste (or hazardous medical waste) constitutes around 15 to 25 percent of total healthcare waste. According to the World Health Organization (WHO), in low-income countries, health care waste is not separated into hazardous and non-hazardous waste which is causing an increase in the actual quantity of hazardous waste. Therefore, such a lack of awareness in developing countries is hindering the growth of the medical waste management market. Figure 3.2.7.1 demonstrate the medical waste generation in kg/bed/day in a few Asian Countries.

The quantity of biomedical waste produced in a health-care facility depends on the amount of water used and is best measured by water consumption. The water consumption depends heavily on factors such as the kind of health-care services provided, number of beds, accessibility to water, climatic situation, level of care and local water-use practices. In high-income countries, biomedical waste generation in secondary- and tertiary-level hospitals is mainly measured on an inpatient ratio (litre of generated wastewater per patient treatment day).

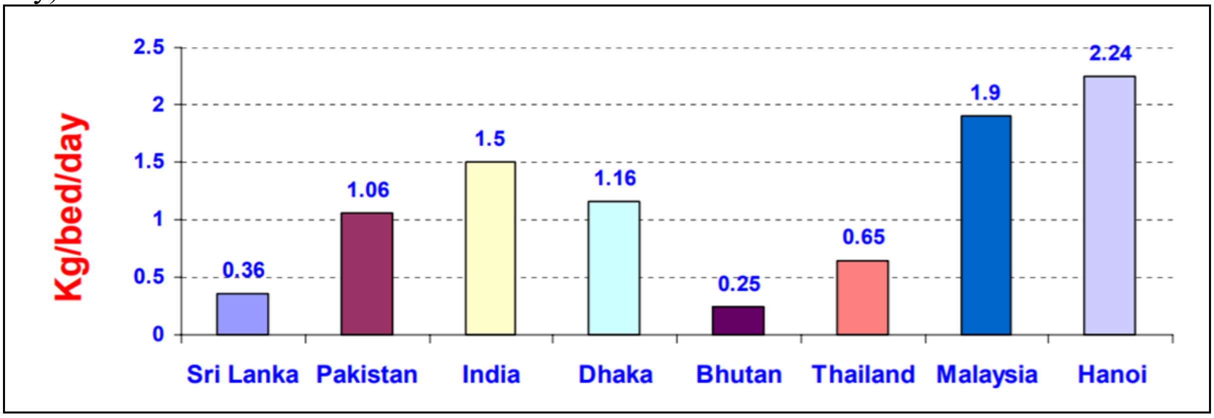

Figure: 3.2.7-1: Medical waste generation in a few Asian Countries in bar chart. Source: (Khan et al., 2019)

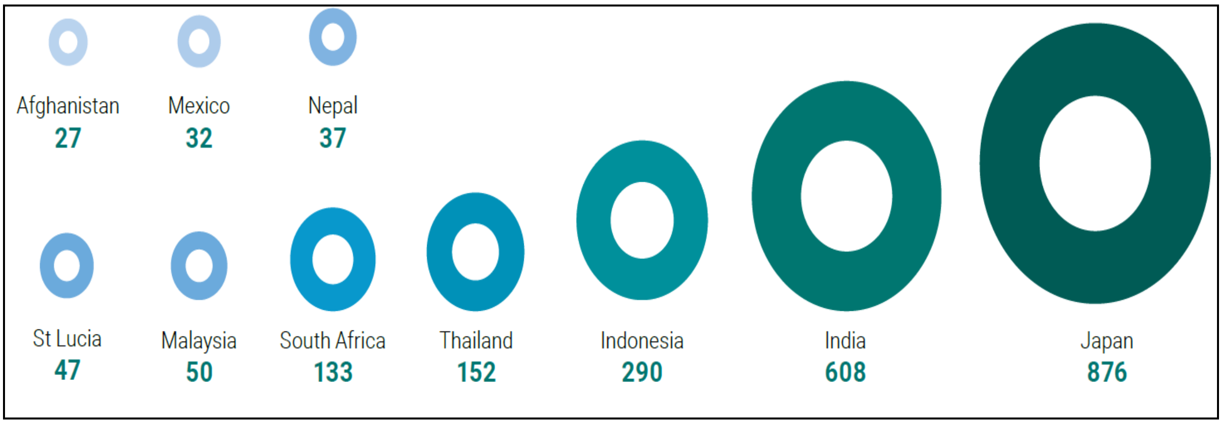

Figure: 3.2.7-2: Medical waste generation in a few Asian Countries Source: (Khan et al., 2019)

Amount of healthcare waste generation (Tonnes per day) in selected countries is shown in Figure 3.2.7.2 (UNEP, 2020b). For healthcare facilities (HCFs) having its own treatment and disposal facility through use of deep burial pits i.e., Primary Health Centres (PHCs) which doesn't fall under coverage area of any Common Biomedical Waste Treatment Facility (CBWTF), interim Storage area used for daily waste collection will serve as Central Waste Collection Area. The collected waste is needed to be stored in this place before it is disposed of by the deep burial pits as per the specifications given under the Biomedical Management Rules, 2016. Figure 3.2.7.3 shows the biomedical waste generation during June–Aug 2020 and business as usual BMW generation in top six affected states in India.

The average medical waste generation rate in each country compared with the environmental performance index of controlled solid waste management in the respective country is presented in Figure 3.2.7.4. The results show that the generation rate of medical wastes in low and middle-income countries is significantly less than that in developed and high-income countries. Overall, the average waste generation rate ranges from 0.3–8.4 kg/bed/day. The United States and Canada generate the highest amount of medical waste (8.4 and 8.2 kg/bed/day, respectively). Kazakhstan and Iran, in Asia, generate the highest amount of medical waste (4.6 kg/bed/day), while in Pakistan and Greece show the lowest amount of medical waste generation (about 0.3 kg/bed/day, each). Data from the Union ministry of environment, forest and climate change Government of India shows. India generated 56,898 tonnes of Covid-19 bio-medical waste between June 2020 and June 2021. Asian Development Bank has estimated the additional amount of HCW due to COVID pandemic sources in a few cities in Asia and the Pacific in their study demonstrated in figure 3.2.7.4.The amount generated HCW due to COVID pandemic sources in some major cities in Asia and the Pacific is shown in Table 3.2.7.1 (ABD, 2020).

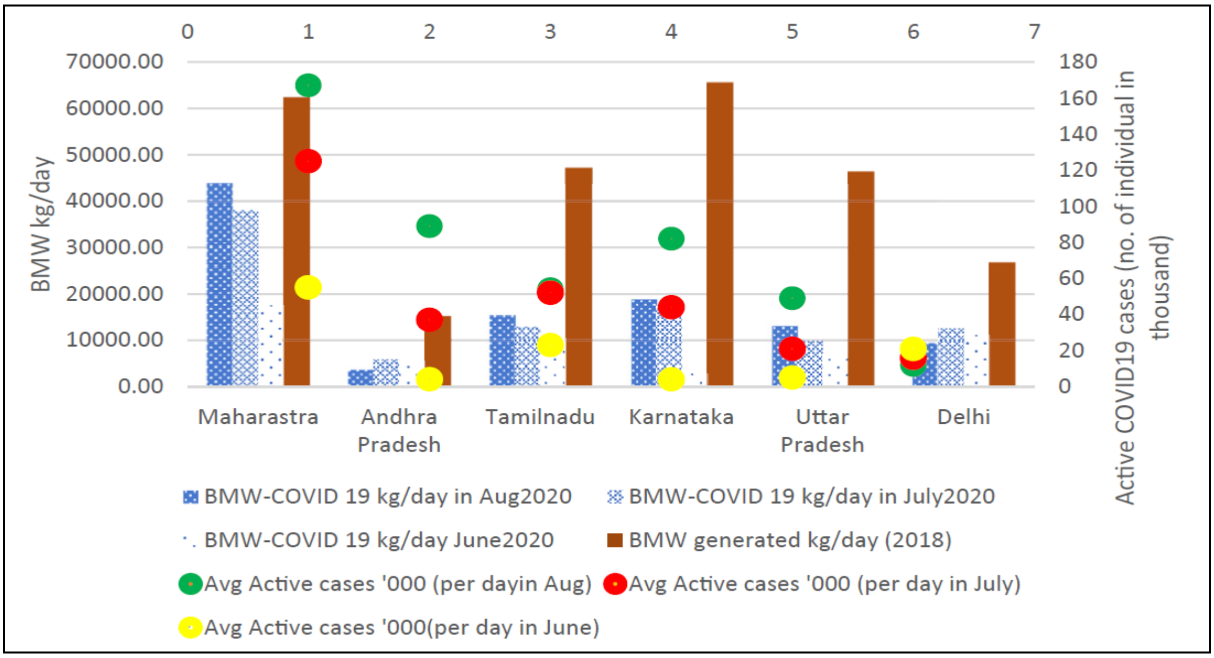

Figure: 3.2.7-3: Active COVID-19 Patients and BMW – COVID-19 generated during June – Aug 2020 and business as usual BMW generation in top six affected states (Bhawan and Nagar, 2020; Kiran et al., 2013)

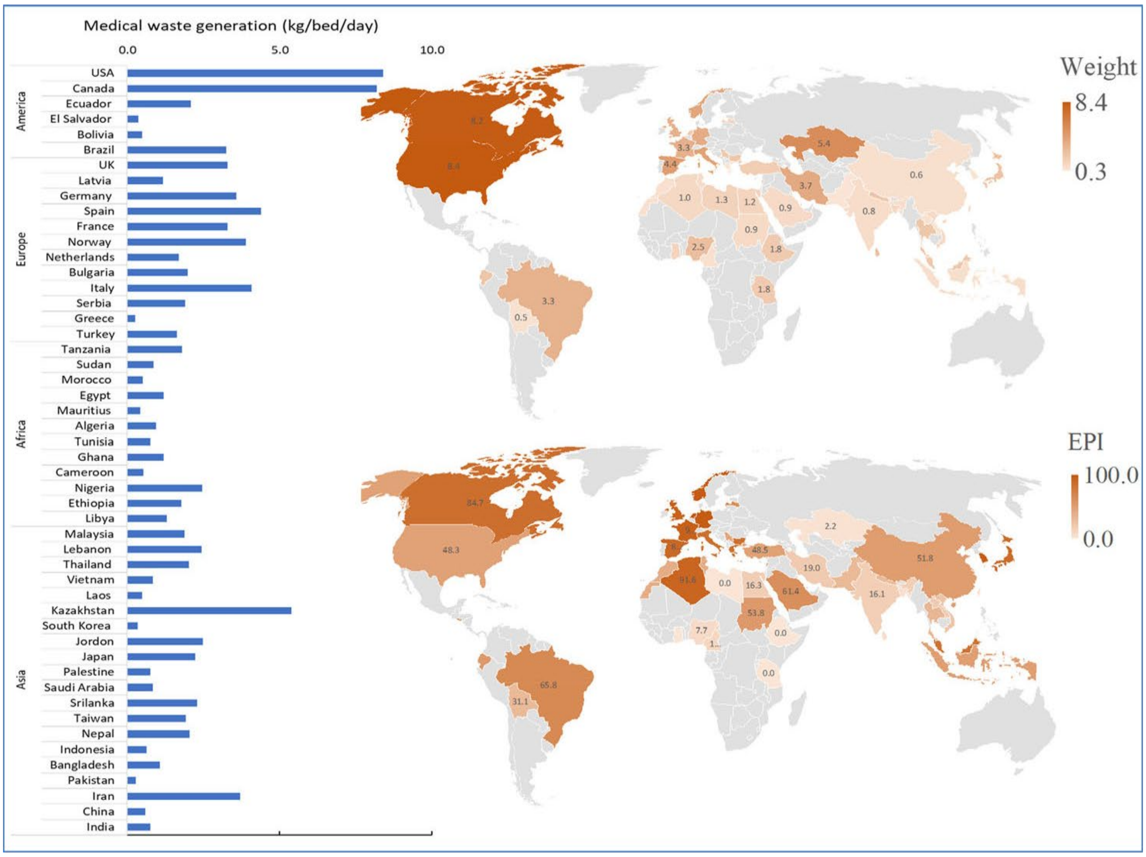

Figure: 3.2.7-4: Amount of medical waste generated in different countries and their environmental performance index (EPI) of controlled solid waste management. Source: (Singh et al., 2022)

Table 3.2.7.1: COVID19HCW sources in a few cities in Asia and the Pacific. Source: (ABD, 2020)

City	**Population (World Population Review)**	**Healthcare waste generated (tonesandday before COVID-19)**	**Estimated additional healthcare waste generation (tonesandday during COVID-19)**	**Percentage of increase due to COVID-19**
Manila	14 million	47	280	496
Jakarta	10.6 million	35	212	506
Bangkok	10.5 million	35	210	500
Ha Noi	8 million	27	160	493
Kuala Lumpur	7.7 million	26	154	492

Almost 85 percent of waste generated by healthcare activity is considered 'non-hazardous waste' and the remaining 15 percent is labelled as "hazardous". While non-hazardous waste may not sound dangerous, the means of safely disposing of this waste can have damaging effects on the environment. The 'hazardous' waste can be infectious, toxic or even radioactive and hence comes with a host of disposal and non-disposal issues. As such, not all HCW is treated equally and different categories of waste require different disposal methods. Globally, the volume of HCW generated (per kg/bed/day) ranges enormously depending on the region and country (**Table 3.2.7.1A**) as adopted from the reported research (Kenny and Priyadarshini, 2021).

Table 3.2.7-1A: Countrywide HCW generation per capita in Africa, America, Asia and Europe

Region	Country and HCW Generated (kgandbedandday)	Region	Country and HCW Generated (kgandbedandday)
Africa	Algeria 0.96 Cameroon 0.55 Egypt 1.03 Ethiopia 1.1 Mauritius 0.44 Morocco 0.53 Sudan 0.87 Tanzania 0.75	America	USA 8.4 Canada 8.2 Argentina 3 Brazil 2.94 Ecuador 2.09 El Salvador 1.85
Asia	Bangladesh 1.24 PR China 4.03 India 1.55 Indonesia 0.75 Iran 3.04 Japan 2.15 Jordan 2.69 Korea 2.4 Laos 0.51 Malaysia 1.9 Pakistan 2.07 Palestine 2.02 Thailand 2.05 Turkey 4.55 Nepal 0.5 Lebanon 5.7 Kazakhstan 5.34 Vietnam 1.57	Europe	Ireland 7.7 UK 3.3 Bulgaria 2 Italy 4 France 3.3 Germany 3.6 Greece 3.6 Netherlands 1.7 Norway 3.9 Spain 4.4 Latvia 1.18

iv. Impact on public health and environment and Climate Change

The Stockholm Convention guidance on best available techniques and best environmental practices states: "If medical waste is incinerated in conditions that do not constitute best available techniques or best environmental practices, there is potential for the release of PCDD [polychlorinated dibenzodioxins] and PCDF [polychlorinated dibenzofurans] in relatively high concentrations" (Secretariat of the Stockholm Convention, 2018). Even with a sudden temporary drop in carbon dioxide emission in 2020 due to the COVID-19-related economic downturn, the year still saw a record-breaking level of carbon dioxide (CO_2) in the atmosphere – 418 parts per million – due to the massive concentrations of human-made greenhouse gas already present in the atmosphere (Borunda, 2020). Then there is solid waste, which has grown from 23 gigatonnes (yes, that is 23 billion tonnes) in 1990 to 78 gigatonnes in 2020 – and a projected 127 gigatonnes by 2050. This expansion of our refuse footprint far exceeds global population growth and can be understood only in the context of a disposable-goods system that combines short-term use and long-term environmental harm.

According to the international organization-Health Care Without Harm (HCWH), the healthcare industry is considered to be the fifth-largest emitter of greenhouse gases (GHGs) worldwide, equivalent to 4.4 percent of global net emissions (Karliner et al., 2020). According to World Health Organization (WHO), 75 percent to 90 percent of healthcare-related waste is non-hazardous, while the remaining percentage, is considered as hazardous (Chartier, 2014). Hazardous waste is further categorised on the basis of its risk of causing infection and injury during its management process. The World Health Organization (WHO) has reviewed small-scale health-care incinerators and reported "significant problems regarding the siting, operation, maintenance and management of [these] incinerators". As a result of these and other concerns, together with the very high costs for modern incineration to meet best available technique (BAT) standards, the WHO report concluded that "small-scale incineration is viewed as a transitional means of disposal for health care waste" (Batterman et al., 2004).

The United Nations Environment Programme tested two hospital waste incinerators that had been built in the mid-1990s and reported that "the bottom ashes [from a hospital waste incinerator] were between 1,410 and 2,300 ng I-TEQandkg" (UNEP, 2020). The extremely high concentrations in the bottom ashes reflect the inefficient combustion in the furnace and the synthesis of polychlorinated dibenzodioxins or polychlorinated dibenzofurans overnight. Similarly, a pilot study by the Swiss Red Cross in Kyrgyzstan used needle cutters, treated the separated plastic syringes and needles in an autoclave, shredded the plastics in a locally made hammer-mill shredder, and sold the plastic pieces to a plastics manufacturer that remelted the plastics to make coat hangers, flower pots and other commodities (UNEP, 2012). Needle cutters were used in Guyana, with the plastic portions treated as infectious waste and the needle portions collected in a 45-gallon plastic barrel with an aluminium funnel. A sharps barrel could hold 150 000 needles. Regular cleaning and maintenance of the needle cutters was found to be crucial.

The Secretariat of the Basel Convention has developed technical guidelines on the environmentally sound management of mercury waste (UNEP, 2018). The guidelines include mercury waste prevention and minimisation, handling, interim storage, transportation, treatment, recovery, long-term storage and disposal. The United Nations Development Programme has developed detailed guidance on the clean-up, transport and interim storage of mercury waste from health-care facilities (UNDP, 2018).Despite having implemented several state-level regulations and being part of many international treaties, safe and effective medical waste management systems are still lacking in many healthcare establishments, particularly in low- and middle-income countries (Convention, 2020; Oruonye and Ahmed, 2020; Dieng et al., 2020). Safe and sustainable medical waste management or wastes from healthcare products are causing concerns globally due to its environment and public health hazards. Therefore, an analysis of current medical waste management systems is an important task for national policymakers and international regulations in the Asia and the pacific Region.

Health risk out of health care waste is a major issue. Although treatment and disposal of health-care wastes aim at reducing risks, indirect health risks may occur through the release of toxic pollutants into the environment through waste treatment or disposal. Landfilling can lead to contamination of drinking water. Occupational Health risks may be associated with the operation of certain disposal facilities. Inadequate incineration, or incineration of materials unsuitable for incineration can result in the release of pollutants into the air. The incineration of materials containing chlorine can generate dioxins and furans, which are potential carcinogens. Incineration of heavy metals or materials with high metal contents (lead, mercury and cadmium) can lead to the spread of heavy metals in the environment. Dioxins, furans and metals are persistent and accumulate in the environment. Only modern incinerators which are able to work at 800-1000°C with special emission cleaning equipment can ensure that no dioxins and furans (or only insignificant amounts) are produced.

Many of the chemicals and pharmaceuticals used in health care are hazardous. Mercury is highly toxic, especially in elemental form or as methyl mercury. It may be fatal, if inhaled and harmful, if absorbed through the skin. The nervous, digestive, respiratory and immune systems and kidneys can be harmed, as well as the lungs. Adverse health effects from mercury exposure can be tremors, impaired vision and hearing, paralysis, insomnia, emotional instability, developmental deficits during fatal development, attention deficit and developmental delays during childhood (WHO, 2005). Silver can turn a person's skin permanently grey and can develop a resistance to antibiotics (Chopra, 2007). Disinfectants like, Chlorine and quaternary ammonium are corrosive which are used in large quantities in health-care facilities (Fritsky et al., 2001). Where chlorine is used in an unventilated place, chlorine gas is generated as a by-product of its reaction with organic compounds. Poisoning can occur through direct contact with pesticide formulation, inhalation of vapours, drinking contaminated water or eating contaminated food. Hazards from genotoxic waste, namely, many antineoplastic drugs are carcinogenic and mutagenic. Radioactive waste can cause headache, dizziness and vomiting to much more serious problems. Radioactive waste is genotoxic, and a sufficiently high radiation dose may also affect genetic material and cause tissue destruction (Levendis et al., 2001); (Matsui et al., 2003), (Brent and Rogers, 2002); (Lee et al., 2002); (Lesley, 2003); (Lee et al., 2004; Nikaido et al., 2004), Developing countries, lack greatly in the ability to implement health Care and medical Wastes policies owing to resource constraints. Multiple studies from developing countries brought forth evidence that hazardous waste is burned in the open air (Kerdsuwan and Laohalidanond, 2015), mixed and collectively combined with municipal waste(Mahmood et al., 2011), illegally recycled, and then resold(Mohankumar and Kottaiveeran, 2007), posing risk of serious and significant threat to both the health of handler and the environment. All the above impact the public Health, Environment and global warming.

v. Health Care and Medical Wastes in Asia and the Pacific Countries

Studies have reported that before the COVID-19 pandemic, over half of the world's population was already at risk of threats from environmental pollution and public health due to unsafe disposal of healthcare waste (Harhay et al., 2009; Pachauri et al., 2019). A study of 24 countries with economies in transition showed that 18 percent to 64 percent of healthcare settings do not use proper medical waste disposal techniques. The report concluded that, on average, only 58 percent of the facilities from 24 low-income countries had adequate safe disposal of healthcare waste. Additionally, unsafe disposal of medical waste in countries with economies in transition is also considered to be a severe cause of infectious diseases responsible for 0.4-1 million deaths each year(Gwyther et al., 2011). According to the World Health Organization (WHO), the number of new infections of hepatitis B, hepatitis C, and HIV caused by contaminated syringes have been 21 million, 2 million, and 260,000, representing almost 32 percent, 40 percent, and 5 percent respectively of all new infections (WHO, 2018b). Among all member countries, the South-East Asia Region (SEARO) including Bangladesh, Bhutan, India, Nepal, Sri Lanka, and Timor-Leste, World Health Organization (WHO), showed the lowest safe disposal setting, with only 44 percent of the facilities having a system for safely collecting, disposing, and destroying healthcare waste. These outcomes complicate health challenges in resource-limited settings with a high burden of disease in countries with economies in transition (WHO, 2016). Key properties of healthcare waste, namely, Moisture content and Combustion residues 15 percent by weight each, Energy value (heating) 15 MJ/kg (3,600 kcal/kg or 6,400 BTU/lb), and Bulk density 100 – 200 kgandm3 shows that there are valuable and energy contents wastes within medical wastes (Parajuly et al., 2019a).

Several materials are generated as the medical waste those can be categorised in different types. Fig. 3.2.7.5.shows the hazardous and non-hazardous or general categories of waste materials generated as medical wastes.

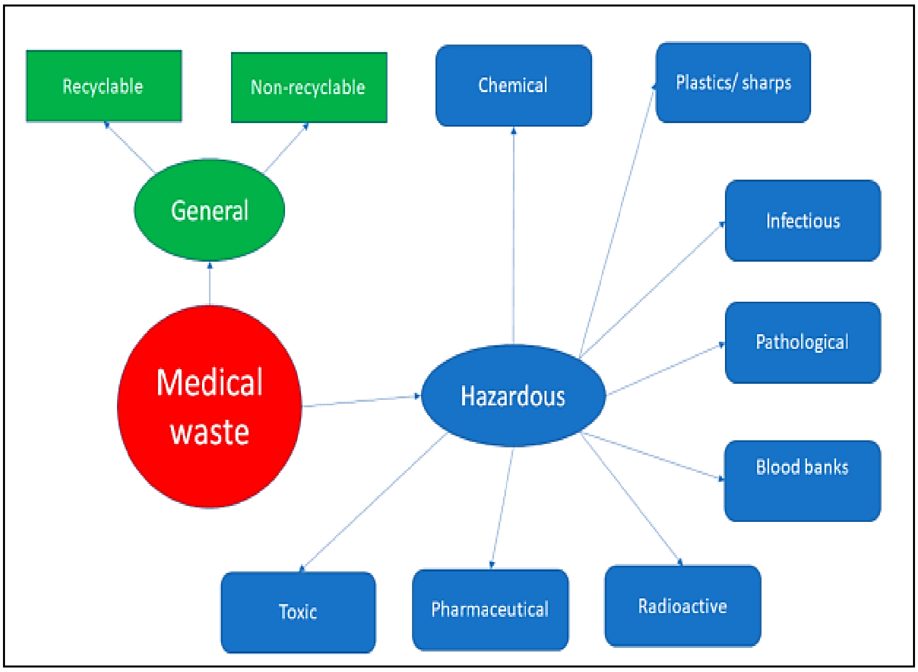

Figure: 3.2.7.5: - Medical waste categories and types. Source: (Giakoumakis et al., 2021)

One aspect of a waste assessment is the characterization of the physicochemical composition of health-care waste. Setting up an efficient recycling programme requires an understanding of the composition of general (non-hazardous) waste. Physicochemical parameters of the infectious portion of the waste stream are useful in establishing equipment specifications or operating parameters for treatment technologies. For example, some steam and microwave treatment systems rely on a minimum amount of moisture to be present in waste; some chemical systems are affected by the organic load and water content; and incineration is influenced by the percentage of incombustibles (ash), heating (calorific) value and moisture content of waste. Common Biomedical Waste Treatment Facility (CBWTF) is a way to treat the health care wastes in many countries. India has generated some 45,954 tonnes of COVID-19 waste in the past one year till May 10, 2021. Meaning, since the pandemic's first wave, it has generated 126 tonnes of COVID-19 waste a day, which is about 20 per cent of the 614 tonnes of biomedical waste that the country generates on any given day.

Biomedical Waste Management in India

The Biomedical waste management Rules, 1998 as revised in 2016 in India requires that no healthcare facility shall establish on-site treatment and disposal facility for BMW, if a service of Common Bio Medical Waste Treatment Facility (CBMWTF) is available within 75 kilometers of travelling distance of the facility. In India at present working with 198 CBWTF and several captive plants. All the public healthcare facilities within reach of 75 kilometers of CBWTF needs to dispose of the BMW through such CBWTF. For the public health care facilities especially in rural areas where there is no CBWTF within range of 75 kilometers, the disposal of BMW can still be made through a CBWTF who is willing to provide treatment services and authorized by the concerned SPCB and PCC to operate in an area beyond 75 Km radial distance. In case of no reach to any CBWTF, the BMW generated from HCFs is disposed in captive treatment and disposal facility or by deep burial pit as authorised by the respective SPCB and and as specified in these guidelines. Nearly 21,870 HCFs have their own treatment facilities and 1,31,837 HCFs are using the CBMWFs. The Biomedical Waste Management in India works on effective business model as the rate of mandatory waste disposal per bed (1 – 2 kg/day) is set by the government to be paid to the operators by the Health Care Units and Hospitals. Biomedical Wastes generated in the units are segregated in four colour bins as per the rules in India. BMWM (principle) Rules, 2016, BMWM (Amendment) Rules 2018 and 2019; Guidelines for Handling, Treatment and Disposal of Waste generated during Treatment and Diagnosis and Quarantine of COVID-19 patients, CPCB, Version 5, April 2022 and Guidelines on management of BMW in universal immunization programme (UIP), CPCB, 8 Feb 2021.

Physical properties, such as bulk density (uncompacted mass per unit volume), are used to estimate storage, transport and treatment chamber capacities, as well as specifications for compactors, shredders and other size-reduction equipment. Common to any waste classification, the physicochemical characteristics of health-care waste will vary from country to country and between health-care facilities within a country. The total number of beds is often used to estimate kg per bed per day. For analysing departments within a health system, Vaccari et al. (2018) suggests using kg per person per month (where "person" refers to both patients and staff) as a more accurate and stable measure of activity, and as a tool to identify departments that could benefit from waste reduction, reuse and recycling. Waste-generation data from other countries must be used with caution because of the wide variability even within a country and the many factors that influence the rates. The data are provided as indicative values and should be viewed only as examples. They may be useful for order-of-magnitude estimations, but should not be used for detailed planning, budgeting or procurement. Even a limited survey will probably provide more reliable data on local waste generation than any estimate based on data from other countries or types of establishments.

The 1st edition of WHO handbook on safe management of wastes from health-care activities known as "The Blue Book" came out in 1999. The 2nd edition of "The Blue Book, 2014" covered newer methods and topics for safe disposal of BMW, new environmental pollution control measures and detection techniques, health-care waste management in emergencies, emerging pandemics, drug-resistant bacteria, and climate changes were covered in the second edition (Chartier, 2014). In 2012, WHO conducted a survey on the BMWM status of 24 countries of West Pacific area, which included countries such as Japan, PR China, Australia, New Zealand, the Philippines, Malaysia, Vietnam, Cambodia, Republic of Korea, Micronesia, Nauru, and Kiribati. The survey included a literature search, review of publications, newspaper articles, and other sources of information. The status in each country was assessed on five main areas of BMW, namely, management, training, policy and regulatory framework, technologies implemented, and financial resources. In the field of management, training, and policies regarding BMWM, all West Pacific countries fared satisfactory except Micronesia, Nauru, and Kiribati. Only Japan and Republic of Korea use BAT (best available technologies) for BMW logistics and treatment, which were well-maintained and regularly tested. Most of the countries had no or very fewer financial resources for BMWM. Therefore, HCWM is still far from ideal in most of West Pacific countries, and additional backing for the expansion of HCWM systems in countries is vital to ensure that within the next decade, safe HCWM systems are applied.

vi. Impact of Medical Tourism

In recent times, the problem of hazard has become very critical mainly due to increasing flow of patients from foreign countries in the form of medical tourism. Medical tourism in different countries, like, India, Singapore, Thailand, etc., where the medical treatment is better available than many other countries, contribute an extra inflow of patients at the rate of about 20 - 30 percent of the domestic patients per year. As a resultant effect, a huge amount of biomedical wastes is generated every year by migrant patients imposing an additional load to both environmental threshold and environmental cost. As a remedial measure, an environmental service tax may be imposed on the medical tourists to solve the problem of extra environmental stress created by them (Das, 2018). The motivation was based in receiving affordable services; patients could save up to 50 percent of medical costs. However, in recent years, the decision factors have become more diverse. Patients choose nations with competitive pricing, quality medical treatments, ease of communication, and low living costs. India is increasingly favoured over other countries for its strong pharmaceutical market, cheap flights and living and quality healthcare. The health and wellness tourism also has grown in popularity; India especially has drawn interest for alternative medicine and Ayurveda centres. A few countries in the Asia and the Pacific have profited significantly from this industry. Medical tourism is a key growth sector for India, as it is projected to be worth $9 billion by 2020 and become 20 percent of the global market share in 2020. As a result, the government of India has encouraged the growth of the medical tourism industry and corporate hospitals through public policy. The medical visa process has also been simplified to allow multiple entries and long-term stay with the introduction of medical e-visas even the easier one. In order to gain credibility and avert suspicions associated with quality of care, top hospitals have been certified by international accreditation schemes that enhance visibility and attract more patients.

3.2.7.2 Overall Assessment on National Policies and Regulations in Asia and the Pacific Countries

i. Local, regional and national policies and regulations including policy and institutional gaps

Many of the Asian resource-constrained countries have only fundamental laws and limited regulatory bodies to enforce the management of healthcare waste. Mishandling and ignorance have created various environmental problems; especially in densely populated countries, such as PR China, India, Pakistan, and Bangladesh (Dey et al., 2023; Patwary et al., 2011; Wang et al., 2012). There are also some countries in the Asian region, namely, PR China, India, Pakistan, Bangladesh, Mauritius, Indonesia, Vietnam, Nepal, Laos, Thailand, Iran, Palestine, Turkey, Kazakhstan, Jordan and Mongolia, that have formulated a broad range of regulations for healthcare waste management by the respective legislations and regularity authorities. However, there is a piece of evidence that suggests most of these countries lack in following regulations, as well as considering legislation in healthcare waste management (W. H. Organization, 2017). However, in last five years as in 2022, there are improvement in the health care waste management in a few countries, namely, India, PR China, Indonesia, Thailand, and Vietnam. Waste management is a sensitive issue all around the world. International regulations and guidelines for safe HCWM are available and have been widely referred to and followed by most countries. This provides a good basis for management of healthcare waste during the COVID-19 pandemic, particularly for waste generated from healthcare facilities (whether existing or additional emergency healthcare facilities recently built).There are countries in the Asian region that have formulated a broad range of regulations for healthcare waste management; **Table 3.2.7-2** shows the legislations and regularity authorities from those countries (Khan et al., 2019).

Table 3.2.7-2: Hospital waste legislation and regulatory authorities. Source: (Khan et al., 2019).

Country	Regulatory authority	Legislation	Reference
India	Ministry of Environment and Forests	Bio-Medical Waste (Management and Handling) Rules, 2016	Bio-Medical Waste Rules, 2016
Mauritius	Ministry of Health, Ministry of Environment	Public Health Act, 1925 and Standards for Hazardous Waste Regulations, 2001	Mohee, 2005
Laos	Ministry of Health	Healthcare Waste Management Regulation, 2004	Phengxay et al., 2005
Pakistan	Ministry of Environment	Hospital Waste Management Rules, 2005	Khattak, 2009
Vietnam	Ministry of Health	Regulation on Healthcare Waste Management	Visvanathan, 2006
Nepal	Ministry of Population and Environment	Health Care Waste Management Guideline2014	Nepal Health Research Council
Cambodia	Ministry of Health	Technical Guidelines on Healthcare Waste Management 2011	Technical Guidelines on Healthcare Waste Management
Mongolia	Minister of Health and DG of the National Emergency Management	Regulation on labelling hazardous waste" (2006)	Waste and Waste Management https:andandwww.un.org › NationalReports, › Mongolia
PR China	Ministry of Health, State Environmental Protection Administration	Medical Waste Control Act 380, Regulation 287	Yong et al., 2009
Iran	Ministry of Health	Medical Waste Management Regulations, 2008	Taghipour et al., 2014
Bangladesh	Ministry of Health and Family Welfare	Environmental Assessment and Action Plan for the Health, Population and Nutrition Sector Development Program (HPNSDP) 2011-2016	MOHFW, February, 2011
Australia	Department of Environment and Science	Clinical and related waste Regulation 2019	Department of Environment and Science
Singapore	National Environment Agency	Environmental public health (general waste collection) regulations 2000	Environmental public health regulations

Health Care Waste Management Legislation – A global perspective

Globally, there are 168 national laws and regulations that address or mention healthcare waste management, of which 57 relate only to healthcare waste streams, while the other 111 address multiple waste streams. There is an important distinction here, because the laws often address waste across the board, and may list a number of different waste streams, but generally without substantive content, which poses a problem for the methodology used to collect the data. Thus, laws addressing a single waste stream are generally more substantial than a law that broadly covers several, with a few exceptions.

Followings are some of the salient features in the National Policies and Regulations in health care waste management in a few countries in Asia and the Pacific.

Australia

(Clinical and related waste Regulation 2019): All clinical or related waste must be treated prior to disposal to landfill, except clinical waste that has been generated in a scheduled area. Clinical or related waste can be treated by one of the following methods, 1. Incineration, 2. Autoclaving and shredding, 3. Chemical disinfection using hypochlorite, and shredding, 4. Chemical disinfection using peroxide and lime, and shredding; or 5. Microwave disinfection and shredding (Table 3.2.7.3).

Bangladesh

(Environmental Assessment and Action Plan for the Health, Population and Nutrition Sector Development Program (HPNSDP, 2011-16): Segregation of medical waste (MW) was started in 2003-2004 along with improved HCWM in Dhaka and Jessore (by PRISM, Bangladesh). Training on improved HCWM in all the medical college hospitals and 30 districts of the country; A National Implementation Coordination Committee (NICC) has been formed by MOHFW for MWM on 26.8.2007. The first incinerator of the country was established in 2007 (in Dhaka), funded by Active Asian Association (Japan) and in 2008 another incinerator and 3 covered vans during 2008 facilitating medical waste management (MWM) in Dhaka city; There has not been significant or widespread improvement in MWM implementation since the rule was promulgated. The primary reasons are as follows: Low awareness and capacity in the HCFs; Inadequate legal provisions, Lack of expertise on the issue and Resource constraints. Appropriate allocation by introducing a budget line in the HCF operation budget can solve the problem.

Cambodia

(Technical Guidelines on Healthcare Waste Management 2011): The contractor for providing Treatment and Disposal services of Medical Wastes are permitted by the relevant authorities should be able to produce a permit which should list the following information: the type of waste categories it is permitted to receive, treat and dispose, the type of treatment facility and the capacities; and the emission limits it needs to comply with and the frequency of testing to demonstrate compliance. The contractor shall prepare and submit Standard Operating Procedures (SOPs), Emergency Response Plans (ERP) and Contingency Plans (CP) upon submission of application for the permit and operate. The medical waste management in Cambodia need to be strengthened.

Table 3.2.7-3: Different types of technologies to treat various types of biomedical wastes in Australia must be verifiable for the treated wastes.

Waste type	Incineration	Autoclaving and shredding	Chemical disinfection using hypochlorite and shredding	Chemical disinfection using peroxide, lime and shredding	Microwave and shredding	Compaction	Landfill
Chemical	□ (if licensed)	□	□	□	□	□	□
Cutptpxoc	□	□	□	□	□	□	□
Human body parts	□	□	□	□	□	□	□
Pharmaceutical	□	□	□	□	□	□	□
Radioactive	□	□	□	□	□	□	□
Treated clinical	-	-	-	-	-	□	□
Untreated clinical	□	□	□	□	□	□□ Other than animal carcasses and sharps	□□ Other than in a scheduled area

PR China

Medical Waste Control Act 380, Regulation 287: The regulatory agency for HCW in the PR China was the Ministry of Health – now the National Health Commission (NHC) – before the SARS crisis in 2002– 2003. The management of HCW was one of the factors of the classification and assessment of health-care institutions. The promulgation of the regulations heralded the beginning of a legal HCW management system in PR China. The laws and regulations include, the Environmental Protection Law of PR China issued by a Standing Committee of the National People's Congress in December 1989 and Regulations on Management of Medical Waste issued by State Council in 2003.

Several measures on HCW management in the country, namely, Manifest Management on Transfer of Hazardous Wastes, Catalogue of Classified Medical Waste, Measures for Management on Medical Waste of Medical and Health-care Institutions; and Measures for Administrative Penalty on Medical Waste Management were established. Based on Prevention and Control of Environmental Pollution law by Solid Waste, the State Council promulgated the Regulation on the Control of Medical Waste (Order No.380) in 2003 as PR China's first legislation to address HCW management. There are different guides and standards have been issued by related ministries: Standard for pollution control on medical waste treatment and disposal(GB 39707-2020), Technical Specifications for Centralized Treatment Engineering of Steam Disinfection on Medical Waste (HJandT 276-2021), Technical Specifications for Centralized Treatment Engineering of Chemical Disinfection on Medical Waste (HJandT 228-2021), Technical Specifications for Centralized Treatment Engineering of Microwave Disinfection on Medical Waste (HJandT 229-2021), etc. The NIP on POPs includes measures in regard to the reduction of dioxin from HCW incineration. A national steering committee does not exist, but various working groups on HCW have been formed. The medical waste management in the country is in good shape in the cities.

India

(Bio-Medical Waste Management and Handling) Rules, 2016: The Bio-Medical Waste (Management and Handling) Rules were implemented in 1998 that have been revised in the year 2016 with several amendment thereafter. The rules enforce the health care facilities to handle wastes carefully staring from the segregated storing systems, transport, collection by contactors by own person, treatment and disposal in eco-friendly manner as well as recycling in accordance with Schedule I, and Schedule-II by the health care facilities and common bio-medical waste treatment facility. Total bio-medical waste generation in the country is 484 TPD from 1,68,869 healthcare facilities (HCF), out of which 447 TPD is treated. Every occupier of the biomedical waste treatment and disposal shall phase out use of non-chlorinated plastic bags within two years from the date of publication of these rules 2016 the work of which is still underway by some defaulting occupiers. Till the Standards are published, the carry bags shall be as per the Plastic Waste Management Rules, 2011.The handling and disposal of all the mercury waste and lead waste are disposed in accordance with the respective rules and regulations. Regulatory framework for Biomedical Wastes (BWM) in India is demonstrated in **figure 3.2.7-6**.

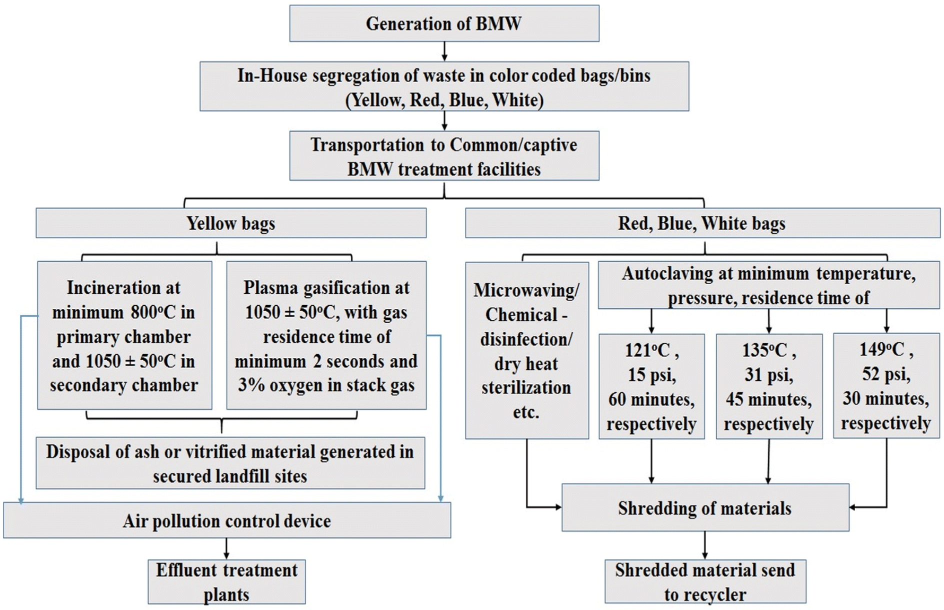

Figure 3.2.7-6: Regulatory framework for Biomedical Wastes (BWM) in India. Source: (Dehal et al., 2022)

Indonesia

Medical Waste Management: The Need for Effective Regulation*:* Article 1 regulation of the Minister of Health No. 7 of 2019 On Environmental Health Hospital aims to realize the quality of a healthy environment for the hospital from physical, chemical, biological, radioactivity, and social aspects, to protect the human resources of hospitals, patients, visitors, and communities around the hospital from environmental risk factors and creating an eco-friendly hospital (Riyanto et al., 2021). According to Indonesian law, HCWM is a part of hazardous waste (HW) management and regulated by laws and regulations such as Environment Protection and Management related to the hazardous material, and the government regulation indicating the position of HCW as part of a hazardous management approach. The details of HCWM are stipulated in the Ministry of Environment and Forestry (MEF) Regulation as "Procedures and technical requirements for the management of hazardous and toxic waste from health service facilities" for regulating sorting, storing, transport, treat, bury, and dispose of hazardous and toxic waste.

Singapore

Environmental public health (general waste collection) regulations 2000: Disposal of recyclable waste, incinerable waste and non-incinerable waste

1. A licensee must transport all incinerable waste to either of the following for disposal:

a) a refuse incineration plant;
b) a disposal facility specified by the Director-General under paragraph.
2. A licensee must transport all non-incinerable waste (except recyclable waste) to a landfill for final disposal and to eliminate or minimise the mixing of recyclable waste, incinerable waste and non-incinerable waste.

Vietnam

Regulation on Healthcare Waste Management, 2007: Regulations on model, technology for treatment of medical solid waste

Hazardous medical waste treatment and disposal models have 3 scales:

- Model 1 (Large scale): Centre for treatment and destruction of medical waste.
- Model 2 (Medium scale): Hazardous medical waste treatment and facility for health facilities cluster.
- Model 3 (Small scale): Treatment and disposal medical waste at source.

The method of medical waste treatment technologies for treatment of hazardous medical wastes include incineration, sterilization by moist heat; microwave technology and other processing technologies. High infectious wastes have to be treated near its sources. The initial method of treating such high-risk waste maybe by one of the following methods: Chemical disinfection, Heat sterilization and Boiling.

ii. Implementation Status of Healthcare and Medical Waste Management Rules and Regulations.

Waste disposal is an essential part of waste management and developed countries around the world have been observed to use different methods for waste disposal, some of which are very high-tech and expensive. **Table 3.2.7-4** shows the different methods of disposal widely practiced in developing countries in Asia. In the last decade, several countries in the Region have begun to improve HCWM. For example, the Lao People's Democratic Republic, Mongolia and Viet Nam have already invested or will invest strongly in the improvement of HCW infrastructure. Several countries, including Cambodia and the Philippines, have improved HCW legislation. New strategies, such as the centralization and privatization of HCW disposal services, have been implemented in Malaysia. Pacific island countries and areas are working towards the development of HCWM plans. (Page no. 58, Status of health-care waste management in selected countries of the Western Pacific Region, WHO).

The five HCW aspects listed in Table include: HCWM (management); HCW training (training); HCW policies and regulatory frameworks (regulation); HCW technologies (technology); and HCW financial resources (financing). In addition to rating the information base of each country, the implementation level in five HCW aspects is listed in **Table 3.2.7.5**. A score of 1 is "insufficient" and 5 is "excellent".

Table 3.2.7-4: General methods employed for disposal of biomedical waste in the various countries.

Name of country	General methods employed for disposal of biomedical waste	References
Mongolia	Open dumping or open burning, incineration, autoclaving	Shinee et al., 2008
India	Landfill, incineration, autoclaving, recycling–reuse	Thakur and Katoch, 2012
Bangladesh	Open dumping	Hassan et al., 2008
Pakistan	Landfill, incineration, recycling–reuse	Ali et al., 2015
PR China	Incineration, on-site burning, mix with domestic waste	Gai et al., 2010

Name of country	General methods employed for disposal of biomedical waste	References
Iran	Incineration, open dumping	Bazrafshan and Mostafapoor, 2011
Turkey	Landfill, incineration, autoclaving	Ciplak and Kaskun, 2015

Table 3.2.7-5: Summary assessment on HCWM in selected countries of the Western Pacific Region. Source: (WHO, 2015)

Country	Information Base	Management	Training	Regulation	Technology	Financing
Australia		-	-	-	-	-
Brunei Darussalam	Poor	-	-	-	-	-
Cambodia	Good	2	2	4	2	2
PR China	Fair	3	3	4	3	3
Fiji	Poor	2	2	2	2	1
Japan	Good	-	-	-	-	-
Kiribati	Poor	2	2	1	2	1
Lao PDR	Fair	2	3	3	3	2
Malaysia	Good	3	3	4	4	4
Marshall Islands	Poor	2	2	1	1	2
Federated States of Micronesia	Poor	1	1	2	1	1
Mongolia	Good	3	4	4	3	4
Nauru	Poor	1	1	2	1	1
New Zealand	Poor	-	-	-	-	-
Palau	Fair	-	-	-	-	-
Papua New Guinea	Poor	-	-	-	-	-
The Philippines	Good	3	3	4	3	2
Republic of Korea	Good	4	4	4	5	4
Samoa	Fair	-	-	-	-	-
Solomon Islands	Fair	2	2	2	1	1
Tonga	Fair	-	-	-	-	-
Tuvalu	Poor	2	2	1	2	1
Vanuatu	Poor	-	-	-	-	-
Vietnam	Fair	3	3	3	2	2

Note: Rating scheme ranges from 1 = insufficient to 5 = excellent; "-" referes to no dataandinformation

It has been observed that the indicators set in the Hanoi Declaration as well as in the relevant SDGs have been addressed in only a few countries in the Asia and the Pacific. India, Japan, PR China and the Republic of Korea have their robust health care waste management systems while several other countries need to establish a robust systems though the respective rules exist in the country. On the other hand, as there is a fixed service charges for the service providers per ben in the health care units, the HCWM business in an effective business model.

iii. Summary of status of HCW Management in different countries in Asia and the Pacific.

The status of healthcare waste management in the countries in Asia and the Pacific is described in the following sub-section. The region is subdivided into East and North-East

Asia, North Central Asia (NCA), The Pacific (Pacific), South-East Asia (SEA) And South and South-West Asia (SSWA).

The Pacific Region

Australia (source: (“Clinical Waste Management” n.d.)

Handling of health care waste

- anatomical waste: For incineration only
- clinical sharps waste: For incineration or autoclaving and shredding
- clinical waste including pathological waste: For incineration or autoclaving and shredding.
- Cytotoxic waste: For incineration only
- Pharmaceutical waste: Storage, destruction and disposal methods must comply with PD2013_043 Medication Handling in NSW Public Health Facilities Pharmaceutical waste must be incinerated at a licensed controlled waste facility.
- Radioactive waste: Radioactive material to be stored onsite in appropriate storage area until it decays to below the thresholds of a “radioactive substance” as defined under the Radiation Control Act and Regulation Waste The resultant PVC wastes represent 5-10 percent of the total waste produced annually in the healthcare sector. Vinyl Council of Australia estimates this total at 26,000 tonnes of PVC per annum. The PVC waste comes in the form of IV bags, oxygen tubing and face masks. Unfortunately, only 25,000 tonnes of this type of waste is recycled locally. The rest is incinerated or transported for recycling in the oversea countries.

Cook Islands

The progressive HCW management practices carried out in Cook Island were

Fiji

The Central Board of Health (CBH), under the Ministry of Health, is responsible for collection, treatment, and disposal of biomedical waste from three regional hospitals in Fiji, including the Colonial War Memorial (CWM) Hospital in Suva. A CBH vehicle collects wastes from all the government hospitals around Suva to be incinerated at the CWM hospital. The incinerator at this hospital has a loading capacity of 260 kilograms (kg) a day. Since the CWM incinerator is old and inefficient, a new incinerator with a capacity of 150 kg a day is being installed at Tamavua Hospital as a backup.

Kiribati. Source: (Organization, 2015)

Kiribati consists of 33 islands scattered over an area of more than 3.5 million square kilometers in the central Pacific Ocean. South Tarawa has two municipal councils— Betio Town Council (BTC) and TeInainano Urban Council (TUC). Per capita gross domestic product is estimated to be A$1,595 (around $1,465). BTC and TUC, respectively, have been reported to handle about 2.5 and 3.6 tons of general rubbish daily which enters the landfill. There is also separate collection for cans and bulky waste. There are other studies that estimate waste generation to be around 6,900 tons a year or 19 tons per day, of which around 75 percent is organic, comprising mainly garden waste and some hard fibrous materials, such as palmandpandanus fronds. Only about 38 percent of generated waste is collected by council authorities, with the remaining waste either disposed of on-site 26 percent, by illegal dumping into the seaandlagoon 35 percent and recycled 1 percent. The nation partially incinerates the medical waste of which 80 percent of waste which is piled behind the hospital adjacent to the ocean for disposal is non-hazardous.

Marshall Islands

There is no specific law or regulation on HCWM in the Marshall Islands. But the National Environmental Protection Act of 1984 and the Solid Waste Regulations of 1989 address several aspects of HCWM. The Cabinet has established a National Strategic Committee to develop a National Solid Waste Strategic Plan.

Micronesia

The Federated States of Micronesia is an independent sovereign island-nation consisting of four states (Yap, Chuuk, Pohnpei and Kosrae), with each state having its own legislation. The legal basis and law for HCWM is the Federated States of Micronesia Public Law 15-09, supplemented by Presidential Order No.1, which now bears responsibility for implementing the Federated States of Micronesia Environmental Protection Act at the national level. There are no policy and guidelines on HCWM in the Federated States of Micronesia. The HCWM system in all four states is weak. At the main hospital, HCW is disposed of in a single-chamber incinerator donated by the Government of Japan in 2009. This incinerator is operated by hospital staff, once or twice per week on a two-hour cycle. The resulting ash is then taken to the Dekehtik dumpsite. Prior to the installation of this incinerator, HCW was often burnt at the dumpsite under controlled conditions.

Nauru

In Nauru, the law in the area of waste is inadequate and mainly consists of the Litter Prohibition Act of 1983 and the draft Environment Management Bill of 2006. The country does not have an existing policy, strategy, guideline or national action plan for HCWM. However, HCW is partly covered by the NIP and the draft National Solid Waste Management Strategy. Waste is treated using an old incinerator, it does not always work. Waste pharmaceuticals are being dumped mainly at a landfill. Proper treatment options and infrastructure for medical and quarantine waste management are recognized needs New Zealand Niue

There is only one hospital on Niue, the Niue Foou Hospital, recently adopted a clinical waste management policy in 2009 which makes several recommendations for waste segregation, storage, and training and public awareness. The chemical waste, which includes developer and fixers for x-rays, are dumped down the drain at the rate of 20 litres per month. After incineration, the ash is removed and dumped at the Makato dumpsite. An impress ordering system has been implemented at the hospital.

Palau

A 2010 solid waste survey estimated that around 1,369 metric tons of solid waste is generated annually by households in Koror.There is no national law or regulation on HCW in Palau. A recycling act was enacted in 2006. There is no policy, strategy, national action plan or guideline for HCWM in Palau.

Papua New Guinea. Source:(Gaitu et al., 2019)

The current healthcare waste management practice in the studied health facility was managed improperly and can pose a risk for human health and the environment. Samoa (Source: ("Status of Health-Care Waste Management in Selected Countries of the Western Pacific Region" 2015)). Samoa has no specific law on HCW, however the Lands, Surveys and Environment Act of 1989 does govern the management of solid waste. The act provides mechanisms to develop an environmental management plan that can be used to set performance criteria for the treatment and disposal of hazardous HCW. Supplementary legislation associated with the 1989 act includes Health Ordinance 1959, covering the health and safety of health-care professionals and workers when handling hazardous HCW. The Health-care Waste Management Plan (2011) could be considered a guideline. A national strategy on HCWM is included in the Health-care Waste Management Plan. Nevertheless, the national plan does not include an action plan.

Tonga

The Waste Management Act (2005) provides a comprehensive legislative base for the effective development and management of the sector. Hazardous Wastes and Chemicals Act No. 28 of 2010, which provides for the regulation and proper management of hazardous wastes and chemicals in accordance with accepted international practices and the international conventions applying to the use, transboundary movement, and disposal of hazardous substances, and for related purposes. Public Health Act No.29 of 1992, deals with public health services in Tonga. Part VI addresses Waste Disposal: Collection and Disposal of Toxic or Hazardous Waste.

Tuvalu

Waste Operators and Services Act 2009- Defines the roles and responsibilities for waste management in Tuvalu, and makes provision for the collection and disposal of solid wastes and other wastes related operations and services in designated areas of Tuvalu, and for related purposes- The management of and regulatory control (including collection and disposal), of medical wastes over medical wastes shall be the responsibility of the Ministry of Health. (Baseline Study for the Pacific Hazardous Waste Management Project - Healthcare Waste)
There is no specific law on HCW and no policy, national action plan or guidelines on HCWM.

Vanuatu

Treatment, disposal, policy and rules

- Public Health Act No.22 of 1994
- Environment Management and Conservation Act No.12 of 2002
- Vanuatu has no existing legislation regulating waste management (Status of health-care waste management in selected countries of the Western Pacific Region, WHO, 2015)

Table 3.2.7-6: Hazardous Healthcare Waste Generation in Pacific Island Countries and Territories. Source: (SPREP, 2016a)

Countries	Average daily HCW (kgandoccupied bed)	Stock piles (tonnes)
Cook Islands	0.5	0
Fiji	0.8	0
FSM	0.9	0
Kiribati	0.2	0.75
RMI	2.8	76
Nauru	1.4	0
Niue	1.2	0.02
Palau	1.4	ND
PNG	0.7	ND
Samoa	0.6	0.2
Solomon Islands	1.1	ND
Tonga	1	0
Tuvalu	0.3	0
Vanuatu	1	0

Countries	Average daily HCW (kgandoccupied bed)	Stock piles (tonnes)
All Pacific island countries	0.8	76
American Samoa	ND	ND
CNMI	ND	ND
Tokelau	ND	ND
Guam	ND	ND
French Polynesia	360 Tonesandyear	0
New Caledonia	324 Tonesandyear	ND
Wallis and Futuna	ND	ND

Asia Region

SL. No	Country	medical waste generation rate (kgandbedandday)	Health expenditure per capita (US $)
1	India	0.8	59
2	PR China	0.6	392.8
3	Iran	3.7	375.1
4	Pakistan	0.3	37.9
5	Bangladesh	1.1	31.8
6	Indonesia	0.7	100.4
7	Nepal	2.1	45.1
8	Sri Lanka	2.3	151.4
9	Saudi Arabia	0.9	1243.6
10	Palestine	0.8	0
11	Japan	2.3	3733.7
12	Jordan	2.5	314.3
13	Korea	0.4	1925.5
14	Kazakhstan	5.4	316.4
15	Lao PDP	0.5	53
16	Viet Nam	0.9	116.7
17	Tailand	2	214.4
18	Lebanon	2.5	655.8
19	Malaysia	1.9	376.1

East and North-East Asia

PR China

The medical waste generation rate ranges from 0.5 to 0.8 kg/bed/day with a weighted average of 0.68 kg/bed/day. The segregated collection of various types of medical waste has been conducted in 73 percent of the hospitals, but 20 percent of the hospitals still use unqualified staff for medical waste collection, and 93.3 percent of the hospitals have temporary storage areas. Additionally, 93.3 percent of the hospitals have provided training for staff; however, only 20 percent of the hospitals have ongoing training and education. It was found that the centralized disposal system has been constructed based on incineration technology, and the disposal cost of medical waste is about 580 US$/ton. The results also suggested that there is not sufficient public understanding of medical waste management, and 77 percent of respondents think medical waste management is an important factor in selecting hospital services. Medical Wastes Management and the present Measures, the administrative department of public health of the local people's government at the county level or above shall order it to correct within a prescribed time limit and give it a warning; if it fails to correct within the said time limit, it shall be imposed on a fine ranging from 1,000 Yuan to 5,000 Yuan; if spreading of infectious disease is caused, the original license issuing department shall suspend or revoke the practice license of the medical and health institution; and if any crime has been constituted, the offenders shall be subject to criminal liabilities.

Japan
Digestive surgery, blood and collagen disease, and cardiac surgery medical wards discharged large quantities of infectious medical waste. The amounts of infectious medical waste discharged per inpatient were also high in these three departments: 1.635 Kg/day/patient in the digestive surgery ward, which was the highest among the inpatient department wards. Conversely.

Infectious medical waste quantities based on beds were lower than those based on inpatients. The most obvious difference in infectious medical waste discharge between patient base and bed base was 0.284Kgandday . Moreover, the estimation of infectious medical waste discharges on the basis of bed basis was underestimated by up to 21 percent compared to the inpatient basis. As regards the disposal practice from medical institutions, a medical institution contracts with specified businesses that are authorized by a prefectural government for collecting, transporting and incinerating infectious waste materials. All infectious waste materials have to be segregated from other wastes. A contractor directly transports infectious waste materials to an incinerator which is authorized by a prefectural government, and these wastes materials are burnt by more than 800 °C soon after collection.

With respect to storage, all infectious waste materials are segregated from other wastes in special storage areas to prevent the spread of infection in medical institutions. A hermetically tight container is used and a notice indicating the type of infectious waste materials is attached to the container. Each label is colored based on the type of waste: labels for blood and body fluids are red, solid materials are orange, and sharp objects are yellow. A regular cart is used for transportation of a container to reduce a risk of direct contact and contamination in medical institutions. A container including infectious waste materials is kept in the special storage areas for the shortest period of time possible and no one except the persons concerned is permitted to enter the storage areas. A sign stating "infectious waste" is posted to be easily visible in each storage area.

Mongolia
A total about 2.65 tonnes of healthcare wastes are produced each day in Ulaanbaatar (0.78 tons of medical wastes and 1.87 tons of general wastes). The medical waste generation rate per kg/patient-day in the inpatient services of public healthcare facilities was 1.4–3.0 times higher than in the outpatient services ($P < 0.01$). The waste generation rate in the healthcare facilities of Ulaanbaatar was lower than in some other countries; however, the percentage of medical wastes in the total waste stream was comparatively high, ranging from 12.5 percent to 69.3 percent, which indicated poor waste handling practices.
It is essential to develop a national policy and implement a comprehensive action plan for HCWM providing environmentally sound technological measures to improve HCWM in Mongolia.

Republic of Korea
Dedicated containers and sealed discharge of HCW is carried out from the generation stage

- Regulations on storage period, storage conditions, images, and color according to the type of medical waste
- Inspection standards provided for dedicated containers
- RFID implemented for medical waste monitoring and handover system
- Infectious medical waste and tissue waste stored at 4 ◦C

- Must be kept at 4 ◦C or less if stored by a collection and transport company in a temporary storage site. Storage period limited to 5 days in dedicated storage facilities and 2 days in other facilities
- For medical waste stored by an intermediate disposal company, daily storage must not exceed 5 days of the disposal capacity, and the storage period is limited to 5 days
- Installation and operation of refrigeration facilities at 4 ◦C or below for collection and transport vehicles; installation of sealed cargo boxes
- Medical wastes other than recycled placenta are disposed of at incineration facilities or sterilization and grinding facilities (on-site and outsourced treatment)
- For medical waste stored by an intermediate waste disposal company, daily storage must not exceed 5 days of the disposal capacity, and the storage period is limited to 5 days
- Residues after incineration are landfilled.

North Central Asia (NCA)

Russian Federation
In accordance with Russian legislation, special sanitary and epidemiological requirements for the management of waste that is generated in the process of the medical or pharmaceutical activities, also in healthcare, medical and diagnostic treatment are set up. In addition, the requirements to waste depositing, waste processing equipment and ways of medical waste handling also are determined in the law. Medical waste has its own internal classification (А,Б,В,Г,Д – subclasses), depending on origin and hazardous qualities of waste). For each subclass certain collection and storage requirements are established in accordance with sanitary regulations and standards of Russian Federation:
Subclass A — non-hazardous waste,
Subclass Б — hazardous waste,
Subclass B — extremely hazardous waste, Subclass Г — waste, by its composition close to the industrial waste AND
Subclass Д — all kinds of wastes containing radioactive components.
Incineration is by far the most reliable and effective method for the treatment of medical waste. Specificity of MPI waste requires compliance with two important disposal rules: the materials must be disinfected and lose the original outlook, i.e. after processing medical waste should not be identifiable from other types of waste. The first rule is evoked by the need of infection spread prevention. The second ensures the elimination of the possibility of contaminated medical instruments re-use.
Due to potential contagiousness of hospital waste, the personnel contact with it should be minimized. **Automated control system** provides the solution to this challenge. The entire process including waste loading is fully automated and does not require staff involvement. The waste is loaded into special containers still in hospital wards and then automatically fed into the combustion chamber.
Thermal treatment is carried out in the combustion chamber. The furnace type is determined by the amount and kind of waste: hearth or rotary kiln. The process is conducted at temperatures of 800-900°C. IV hazard class residue is produced in the amount of not more than 10 percent of the original waste volume when the combustion is finished.
Incineration plants are equipment with multi-stage flue gas cleaning system for environmental purposes. With regard to medical waste, such gas cleaning is of particular importance, as materials may contain toxic substances. Combustion gases enter the afterburner chamber, where dioxins formed during combustion are destroyed at temperatures

up to 1200°C. Then, a flue gas is quenched in the scrubber to the temperature not exceeding 300°C.

South and South-West Asia (SSWA)

National data on medical waste generated in the country is collected from hospitals by direct visit to the hospitals. The Ministry of Health and Department of Health Services (DoHS) are the nodal national and regional bodies for conducting the survey. General data about the amount of health-care waste generated is not available to the public. As per study conducted by the MoH in 2015, the health-care waste generation rate is ~1.35 kg per patient per day.

- Average per patient per bed per day waste generation of the country– 1.35 kg/bed/day
- Total quantity of hospital waste generated in the country – 1.35 kg/bed/day * 27211 beds (as given in records)
- Approximate figures based on extrapolation would be ~36735 kg/day. The actual amount would be more as it would also include waste from non-bedded facilities and laboratories and blood banks and veterinary institutions, etc.

National rules and policies on medical waste: The country has a national policy called the 'Health-care Waste Management Guideline 2014'. It provides instruction for all level of health-care facilities ranging from immunization camp to large teaching hospitals on implementing a safe health-care waste management system.

Collection and transportation: There is no central facility for the treatment of health-care waste. The waste generated in hospitals is segregated into different coloured bins and transported to onsite treatment facilities in different colour-coded trolleys. On many occasions, all the waste is mixed up and finally transported together to the final disposal sites.

Treatment and disposal: Treatment technologies recommended by HCWM guidelines in the country include biological procedure, autoclave, chemical disinfection, encapsulation, sanitary landfill, burial, septic and concrete vault, incineration and inertization.

Pakistan

The country generates hospital waste at a rate of about 0.667 kilograms per hospital bed per day, on average (Ali et al., 2016). About 10 percent–25 percent of this waste is infectious, and hence hazardous. Owing to poor sanitation practices, the hazardous waste is mixed with general waste, potentially worsening the problem of waste management. Proper management of healthcare waste is therefore vital for public health and the environment.

Disposal of Health-Care Waste

Though the Hospital Waste Management Rules (2005) have been in place for many years, waste disposal in cities and rural areas varies from highly dangerous operations (in most rural areas and small towns) to state-of-the-art services (in several large private and public sector hospitals). Sustainable health-care waste management has more to do with segregation at source, to separate the infectious 15 percent from the municipal waste that is generated in the wards (Ali et al., 2016).

- Reschedule municipal solid waste collection frequency according to workforce availability.
- Reallocate available assets for the management of infectious medical waste.
- Avoid recycling activities to prevent human contact with potentially infectious domestic and medical waste.

Sri Lanka (Source: World Health Organization. Regional Office for South-East (2017)

Total quantity of medical waste generated in the country–15-20MT per day (island-wide) and 4MT per day (Colombo city) (old data). Total quantity of medical waste generated in the country can be estimated at 27 tonnes/day (average per patient per bed per day waste generation of the country – 0.36 kg/bed/day). According to another estimate, it is cited at 5400 MT/annum.

Sri Lanka has a draft policy on "Health-care Waste Management," 2001, and a Health Sector Policy under the National Cleaner Production Policy. This policy focuses on efficient use of resources, minimizing wastage of resource and making all processes more environmentally friendly (covering – administration, waste management, laundry, food supply, disinfection, patient care, water and power usage). This policy is the key to green hospitals.

- The National Environment Act (NEA) No. 47 regulates health-care waste management in the country.
- Hazardous waste should be collected in yellow polythene bags (with the international biohazard symbol) of minimum 300µm gauge.
- Sharps are required to be placed in specific cardboard or plastic (puncture and leak proof) yellow boxes with red stripes and a biohazard symbol. These boxes are to be designed with a small opening so that items can be dropped in but no item can be removed.

Subregion: South-East Asia (SEA)

Brunei Darussalam

There are five basic processes for the treatment of hazardous components in healthcare waste, in particular, sharps, infectious and pathological wastes: thermal, chemical, irradiation, biological and mechanical. There are various treatment and disposal methods for all the healthcare waste categories as recommended in the World Health Organization (WHO) Guidelines on the Safe Management of Waste from Healthcare Activities (2013 Edition). Municipal solid waste has become a major concern now-adays as the amount of waste generation has increased tremendously due to rapid urbanization and industrialization, population growth and improved life-style. Brunei has a per capita solid waste output of 1.4 kg per capita per day, which is second only to Singapore among the ASEAN countries. From the total waste produced, 70 percent goes directly to Brunei's six landfills, a meagre 2 percent is used for making compost, and the rest is disposed of in other conventional ways. The surge in GDP of 2.3 percent between 1999 and 2007 and increased number of registered businesses from 2,577 in 1998 up to 7,240 a decade later is a growing concern for proper waste management. The paper highlights the existing solid waste management practice and focus on the strategies that will lead this nation towards sustainable waste management.

Cambodia

Given the sustained threat posed by COVID-19 in Cambodia, the MOH requested ADB in 2021 to provide $25 million additional loan financing for the ongoing project. The project will include $5 million grant financing from the Japan Fund for Poverty Reduction (JFPR, 2020) to support interventions on COVID-19 surveillance, response and clinical care. The JFPR grant will finance ICT and oxygen therapy equipment; ambulances; consulting services and specified training, workshops and community mobilization expenditure. The proposed additional financing will support the Ministry of Health (MOH) in responding to the coronavirus disease (COVID-19). The additional financing will provide targeted investments for additional 81 provincial and district referral hospitals not covered under the original project. It will focus on upgrading of hospital clinical care, laboratory, infection prevention and control, and human resource capacity to respond to COVID-19 and other public health threats. The proposed additional financing loan will help strengthen surveillance, response, and risk communications capacity for COVID-19 and other communicable diseases nationwide. The additional financing will complement ADB's support under the COVID-19 Active Response and Expenditure Support (CARES) Program.

Indonesia

Currently available medical staff in Indonesia are insufficient to deal with potentially increasing demands for managing COVID-19 cases. This pandemic highlighted the human resources challenges the country's health system has been struggling with, characterized by an inadequate physician-to-population ratio, an inequality of physician geographical distribution, and a significant shortage of nurses and midwives. The ratio of physicians to population stands at only 0.38 physicians per 1,000 population. The country's population of 264 million is currently served by only 1,206 pulmonologists, 4,134 anesthesiologists, 350 intensivists, 6,084 pediatricians and 1,811 clinical pathologists. Indonesia's COVID-19 rapid response task force has estimated that the country will need an additional 1,500 doctors (especially pulmonologists, anesthetists, and general physicians) and 2,500 nurses to manage the surge of COVID-19 patients. Furthermore, 22–26 percent of all active pulmonologists, internists, anesthesiologists, and radiologists work in DKI Jakarta, a province with 3 percent of the total population. The Ministry of Health (MoH), during the pandemic has recruited 2,785 volunteers that were assigned to two field hospitals and four other MoH-owned hospitals. The volunteers were general practitioners (62 percent) and nurses (27 percent). Only 24 (1 percent) of the volunteers were specialist doctors, and the rest were other healthcare professionals.

Lao People's Democratic Republic

The health-care waste (HCW) management at each health-care facility level at two selected sites in the Lao People's Democratic Republic (Lao PDR): Vientiane Municipality; and Bolikhamxay province. It focused on the amount of HCW, its segregation and the factors influencing HCW management, particularly segregation procedures. A high proportion of incorrectly segregated medical waste was found at each level of health-care facility. Re-segregation revealed 39, 62, 57 and 37 percent at national hospital, provincial hospital, district hospital and health centre level, respectively, was poorly segregated. The mean of generated HCW was 0.62 kgandbed per day (Vientiane Municipality) and 0.38 kgandbed per day (Bolikhamxay) at two study sites. A higher proportion of medical waste (MW) from the inpatient department at the primary health-care level was found. Thus, HCW management at primary health-care facilities needs more attention and should be better understood.

Malaysia

Malaysia recorded 8904 coronavirus disease (COVID-19) cases and 124 deaths as of 27 July 2020. Globally, everyday there are thousands of new cases of COVID-19 being recorded. Due to the high number of infections globally and nationwide the increase in the amount of clinical waste (CW) generation was expected. Malaysia has reported a 27 percent (by weight) increase in the generation of CW which was mostly attributed to COVID-19 related waste. This article presents the impacts of COVID-19 in waste generation, policy and regulation of CW management (CWM) in Malaysia and a case study on the CWM at a selected hospital used as a COVID-19 focal point. The current practice of CWM due to COVID-19 related cases follows the existing policy and legislation of CWM detailed in the Schedule Waste Regulation (2005), Environmental Quality Act, 1974, and with the standard operating procedure provided by the Ministry of Health, Malaysia. The case study conducted through survey and questionnaire interviews revealed that the CWM in government hospitals followed existing guidelines for CWM for COVID-19 waste, with some additional precautions and rules by the waste management contractors.

Myanmar
A plastics trader in Insein township told Myanmar Now they buy more than 700 pounds (317kg) of medical waste a week from YCDC garbage collectors in Yangon, Mandalay, Kyaukse and Pathein (YCDC, 2020).
A 2017 report by the health ministry and the Myanmar Medical Association, which she helped write, documented poor waste management practices at Yangon hospitals, including a failure to separate hazardous and non-hazardous waste.
Improper disposal of hazardous waste is punishable by up to three months in prison and fines up to 500,000 kyat under YCDC bylaws.

Philippines
MANILA, Philippines Since the COVID-19 pandemic began in the Philippines, San Lazaro Hospital in Manila City one of the government hospitals at the forefront of the country's battle against the severe respiratory illness has been generating an average of 10,000 kilograms of infectious medical waste every month. From March to June, it produced an estimated 29,473 kilograms of infectious healthcare waste, which according to the Department of Health, includes used personal protective equipment (PPE), dressings, swabs, blood bags, urine bags, sputum cups, syringes, test tubes and histopathological waste. Also treated as infectious waste is liquid waste, such as urine, blood and other body fluids. San Lazaro Hospital, a 500-bed medical facility, has been admitting many of the COVID-19 patients in the outbreak epicentre of the National Capital Region.It is also one of the laboratories for coronavirus testing in the Philippines.

Singapore
In Singapore, medical waste that poses biohazard waste risk to public health is classified as biohazardous waste and would require careful disposal. Examples of biohazardous waste include used syringes and items that are visibly soiled with patients' bodily fluid and blood (e.g. used Personal Protective Equipment). From 2016 to 2020, the amount of biohazard waste generated and disposed of increased from 4,400 to 5,700 tonnes (about 5 percent per annum). The increase may be attributed to several factors, including an increase in the number of patients seen in our hospitals; an increase in the treatments and procedures performed for these patients, particularly if they older and are more ill; and additional infection control and biosafety measures, especially in the ongoing COVID-19 pandemic. Biohazardous waste must be collected and disposed of safely to prevent cross-contamination risks and safeguard public health. Healthcare workers are trained to segregate biohazardous wastes safely, which are collected by toxic industrial waste collectors licensed by the National Environment Agency (Agency, 2020) for proper disposal. For patient safety and care, it is not always feasible to avoid, reduce or reuse consumables which are necessary in treatment processes. However, hospitals and clinics have been mindful in reducing and recycling non-biohazardous waste, including general waste such as office administrative waste, food waste and packaging material, where possible. For example, plastic packaging materials of sterile equipment, fluids, and glove wrappings would be collected as recyclable waste.

Thailand

There are recurring themes within the reviewed literature, mainly concerned with inadequate personnel training. For example, although health centres in Thailand should follow governmental guidelines to control and manage waste, implementation is often weakly regulated and poorly managed, leading to incorrect and ineffective handling of waste by healthcare practitioners and waste workers (Puangmanee and Jearanai, 2020). Similarly, while healthcare waste is strictly regulated, appropriate source segregation of wastes is often inadequate, possibly resulting from limited knowledge about waste management, or even complacency, among hospital staff (Wyssusek et al., 2019).

Timor-Leste
No specific rules And handling system of HCW

Vietnam
Nowadays Insights of healthcare waste management practices in Vietnam, together with the economic development, public health activities have gained substantial attention with increasing number of hospitals during the past decades. A multi-method approach involving site visits, questionnaires, and interviews, in combination with secondary data revealed that the healthcare waste (HCW) generation, varied with different specialties (general or pediatric and obstetric hospitals) and different level of hospitals (central, provincial, district levels). The HCW generation from different kinds of surveyed hospitals varied from 0.8 to 1.0 k/bed/day for domestic waste, 0.15 to 0.25 kga/bed/day for infectious and hazardous waste, and less than 0.1 kg/bed/day for recycled waste. Only 94.3 percent of central hospitals, 92 percent of provincial hospitals, and 82 percent of district hospitals complied with national regulation in hazardous medical waste treatment. For healthcare wastewater treatment, the actual operating rates were 91 percent, 73 percent, and 50 percent for central, provincial, and district hospitals, respectively (VPDSC, 2021). The cost for HCW management accounted for only 10–15 percent of the total budget allocated for the medical facilities. Most of the provincial hospitals spent about $0.2–$0.4andbedandyear for HCW management. This is the root cause of ineffective HCW management.

iv. Occupational safety and health standards of waste workers

Occupational safety and health (OSH) are generally defined by the International Labour Organisation (ILO) as the science of the anticipation, recognition, evaluation and control of hazards arising in or from the workplace that could impair the health and well-being of workers, taking into account the possible impact on the surrounding communities and the general environment. This domain is necessarily vast, encompassing a large number of disciplines and numerous workplace and environmental hazards. The scope of OSH has evolved gradually and continuously in response to social, political, technological and economic changes. The International Organisation for Standardisation (ISO), Geneva has developed the ISO 45001, the international standard for occupational health and safety management which is a replacement of BS OHSAS 18001. Organizations who are already certified to BS OHSAS 18001 will need to migrate to ISO 45001 by the end of March 2021. This standard gives mandatory requirements of different aspects of occupational health and safety management in the organisation. Measures to prevent occupational safety and health should also be taken care of by providing appropriate personal protective equipment (PPE).

Every year more than 1.1 million people die from occupational accidents or work-related diseases in Asia and the Pacific and Work-related diseases and injuries were responsible for the deaths of 1.9 million people in 2016 in the world, according to the first joint estimates from the World Health Organization (WHO) and International Labour Organization (ILO). In India and PR China, the rates of occupational fatalities and accidents are similar at, respectively, 10.4 and 10.5 per 100,000 for fatalities, 8,700 and 8,028 for accidents (ILO, 2008). Work-related diseases and injuries strain health systems, reduce productivity and can have a catastrophic impact on household incomes, the report warns. Globally, work-related deaths per population fell by 14 per cent between 2000 and 2016.The poorest, least protected, least informed and least trained are the most affected. Women, children, disabled workers, migrant workers, and ethnic minorities are often involved Occupational accidents and diseases have an impact not only on the lives of individual workers but also on the productivity and profitability of their enterprises and ultimately on the welfare of their entire societies. Governments, workers and employers in Asia and the Pacific are increasing their efforts to prevent accidents and diseases at the workplace.

The study described about the physical strength of the workers in the field. The study stated that the majority of the workers were faced the problem of musculoskeletal disorders. Similar findings were reported (Kuijer and Frings-Dresen, 2004), that the workers were frequently complained strain, cutting injury, laceration, twisting and soft tissue injury, injury by sharp object, cut by broken glass, or piercing object and straining of the body. Study stated that training is one of the major aspects in the waste collection activities but it was not happened for the workers. Therefore, it has created problems in the proper waste collection methods as well as the injury for the workers (Jaiswal, 2004; M and Jaiswal, 2020).

Workers' health surveillance at national, industry and enterprise levels should be organized so as to take into account several factors, including, the need for a thorough investigation of all work-related factors; the nature of occupational hazards and risks in the workplace which may affect workers' health; the health requirements of the working population; the relevant laws and regulations and the available resources; the awareness of workers and employers of the functions and purposes of such surveillance; and the fact that surveillance is not a substitute for monitoring and control of the working environment. Following are the National programmes, profiles and policy documents in a few countries.

- ASEAN: The ASEAN Occupational Safety and Health Network: Good occupational safety and health practices 2008and2009
- Cambodia: The first occupational safety and health master plan 2009 - 2013
- Indonesia: Vision, mission, policy, strategy and program of National Occupational Safety and Health (OSH) 2007-2010
- India: National Policy on Safety, Health and Environment at Workplace
- Lao People's Democratic Republic: 2nd National Occupational Safety and Health (OSH)Programme: Lao PDR 2011-2015
- Malaysia: Occupational Safety and Health Master Plan for Malaysia 2015
- Mongolia: National occupational safety and health profile of Mongolia
- Singapore: Workplace safety and health profile: Singapore (2008)
- Thailand: National profile on occupational safety and health of Thailand 2012
- Viet Nam: National programme on occupational safety and occupational health in period of 2011-2015

v. Protective measures of informal and formal workers with regulatory frameworks.

More than 60 per cent of the global workforce is in informal employment and the large majority of those people face serious decent work gaps and are among the 71 per cent of the global population who have no or little access to social protection. For most of them, the lack of social protection is both a cause and a consequence of informality. The 2030 Agenda for Sustainable Development sees poverty reduction in all its dimensions and inclusive growth as one of the world's greatest challenges. The 17 Sustainable Development Goals for transforming our world include the universal agenda of implementing nationally appropriate social protection systems with substantial coverage for the poor and vulnerable, in recognition of the value of unpaid care and domestic work. This will be achieved through provision of public services and through the adoption of equitable policies within, and among, countries. A lack of decent jobs has resulted in more than 50.0 percent of workers turning to informal employment that results in low productivity and a volatile income. This problem is exacerbated in many developing countries in Asia by a gender divide in the availability and quality of jobs available to men and women. The new agenda calls for greater compliance with labor standards for those engaged in informal employment.

Informal workers are those workers who do not have access to labour protections, or to social protection through work. They are found both within the formal sector (within registered enterprises), and the informal sector (within unregistered enterprises), and within households. Informal workers are the majority of the world's workers, making up 61 percent of total global employment, and 90 percent of total employment in low-income countries. In low-income countries informal employment is dominated by self-employment (72 percent), although this drops to just under 50 percent in middle income countries. The informal economy exhibits strong gender segmentation, with women disproportionately concentrated in the types of occupations which have a higher chance of low returns.

For most workers in the informal economy, the lack of social protection is a challenge not only in their daily struggles to make ends meet but in their aspirations to obtain decent work, rights and dignity that undermines inclusive growth, weakens social justice and compromises the realization of human rights. The Sustainable Development Goals (SDGs) adopted in the 2030 Agenda for Sustainable Development aim to implement nationally appropriate social protection systems and measures for all, including floors, and by 2030 achieve substantial coverage of the poor and the vulnerable (target 1.3). In addition to its link to the achievement of Goal 1 on ending poverty, social protection also contributes to the achievement of goal 2 on ending hunger; goal 3 on ensuring good health and promoting well-being; goal 5 on achieving gender equality and empowering women and girls; goal 8 on promoting sustained, inclusive and sustainable economic growth, full and productive employment and decent work; goal 10 on reducing inequality; and goal 16 on promoting peace, justice and strong institutions.

A majority of people in the Global South depend on informal employment for subsistence. They contribute to the economy and society through market and non-market activities that are not well recognised or valued, which leaves a majority of informal workers and their families outside the realm of public policy. Social protection systems, occupational safety and health (OSH), together with measures to raise productivity and wages and support the representation and voice of workers, can be directed to tackle the vulnerability of informal economy workers and their families, facilitate transition to formality and become a real pillar of inclusive development (*ASIAN DEVELOPMENT BANK 2016 ANNUAL REPORT*, 2016).

The lack of social protection constitutes a significant source of vulnerability for workers in the informal economy. If they do not have access to health care and at least a basic level of income security, they are likely to be trapped in a vicious cycle of vulnerability, poverty and social exclusion. This constitutes an enormous challenge not only to their individual welfare and enjoyment of human rights (in particular the right to social security),but also to their countries' economic and social development (OECD., 2019; I. L. Organization, 2017; Zegers, 2017).Ensuring access to social protection addresses one of the major decent work gaps for workers in the informal economy and can make an important difference in their lives. If workers enjoy at least a minimum level of income security in case of illness, injury, disability or maternity and during old age, as well as effective access to health care without having to pay the cost of treatment out of pocket, they can plan better for their futures and are better able to seize economic opportunities (I. L. Organization, 2017). Social protection coverage therefore contributes to enhancing the productive capacity of workers in the informal economy and can help to facilitate their transition to the formal economy which supports the monitoring indicators of Hanoi 3R declaration and SDGs.

Successful examples of the extension of social security coverage to workers in the informal economy have focused on two broad policy approaches. In many countries, the extension of social security to larger groups of the population has focused on the extension of contributory mechanisms (typically social insurance) and in that way has contributed to the formalization of employment. Frequently, this approach prioritizes groups of workers who are relatively close to the formal economy and have some contributory capacity and who are therefore more easily included in social insurance mechanisms In other countries, social security coverage has been extended to larger population groups through the largescale extension of non-contributory (tax-financed) social protection mechanisms to previously uncovered groups, independently of their employment status. Such schemes are largely financed by government revenue stemming from taxation and in some cases by mineral resource revenue or external grants as well.

3.2.7.3. Circular Economic opportunities of healthcare and medical waste

i. 3R economic opportunities in healthcare and medical waste

Nearly 75 to 90 percent of hospital wastes are similar to household refuse or municipal waste and do not entail any particular hazard. The most unique and hazardous wastes mostly come from hospitals, producing sharp objects and pharmaceutical wastes. These are hazardous to health because used needles and syringes, soiled dressings, blood, other bacteria, and even contaminated and expired drugs can release pathogens and other toxins. These will affect the health of the people and the environment. The healthcare industry should promote recycling or require clinics and hospitals to recycle. Dry wastes components like, plastics, papers, and glass can be recycled or co-processed in cement kilns as Alternate Fuel and raw materials (AFR) or to waste-to-energy plants for producing heat and power (Ghosh et al., 2022). CE is defined as, "Circular economy is a paradigm shift from the traditional concept of linear economy of extract-produce-consume-dispose-deplete (epcd2) to an elevated echelon of innovative resource conservation through changed concept of design of production processes and materials selection for higher life cycle, conservation of all kinds of resources, material and energy recovery all through the processes, and at the end of the life for a specific use of the product will be still fit to be utilized as the input materials to a new production process in the value chain with a close loop materials cycles in a sustainable business model that improves resource efficiency, resource productivity, creates employment opportunities, and provides environmental sustainability" (Di Maria et al., 2020; Ghosh et al., 2022). Organic matter such as paper, plants, and food scraps can go through the process of biological decomposition, which produces benefits for agriculture. This process of reprocessing speeds up the decomposition of these organic matters. These wastes may be used for biogas generation in bio-methanation plants and composting which naturally turns organic waste into rich manure.

3R Opportunity using HCW in Philippines

The waste-to-energy plant in Quezon City, Philippines treating medical waste via Pyrolyzer-Rankine Cycle power plant are found to be feasible. Four hospitals are estimated to supply 579 kg of infectious waste per day having average calorific value of 29,062 kJandkg. With a discount rate of 8.4 percent, the Net Present Value (NPV) of the plant's net cash flow in 20 years operation is Ph₱ 198 million (US$ 3.9 million) and Benefit-to-Cost ratio is found to be 4 with 5 years payback period. Throughout 20 years of operation, the Return on Investment (ROI) is calculated to be 297 percent, excluding the social cost that will be avoided by the Quezon City government. Moreover, apart from revenue from the electricity generated, the public will be spared from the risks associated with improper disposal of infectious medical waste

ii. Amount of illegal dumping and illegal export-import and illegal recycling and inappropriate disposal and reuse and recycling

There is no authenticate data available though there are some reports by some NGOs about the illegal dumping, illegal export-import, illegal recycling and inappropriate disposal and reuse and recycling of health care wastes in several countries in the Asia and the Pacific, no authenticate reports have been found in the literature. Hence, the same could not be presented in details. All these aspects have adverse impact on the human health and the environment. These need to be prevented in case there is any authenticate reporting.

iii. Role of Public-Private-Partnership (PPP) and Business models

Public-Private-Partnership (PPP) offers monetary and non-monetary advantages for the public sector. It addresses the limited funding resources for local infrastructure or development projects of the public sector thereby allowing the allocation of public funds for other local priorities. PPP is a mechanism to distribute project risks to both public and private sector which is geared for both sectors to gain improved efficiency and project implementation processes in delivering services to the public. Most importantly, PPP emphasizes Value for Money (VfM) – focusing on reduced costs, better risk allocation, faster implementation, improved services and possible generation of additional revenue. Typical structure of a health care PPP model is demonstrated in Fig. 3.2.7. 7.

"Public-Private Partnership (PPP) can be broadly defined as a contractual agreement between the government and a private firm targeted towards financing, designing, implementing and operating infrastructure facilities and services that were traditionally provided by the public sector. It embodies optimal risk allocation between the parties – minimizing cost while realizing project developmental objectives. Thus, the project is to be structured in such a way that the private sector gets a reasonable rate of return on its investment". Source:(Republic of the Philippines Public-Private Partnership Canter n.d.) (Organisation for Economic Co-operation and Development, 2012)

The stark reality of healthcare has become evident in the last three years. The Covid-19 pandemic outbreak had projected the prevailing gaps in the medical sector, which is needed to be forged to make medical and health care an affordable one to all a pathway to succeed the UN goal SDG 3. Governments today face a wide range of complex healthcare challenges spurred by changing demographics, a growing burden of chronic disease, rising healthcare costs, more informed patients and rapidly changing healthcare technologies. Healthcare systems are increasingly strained and are struggling with how to expand access and deliver high-quality healthcare services, all while controlling costs. These pressures will only increase as countries seek to implement Universal Health Coverage and achieve the aim of Sustainable Development Goal 3 ("to ensure healthy lives and promote wellbeing for all at all ages") by 2030. Additional investment in health will be needed in many countries, particularly in developing countries where healthcare infrastructure remains inadequate, and facilities lack the necessary management skills and patient care workforce to address the growing demands of caring for their population.

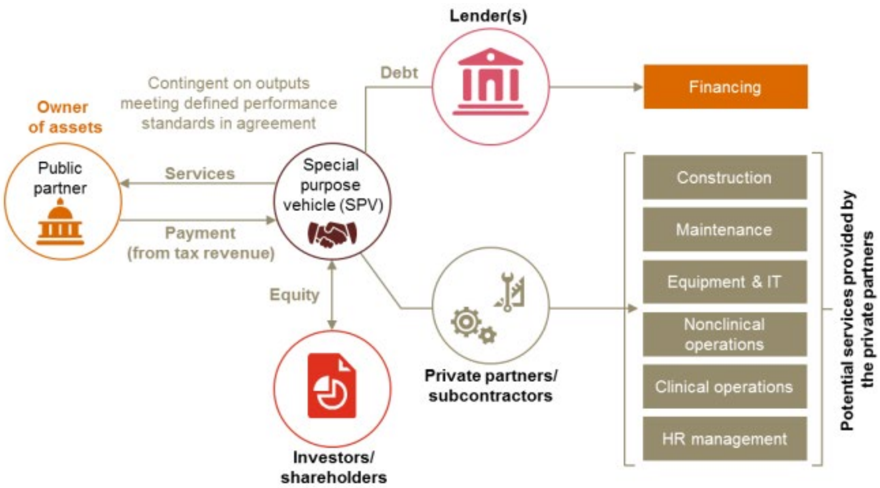

Figure 3.2.7-7: Structure of a health care PPP model. Source: (Abuzaineh, 2018)

Affordability and accessibility are major concerning factors in the medical sector deciding the life and death of the human so the PPP model was introduced in the healthcare sector deliver proper medical care to all.

1. *Expertise:* The experience and management expertise of the private sector in building and running successful organisations can be crucial in revamping medical facilities.
2. *Finance:* The private sector can bring in large monies needed to build best-in-class healthcare facilities that benefit the masses.
3. *Affordability:* PPP operates on a high volume, low margin model, which can ensure universal health coverage and provide quality care at affordable cost.
4. *Technology:* New-age innovative technology adopted by private players can make healthcare accessible to rural areas. A strong case in point is tele-medicine.
5. *Efficiency:* The PPP model can help drive efficiencies and help run hospitals and clinics like well-oiled machines.
6. *Specialist doctors:* Change in government policies can help create more specialist doctors to address immense shortage in the country. Reviving of Post Graduate Diploma courses by the Centre is a great step in this direction.

iv. Facilities and technologies for the resource recovery

Waste recovery is the best choice where the generation of waste becomes inevitable. There are a number of initiatives in different countries in the Asia and the Pacific where several technologies are used for recovery of healthcare wastes. Incineration used to be the method of choice for most hazardous healthcare wastes and is still widely used. However, recently several alternative treatment methods are developed and implementation of those are becoming increasingly popular. The final choice of treatment system should be made carefully, on the basis of various factors, many of which depend on local conditions. Following factors are associated with the efficiency of resource recovery from healthcare wastes.

• disinfection efficiency; • health and environmental considerations; • volume and mass reduction; • occupational health and safety considerations; • quantity of wastes for treatment and disposal and capacity of the system; • types of waste for treatment and disposal; • infrastructure requirements; • locally available treatment options and technologies;	• options available for final disposal; • training requirements for operation of the method; • operation and maintenance considerations; • available space; • location and surroundings of the treatment site and disposal facility; • investment and operating costs; • public acceptability; • regulatory requirements.

A schematic diagram on energy, fuels and materials production from medical waste and medical waste fractions using various treatment technologies are shown in **figure 3.2.7-8.**

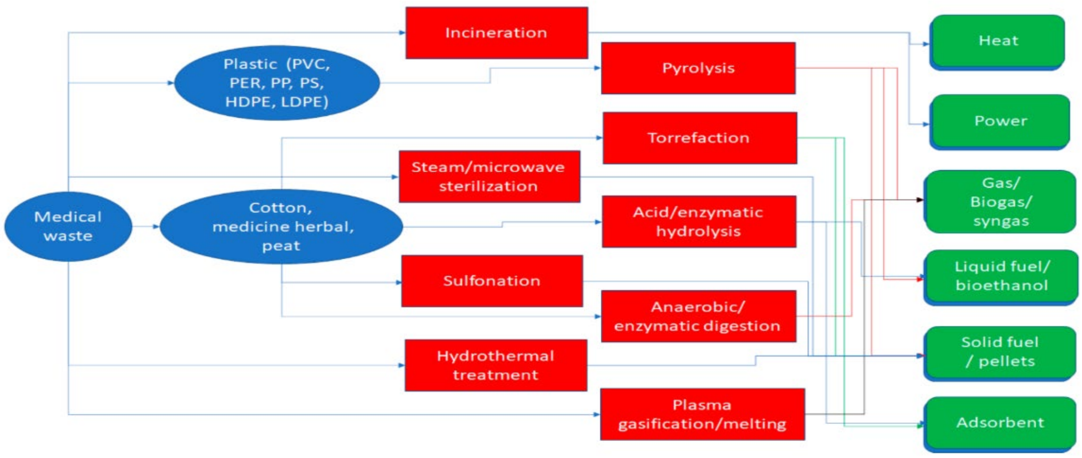

Figure 3.2.7-8: A schematic diagram on energy and fuel sand materials production from medical waste and medical waste fractions via various treatment technologies. Source: (Giakoumakis et al., 2021)

The treatment technologies consist of, (i) acid hydrolysis, (ii) acid and enzymatic hydrolysis, (iii) anaerobic digestion, (vi) autoclaving, (v) enzymatic oxidation, (vi) hydrothermal carbonization and treatment, (vii) incineration and steam heat recovery system, (viii) pyrolysis and Rankine cycle, (ix) rotary kiln treatment, (x) microwave and steam sterilization, (xi) plasma gasification and melting, (xii) sulfonation, (xiii) batch reactor thermal cracking, and (xiv) torrefaction, as regards their capability to produce energy, fuels, and materials.

Typical Investment Cost for Incineration plant for Health care wastes in Indonesia shown in **figure 3.2.7-9**. It is observed that incineration of 100 kg/hour costs nearly USD 68000, which is very expensive.

Investment costs for incinerators in Indonesia

Capacity	Equipment description	Costs (US$)
50 kg/hour	Manual loading, manual de-ashing, two-chamber system (temperature >1000 °C), without flue-gas cleaning	48,600
50 kg/hour	Manual loading, manual de-ashing, two-chamber system (temperature >1000 °C), including flue-gas cleaning: quenching and water jet scrubber	58,140
100 kg/ hour	Manual loading, manual de-ashing, two-chamber system (temperature >1000 °C), without flue-gas cleaning	57,600
100 kg/ hour	Manual loading, manual de-ashing, two-chamber system (temperature >1000 °C), including flue-gas cleaning: quenching and water jet scrubber	68,400

Source: J Emmanuel, personal communication, data compiled for the UNDP GEF Global Healthcare Waste Project (http://www.gefmedwaste.org)

Figure 3.2.7-9: - Investment Cost for Incineration in Indonesia. Source: (WHO, 1999)

A few technologies may be adopted for the resource recovery and adoption of circular economy. Waste-to-energy technologies may be used for treating a portion of health care wastes. However, the generation of fly ash and bottom ash in this technology creates problems of handling 15 to 20 percent of ash generated from the process. The co-processing technology may be a green technology which may be adopted for utilizing the waste as AFR (Alternate Fuel and raw material) that results in conversion into energy in the kiln and the rest portion converted into clinker finally the cement resulting 100 percent utilization of waste leading to generation of zero ash and waste. Plasma Gasification also may be used to converts hazardous wastes into non-harmful slag, which will later be used as syngas. These technologies will not only help the environment, but also ensure the safety of the healthcare personnel and civilians so that they don't get contaminated or infected with the germs and bacteria that are found in medical waste. **Figure 3.2.7-10** BMW categories, type of bags and containers used, and their treatment and disposal in India. Table 3.2.7-6 demonstrates the comparison of various types of treatment technologies.

Table 3.2.7-7: Comparison between various types of treatment technologies

	Incineration	**Autoclave**	**Microwave**	**Chemical Disinfection**	**Plasma Pyrolysis**
Investing and Operating cost	High	Moderate	High	Low	High
Suitability of the waste	Not for radioactive	All except pathological	All except cytotoxic, radioactive	Liquid waste	All
Ease of operation	No	Yes	Yes	Yes	No
Waste Volume reduction	Significant	Less	Significant	-	Significant
Odour Problems	Yes	Slight	Slight	Slight	-
Environmental friendly	No	Yes	Yes	No	Yes

The Internet of Things (IoT) and artificial intelligence (AI) are two fastest-growing technologies in the world. With more people moving to cities, the concept of a smart city is becoming a domestic requirement in the countries. The idea of a smart city is based on transforming the healthcare sector by increasing its efficiency, lowering costs, and putting the focus back on a better patient care system. Implementing IoT and AI for remote health care monitoring (RHM) systems requires a deep understanding of different frameworks in smart cities. These frameworks occur in the form of underlying technologies, devices, systems, models, designs, use cases, and applications. The IoT-based RHM system mainly employs both Artificial Intelligence (AI) and machine learning (ML) by gathering different records and datasets.

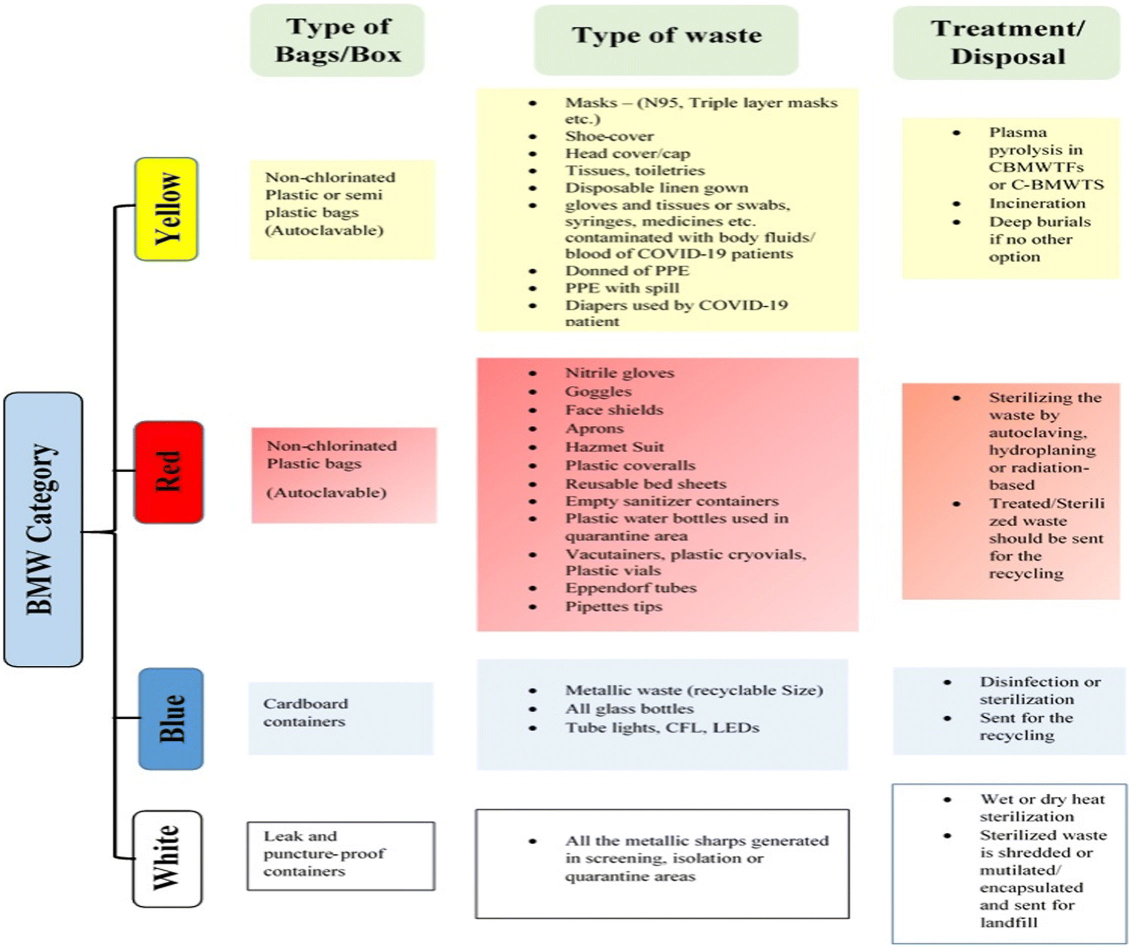

Figure 3.2.7-10: BMW categories, type of bags and containers used, and their treatment and disposal in India. Source: (Alshamrani, 2022).

Figure 3.2.7-11 shows a schematic Machine Learning Algorithms (ML). On the other hand, ML methods are broadly used to create analytic representations and are incorporated into clinical decision support systems and diverse healthcare service forms providing clinical decision support systems, a unique treatment, lifestyle advice, care strategy and medical waste management systems are proposed to health care units (Alshamrani, 2022).

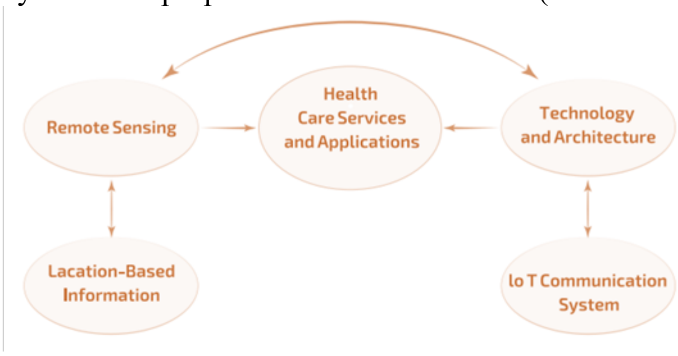

Figure 3.2.7-11: Machine Learning Algorithms. Source: (Alshamrani, 2022).

Waste produced from health care activities, from contaminated needles to radioactive isotopes, can cause infection and injury, and inadequate management is likely to have serious public health consequences and deleterious effects on the environment. Safe health care waste management involves multiple steps from segregation to transport, treatment and final disposal. The Global analysis of health care waste in the context of covid-19 -Status, Impact and Recommendations, published in 2022 concluded from case studies that the healthcare management process can have a small number of measurable elements presented in **Table 3.2.7-8** as per the feedback of some of the countries.

Table 3.2.7-8: Key Elements that helps healthcare waste management. Source: (Alshamrani, 2022)**.**

Countr(ies)	Monitoring	Standards and training	Waste reduction, recycling and reuse	Centralized and non-burn treatment technologies
Colombia	✓	✓		
United Kingdom	✓		✓	
Ghana	✓	✓	✓	✓
India	✓	✓	✓	
Lao People's Democratic Republic		✓		✓
Liberia	✓	✓		
Madagascar		✓		✓
Malawi				✓
Nepal			✓	✓
Philippines	✓	✓		

v. Emergency response during pandemic such as COVID-19

Since the outbreak of Coronavirus Disease 2019 (COVID-19) in the city of Wuhan in the People's Republic of PR China, in the early December 2019 the COVID-19, the pandemic has taken the world by storm and ravaged almost every country in the world. In fact, on January 30th 2020, the World Health Organization (WHO) announced that the COVID-19 outbreak was a public health emergency of international concern and on March 11th the WHO described the COVID-19 outbreak as a pandemic (Holohan and Ghebreyesus, 2020).

During the COVID 19 pandemic in several cities the health care waste generation was increased by 30 to 100 percent above the health care waste generation in normal days. In April 2020, the highest rate of medical waste was estimated at around 14,500 tons during the COVID-19 pandemic, while the amount of medical waste peaked to 240 tons per day in Wuhan City. Most of the countries and WHO developed and issued guidelines to handle and dispose the COVID wastes and implemented. However, there were fall outs of waste management during the pandemic which was a disaster in many of the cities. Uncontrolled recycling and reuse of the COVID wastes was a concern. However, there is no much of reports available that proves significant impact of COVID waste for spreading infections.

The main types of healthcare waste related to COVID-19 is presented in Table 3.2.7.7. According to an assessment by the United Nations Development Programme (UNDP) of five

Asian cities, COVID-19 increased the amount of hazardous healthcare waste by 3.4 kg and bed and day. This is approximately 10 times more than the average volume of hazardous healthcare waste, which ranges from 0.2 to 0.5 kg and bed and day (WHO, 2018b). Although such calculations are dependent on a number of variables, including how healthcare facilities classify waste, they highlight the large and sudden increases in waste volumes that have occurred in some cities and countries. It is estimated that at least 115 000 healthcare workers have died of COVID-19. The immediate focus of global efforts was to increase availability of PPE focusing establishing a global supply portal, involving seven major United Nations (UN) partners that coordinated PPE donations and shipments according to country needs. In addition, the coalition of global partners aimed to increase PPE production by signalling predicted global needs to manufacturers. As the UN and its member states grappled with the immediate task of securing supplies and assuring their quality, less attention and resources were devoted to the safe management of COVID-19-related healthcare waste.

Table 3.2.7-9: Types of PPE and requirements of safe handling and treatment

Types of PPE	Types of Wastes	Required safe handling and treatment
Mask, Gloves and Gown	Infectious	Yes
SARS-CoV-2 rapid antigen test	Non-hazardous	Most components are recyclable; a very small volume of reagent may require safe handling and disposal if dealing with large numbers of tests.
PCR testing cartridge	Chemical	Yes (contains guanidinium thiocyanate)
Vaccine Vial	Non-Hazardous	No
Vaccine needle	Sharp	Yes (packaging material is recyclable)
Plastic packing and containers	Non-Hazardous	No

Meanwhile, the environment and climate crisis continue to accelerate. There is growing appreciation that healthcare investments must consider environmental and climate implications, including implications for how PPE is procured, used, managed and treated. One estimate suggests that, based on country mask mandates and public mask use, in 2020, up to 3.4 billion single use masks were discarded each day, resulting in a sizable, additional volume of plastic waste. Most of the mask waste for disposal is plastic, and a sizeable proportion of this waste, especially in low- and middle-income countries with limited waste management systems, ends up polluting terrestrial and marine ecosystems (Benson et al., 2021).

Healthcare facility preparedness is a key component of the response to the COVID-19 pandemic and it is crucial to ensure appropriate space, supplies and personnel, prioritizing care, activating triage procedures and training staff on infection prevention, control and clinical management for COVID-19 and the development of vaccines and its distribution and administering management. Potential risks and crises are to be identified and comprehensive plans to be built to mitigate them. With the identified risks, the mitigation plans are to be triggered to safeguard the people, property and business operations. The impacts of poor waste management and climate change are felt especially in impoverished communities that lack safely managed, resilient water and sanitation supplies, and have poor-quality health care. Furthermore, plastic production has more than doubled, raising concerns about both the short-term impacts on fresh water, oceans and air quality (from burning), and the longer-term impacts of persistent nano-plastic particles since the start of the COVID-19 pandemic (Shams et al., 2021).

As of 7 December 2021, WHO reported that nearly 8 billion doses of vaccine have been administered globally. All vaccinations administered involve syringes and needles and must be disposed of in safety boxes up to 79 million boxes have been shipped. These vaccination activities will generate over 144,000 tonnes of additional waste, comprising 88,000 tonnes of glass vials, 48,000 tonnes of syringes plus needles and 8,000 tonnes of safety boxes. In addition, more than 140 million test kits, with a potential to generate 2600 tonnes of general waste (mainly plastic) and 731 000 litres10 of chemical waste – an equivalent of one third of an Olympic-size swimming pool have been shipped. Approximately, 97 percent of plastic waste from tests is incinerated *(19)*. This puts a further burden on already strained waste management systems and increases pollution where incineration is not well controlled. The quantity of waste calculated from the test kits is based on the assumption that each test kit, except PCR kits, generates 11 g of plastic waste. A study by Celis et al. (2021) found that each PCR test kit generates 37 g of plastic waste. Additionally, 5 mL of liquid chemicals is generated for all test kits. These has a significant impact on the waste management in the countries in the Asia and the Pacific Region.

COVID 19 prevention protocols should always be exercised in order to protect against infection: a) Wash their hands frequently, b) Cover coughs and sneezes, c) Keep safe distance, d)Use face masks, and e) Inform the group by phone or messenger and stay at home if feeling ill. A survey, conducted through paediatric emergency medicine research networks (REPEM) and United Kingdom and Ireland (PERUKI), highlighted differences and gaps in preparedness and response to the COVID-19 pandemic, a lack in early documented contingency plan, provision of simulation training, appropriate use of Personal Protective Equipment (PPE) and appropriate isolation facilities (Bressan et al., 2020). Prevention and treatment services for noncommunicable diseases (NCDs) have been severely disrupted since the COVID-19 pandemic began, according to a WHO survey released.

Emergency Preparedness for handling HCW in Pandemic

Effective plans for emergency preparedness and response during pandemic for health care wastes handling and disposal should be developed taking the leaning form the present pandemic. Uncontrolled recycling and reuse of the COVID wastes is a concern. However, there is no much of reports available that proves significant impact of COVID waste for spreading infections.

3.2.7.4 Conclusion and Way Forward

The recycling services segment value was pegged at around US$350 million in 2019, a robust growth is projected in the next five years. Asia and the Pacific Medical Waste Management will have a potential of a huge market size for both Hazardous and Non-hazardous type for Collection, Transportation and Storage Services, Treatment and Disposable Services, e.g., Incineration, Autoclaving, Microwaving, Recycling services for the Waste Generators, e.g., Hospitals, Laboratories and Research Centres, Nursing Homes.

On the Post Hanoi declaration, in the 5th Regional3R Forum for Asia and the Pacific a core set of nine 3R policy indicators were finalized as:

1. Per capita total municipal solid waste (MSW) generation and disposal.
2. Recycling of individual components of MSW and overall recycling rate (%)
3. Proper classification and inventory of hazardous waste developed.
4. Indicators based on macro-level material flows.
5. Amount of agricultural biomass and livestock waste recycled.

6. Marine and coastal plastic waste management plans and regional initiatives initiated.
7. Generation of e-waste, their disposal and recycling. Guidelines for environmentally sound e-waste management focusing occupational safety and health standards.
8. New EPR policies enacted or existing policies and guidelines strengthened.
9. Greenhouse Gas (GHG) emissions from waste sector and possible routes for minimization.

Ha Noi 3R Declaration – Status of HCW in the Asia and the Pacific Regions to address Sustainable 3R Goals related to Healthcare waste

Though a few goals and indicators have been addressed in a few of the countries in the region, huge gap exists in many of the countries to initiate and improve. Goal 16 of Hanoi 3R Declaration to promote the 3R concept in health-care waste management has been addressed by a number of countries in the Asia and the Pacific Regions which may be seen from different case studies and the activities in different countries in the region. Goal 1 and 3 of Hanoi 3R Declaration (H3RDn) could be achieved in many countries by increasing the efficiency of collection of HCW in segregated manner, increasing the recycling rates of recyclables (e.g., plastic, metal, and other non-hazardous materials within health care wastes), by introducing new policies instruments and measures, setting up financial mechanisms and institutional frameworks involving relevant stakeholders (e.g., producers, consumers, recycling industry, users of recycled materials, etc.) and development of modern recycling industries. There are scopes from improvement in many countries while countries like, India, PR China, Japan, Australia and Republic of Korea have established appropriate policies and implemented efficient HCW Management systems. There are a few countries, like, Malaysia, Sri Lanka, Vietnam, Federation of Russia who initiated the process very recently while the rest of the countries in the region need to establish policy instrument for initiating the implementation of HCW management systems.

Goal 5 of H3RDn is addressed by several small- and medium-sized enterprises involved in health care waste management and recycling to increase the resource efficiency and productivity. The operators of HCW treatment facilities in a few countries created decent work environment for the workmen by covering them under different social welfare schemes of respective national and local governments. In these units national and local environmental standards have been applied using appropriate technologies and environmentally friendly practices with the application of clean technologies and cleaner production to improve environmental sustainability.

In countries like, India, PR China, Japan, Australia, Republic of Korea, Malaysia, Sri Lanka, Vietnam and Federation of Russia have been encouraging hospital industries and respective service providers handling healthcare wastes for greening the value chain in socially responsible and inclusive ways while building local capacity and competence in handling HCW in cities addressing goal 6, goal 8 and goal 9 of Hanoi 3R Declaration. The HCW have classified as hazardous and non-hazardous HCW in many countries in the region while the disposal facilities in many countries are not adequate excepting a few countries like, India, PR China, Japan, Australia and Republic of Korea

The HCW have addressed Goal 12 of Hanoi 3R Declaration and reduce the potential of inclusion of plastics in the marine and coastal environment by segregation, treatment and recycling of the recyclable portion both in urban and Rural Areas. The HCW have addressed

Goal 25 of Hanoi 3R Declaration to protect public health and ecosystems, including freshwater and marine resources by eliminating illegal activities of open dumping, including dumping in the oceans, and controlling open burning of HCW in both urban and rural areas.

Health Care Waste Management and the Sustainable Development Goals

Countries in the Asia and the Pacific are experiencing significant challenges due to a lack of policies, infrastructure, awareness and financial resources. Healthcare waste (HCW) contains a significant number of hazardous contents. Solution to the HCW is a significant action to curb the extraction of natural resources. Proper management of HCW based on the principles of circular economy and 3Rs are vital to environmental sustainability, protection of health of human and living beings as well as towards harvesting the secondary raw materials sources for other production processes. The collection, treatment and circulation of HCW and E-wastes are the most potential elements to evolve an effective and excellent business model which is already working in many of the countries in Asia and other regions in the globe.

As the HCW contain different types of Infectious, Hazardous and Radioactive materials including metallic sharps, It's likely to be infectious, or potentially infectious, and is often contaminated with bodily fluids in some way and but the term can also be used to refer to general waste from any medical practice, as well as specific waste streams typically found in the medical industry. Hence the intervention of informal scavengers needs to be restricted while in many of the countries in the region, the system is not effective.

In particular, the transfer of technology to Asia and the Pacific countries needs to consider the informal sector's dominance and success. Innovative models that allow the informal sector to be involved in the process by adopting safe segregation, collection and recycling practices while hazardous operations are transferred to formal recycling recyclers are the key to a successful HCW management initiative.

The Ha Noi 3R Declaration is due to expire in 2023. It is now necessary to align the new goals with the targets within SDGs that are relevant to healthcare waste. Success in healthcare waste management will speed progress towards meeting several of the UN Sustainable Development Goals, particularly:
Goal 3: Good health and wellbeing,
Goal 5: Enforce Gender Equality
Goal 6: Clean water and sanitation,
Goal 8: Decent work and economic growth
Goal 9: Increase Industry, Innovation and Infrastructure
Goal 11. Mobilize Sustainable Cities and Communities
Goal 12: Responsible consumption and production and
Goal 13: Climate action
Goal 14. Life Below Water

Table 3.2.7-10: SDG Goals, Targets, and Indicators associated with Healthcare-waste. Source: (The Global Goals, 2015)

SDG Goal	SDG Target	SDG Indicator
Goal 3. Establish Good Health and Well-Being Ensure healthy lives and promote well-being for all at all	**3.3 Fight Communicable Diseases** By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases. **3.9 Reduce Illnesses and Death from Hazardous**	

SDG Goal	SDG Target	SDG Indicator
ages	**Chemicals and Pollution** By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination **3D. Improve Early Warning Systems For Global Health Risks** Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks.	
Goal 5: Enforce Gender Equality Achieve gender equality and empower all women and girls	**5.1 End discrimination against women and girls** End all forms of discrimination against all women and girls everywhere.	
Goal 6. Improve Clean Water and Sanitation Ensure availability and sustainable management of water and sanitation for all	**6.3Improve Water Quality, Wastewater Treatment and Safe Reuse** By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	
Goal 8. Decent Work and Economic Growth Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	**8.3 Promote Policies to Support Job Creation and Growing Enterprises** Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services **8.4 Improve Resource Efficiency in Consumption and Production** Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-Year Framework of Programmes on Sustainable Consumption and Production, with developed countries taking the lead. 8.8 **Protect Labour Rights and Promote Safe Working Environments** Protect labour rights and promote safe and secure working environments for all workers, including migrant workers, in particular women migrants, and those in precarious employment	**8.4.1** Material footprint, material footprint per capita, and material footprint per GDP **8.4.2** Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP
Goal 9: Increase Industry, Innovation and Infrastructure Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.	**9.4 Upgrade all Industries and Infrastructures for Sustainability** By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities.	
Goal 11. Mobilize	**11.6Reduce the Environmental Impact of Cities**	**11.6.1** Proportion of

SDG Goal	SDG Target	SDG Indicator
Sustainable Cities and Communities Make cities and human settlements inclusive, safe, resilient and sustainable	By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management	municipal solid waste collected and managed in controlled facilities out of total municipal waste generated, by cities
Goal 12. Influence Responsible Consumption and Production Ensure sustainable consumption and production patterns	12.4 **Responsible Management of Chemicals and Waste** By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment **12.5 Substantially Reduce Waste Generation** By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse **12.6 Encourage Companies to Adopt Sustainable Practices and Sustainability Reporting** Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle.	**12.2.1** Material footprint, material footprint per capita, and material footprint per GDP **12.2.2** Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP **12.4.2** (a) Hazardous waste generated per capita; and (b) proportion of hazardous waste treated, by type of treatment **12.5.**1 National recycling rate, tons of material recycled
Goal 14. Life Below Water Conserve and sustainably use the oceans, seas and marine resources for sustainable development	**14.1 Reduce Marine Pollution** By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution	

The status of above SDG indicators including the trend analysis related to healthcare waste management in the Asia and the Pacific countries are very difficult to measure. Due to the limitations and inadequate availability of reallife data, the data mining for reporting is also not available in plenty.

Effective hospital waste management (HWM) has become a significant environmental and green healthcare domain issue, which needs a focused attention by the governments. Despite the severe nature of this issue, there is little attention given to it in the developing countries in the Asia and the Pacific, all of which evidently lack in waste management strategies, robust policies regulation and legislation, appropriate knowledge and awareness, allocating sufficient funds, and most importantly, their implementation. The current situation in the resource-constrained countries, proper segregation of waste at source and accordingly disposal and recycling at a minimum cost and effective business model will help improve the present condition. Sorting at source, health care waste storage, transportation, and disposal are the main bottlenecks in many countries. Subsequently adoption of new technologies can help in reducing the management cost with minimum labour requirements as well as the risk mitigation. A national model should be developed for taking care of the health care wastes while economy and employment generation will be a part of the model.

Recent outstanding technological advances in artificial intelligence, the Internet of Things, and blockchain technology have made significant contributions in solving environmental challenges. This study aims to address how blockchain technology would meet the requirements of HWM. The applications may be classified into waste generation, waste separation and packaging, waste storage containers, waste collection, temporary waste storage area, waste treatment, off-site and on-site transport of waste, waste disposal, hospital staffs training, waste management regulations, hospital sewage system, energy, and waste recycling and reuse for establishing system and ease in implementation.

Progress in both the technological aspect and the management strategies are the most important. A cooperative initiative and Mutual Multilateral Cooperation and Support Platform (MMCSP) among the developed and developing countries in Asia and the Pacific is required and may be formed. NGOs, healthcare business sectors and other international bodies could also be involved in developing a progressive plan. A dedicated budget is needed in the national and local levels of the governments to tackle the situation. The Extend Producer Responsibility (EPR) must be applied to the health care waste management in the national levels while the transboundary movement of the waste needs to be controlled. The illegal use of health care waste is a vulnerable are that must be prevented by laws and its implementation. Illegal use of health care waste creates contamination even death of people mainly in rural areas where the awareness level in at the poorest levels.

Research should conduct more in-depth studies on healthcare waste management practice in regions where it is not given much attention. It is also observed that the existing legislation is not practically implementable in the present situation of the country. Behavioural and socioeconomic studies should be conducted to provide a solution for system improvement and to find loopholes in the current rules and policies that do not fit in circumstances of developing countries owing to the scarcity of resources. Data management is another issue which should be looked into to know the present condition for taking appropriate actions. More data should be generated with the help of scientific studies to pave the way for future researchers to develop environmentally sustainable healthcare waste management methods.

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3.2.8 Wastewater Management- Challenges, Treatment and Circular Economic Opportunities

3.2.8.1 Regional overview on wastewater management, challenges and treatment

Water consumption in Asia and the Pacific Region

Asia and the Pacific region accounts for 36 percent of the global surface water runoff. The highest amount of water resources are available in the PR China, Indonesia and Bangladesh (UNESCAP, 2016). Although, the region has significant amount of water resources, per capita availability is mostly below the world average. Water security is one of the major challenges in Asia and the Pacific region, which needs urgent attention. Two third of the region's population (especially in the PR China and India) experience water scarcity for at least one month per year. Efficient management of this scarce resource while meeting the increasing regional demand has become a key challenge. Frequent climate changes are increasingly affecting the water security in the region. Countries such as Afghanistan suffer from the high water shortages due to arid climate.

Annual percentage water withdrawal by different sub-regions of Asia is shown in ***Figure 3.2.8-1.*** Industries are competing for water due to the economic expansion in the region. Irrigation for agricultural practices consumes highest share of water in the region, accounting for 60-90 percent of annual wastewater withdrawals. Indian sub-continent in South Asia and Islands of the South Pacific have the highest water withdrawals for agriculture (90-92 percent) of the total water consumption (UNESCAP, 2016) . The leading sectors demanding high consumption of water are chemical and pharmaceutical and the food industries. Most of the countries in the region are able to meet >50 percent of household water requirements within their available resources. Industrial processes consume significant quantities of water which is often released to the environment and therefore, additional treatment is required to meet the regulations.

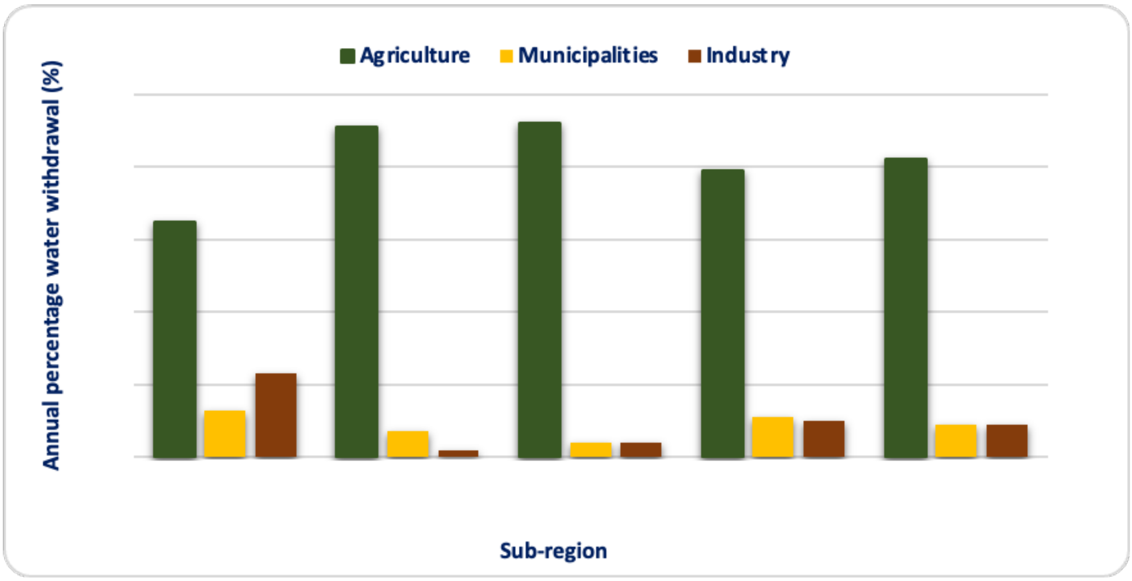


Figure 3.2.8-1: Annual percentage water withdrawal by different sub-regions of Asia and the Pacific region. Source: (UNESCAP, 2016)

Sewerage and drainage systems

Despite the achievements in Asia and the Pacific (home to 60 percent of the world's population), 1.5 billion people living in rural areas and 0.6 billion in urban areas still lack adequate water supply and sanitation facilities. A brief introduction on sewerage and drainage systems is provided in this section.

Overview of on-site sanitation facilities in Asia and the Pacific Region

The countries such as Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Nepal, Sri Lanka, Thailand, and Vietnam are dependent on septic tanks and other low-cost onsite sanitation facilities such as double-vault latrines, composting toilets, and pour-flush toilets with twin pits. These on-site sanitation systems have resulted in low treatment efficiencies around 30-60 percent, which is lower than centralized sewerage systems using aeration. According to a study conducted by World Bank in 2015, 75 percent of the septic tanks in Vietnam and 66 percent in Indonesia have never been emptied (APWF, 2018). Septic tank coverage in some of the Asia and the Pacific countries such as Indonesia, Philippines, Malaysia, Vietnam and India are around 60 percent, 71 percent, 21 percent, 41 percent and 22 percent respectively. Septage management is a critical issue in Asia and the Pacific region. Following is a case study of the septage management in Vietnam.

Box 3.2.8-1: Septage management by SADCO (Haiphong, Vietnam)

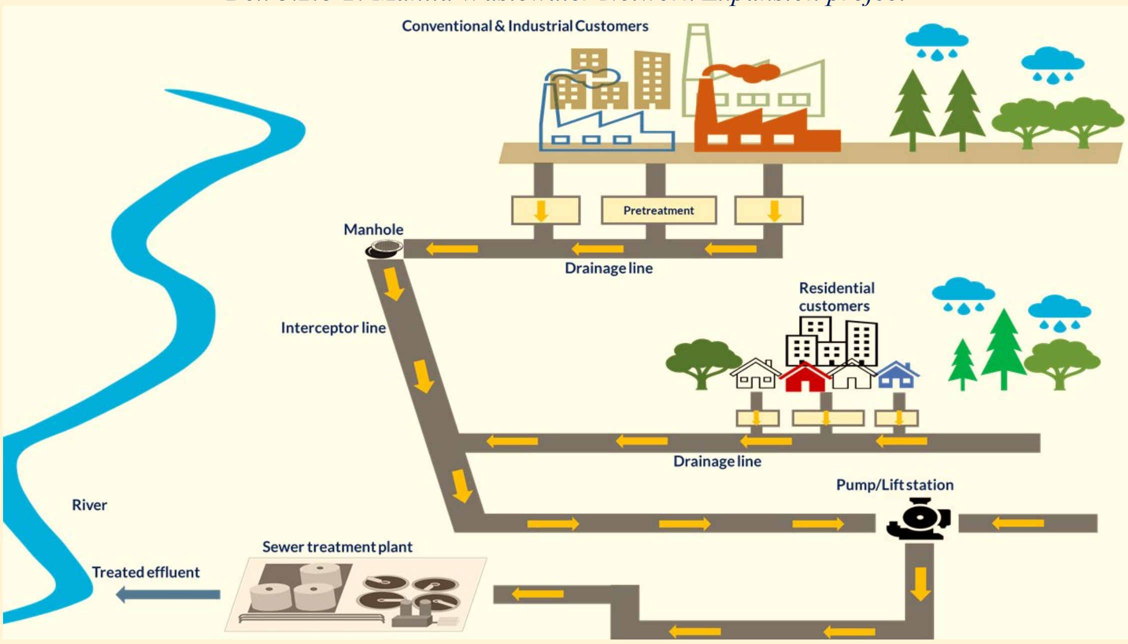
Photo Source: HPSADCO (2021)

Septage management in Haiphong city is conducted by the Haiphong Sewerage and Drainage Company (SADCO) and four other private companies. SADCO Company is in charge of the collection and transportation of the sludge from household septic tanks and the operation of sludge treatment plants. A special type of access cover has been provided to enable faster septic tank emptying. The cost for septage treatment is recovered by the wastewater charges, which is around 20% of the water charges. De-sludging is conducted for 160,000 households using the septic tank database supported by the GIS system. The collected sludge is treated using several methods including solid-liquid separation in a sedimentation tank, sending to a stabilization pond and sludge drying bed.

Overview of off-site sanitation facilities in Asia and the Pacific Region

Although, centralized sewerage systems are the most adequate solutions in densely populated areas, they are not widely used in many countries of Asia and the Pacific Region mainly due to the large investment cost required for the construction. The countries such as Japan, Singapore, the Republic of Korea, Malaysia and the PR China have expanded their sewerage network while, other countries are still in the development phase. Several sewerage development projects are being implemented with the support of international organizations such as Japan International Coordination Agency (JICA) or the Asian Development Bank (ADB). Following is an example for the Manila wastewater network expansion project.

Box 3.2.8-2: Manila Wastewater Network Expansion project



MWSS (Metropolitan Waterworks and Sewerage System)andManila Water Company has initiated integrated wastewater management through the development of sewerage systems and septage management (ADB, 2013). Manila Water Company was given complete responsibility for the operation, maintenance and management of the water supply and sewerage systems in Manila. Before privatization of the public water services in Manila, little sewage collection and treatment was conducted. It was expected to have all the homes and businesses connected to a sewer network, but this would require a lot of up-front investments in the treatment plants and sewer lines. Therefore, Manila Water has taken the advantage of the existing household based septic tanks which pre-treat the sewage. They have adopted the combined sewer drainage approach, for partially treated black water from septic tanks and untreated grey water from the showers, kitchen and laundry. Company has installed interceptor boxes at the canal outfalls and divert dry weather flows to the sewage treatment plants. The target is to achieve 100 percent sewer coverage by the end of the concession in 2037.

However, sewerage development is not making much progress in Southeast Asian countries. Incentives for the construction of a sewerage network and peoples' willingness to pay for the associated sewerage charges are low. Also, slums in many large cities in Southeast Asia are one of the major obstacles for the construction of sewerage systems. Sewerage treatment ratio in many developing countries such as Lao PDR, Cambodia, Myanmar, Nepal, Vietnam, Sri Lanka, and Indonesia is less than 10 percent. In the Republic of Korea and Japan, this ratio is much higher.

3.2.8.2 National policies and legislations on wastewater treatment and sanitation

A proper wastewater treatment system with sustainable sanitation service should be an integral part of the mid-term and long-term strategic plans.3rd Asia and the Pacific Water Summit (APWS) in Yangon, 2017, encouraged the policy makers to discuss about the regional initiatives to achieve goals of SDG 6 (APWF, 2017). It addressed the advance research and development to generate innovative solutions particularly in the water use efficiency and improve sanitation and wastewater management. United Nations Economic and Social Commission for Asia (UNESCAP) promotes the economic integration and cooperation between the countries in the region for the achievement of key developmental goals of SDG (UNESCAP, 2016). UNESCAP addresses the wastewater related issues and supports innovative delivery models and approaches with the potential to expand the access to safe water and sanitation products and services in Asia and the Pacific region. Ha Noi 3R Declaration discusses the critical importance of integrated waste management in the water sector (UNCRD, 2013a). It emphasizes on the collaboration among the different stakeholders (governments, civil society, private sector, local communities and international organizations) to deal with the diversified waste streams.

National-Level Regulations

Figure 3.2.8-2 shows some of the national wastewater and sanitation regulations in Asia and the Pacific Countries. State sewerage and waste water policy, India in 2016 supported the implementation of India's National urban sanitation policy at the state level of Rajasthan (IRC, 2016). It promoted the improved health of urban population via sustainable sanitation services. This policy has improved the guidelines for wastewater collection and treatment, onsite and offsite sanitation and safe reuse. It also encouraged research and development via establishing a "State Water and Wastewater Training Centre". India has urban fecal sludge management policy to facilitate nationwide implementation of fecal sludge management services (CSE INDIA, 2017). It has specific milestones for fecal sludge management to achieve 100 percent safe sanitation. India's policy for treated wastewater reuse, announced by the Gujarat government promotes the use of treated wastewater and setting up sewage treatment plants in all major towns and cities of Gujarat. This treated wastewater would be used in industrial units, thermal power plants, gardening and in the construction sector.

Integrated wastewater management policy in Shenzhen, PR China is one of the regulations that contributed for the development of wastewater management sector (UNESCAP, 2015). They have established a relatively complete legal system for water management, and it is one of the cities in the country to combine water related government functions into a single government agency known as Shenzhen Water Resource Bureau.

Examples some of the countries having regulations on wastewater and sanitation include Vietnam, India, Japan, PR China, The Republic of Korea and the Philippines (Figure 3.2.8-2).

Figure 3.2.8-2: National wastewater and sanitation regulations in selected Asia and the Pacific Countries. Source: (UNESCAP, 2015).

To properly promote sewerage works subsidized by the national government, the Sewerage Law of Japan stipulates the structural criteria and standards for effluent quality; guidelines for planning, construction, and installation of pretreatment facilities; household connections; user fees; national government financial support; and the respective roles of national and local government (ADB, 2016). The Johkasou law provides the guidelines on manufacturing, installation, operation and de-sludging of the Johkasou systems. This law mandates the johkasou owner to engage a maintenance contractor and a de-sludging contractor for the facility at least once a year. The waste management and public cleaning law in Japan mandates local governments to establish a household wastewater treatment plan including a sludge disposal plan.

A comprehensive legal framework for environmental sanitation including urban and industrial wastewater management, currently exists in Vietnam. The law of environmental protection 2014, Decree No.38and2015andND-CP on waste management and the national regulation on surface water quality regulates the activities for the protection of quality of water resources in Vietnam (ARCOWA, 2018). The unified sanitation sector strategy and action plan in Vietnam includes the national rural clean water supply and sanitation development (UNESCAP, 2015). Based on the revised sewerage development policy in Vietnam, percent sewerage coverage should reach 50 percent and 100 percent by 2025 and 2050 respectively. 50 wastewater treatment plants were constructed by 2020, accounting for the treatment of 35 percent of the urban domestic wastewater. Over 60 percent of the urban wastewater remained untreated even after 2020.Some provinces have issued local regulations on wastewater collection and treatment based on Decree No. 80and2014andND-CP (ARCOWA, 2018) .

It could be observed that, most of the countries in Asia and the Pacific region have developed national water and sanitation policies. However, all of these policies are not adequately dealing with all the issues associated with sanitation practices. Some of the factors that are having negative impact on the growth of wastewater market are shown in the ***Figure 3.2.8-3.***

The potential for the reuse of treated wastewater and sludge in most of these countries remains underappreciated in the wastewater related national strategies in Asia and the Pacific countries except for Singapore which uses high standard technology to treat the wastewater for reusing purposes. In most of the countries such as India, insufficient sanitation infrastructures (sewerage systems and onsite treatment facilities) and lack of tertiary treatment for the wastewater has become a barrier to safe reuse of water. Therefore, despite these regulations, majority of the wastewater is discharged into the waterways. These situations indicate the lack of proper formulation of policies and regulations in the wastewater reuse sector.

In some of the Asia and the Pacific countries, there is no proper coordination between the various sectors involved with wastewater sector which needs to be further strengthened when formulating of these policies. Developing coordination between sectoral policies is of significant importance for the formulation of successful national policies in these countries. Also, except for the developed countries such as Japan, there are insufficient policies to influence the innovations in wastewater treatment and reuse sector. Political and economic support (incentives) are highly effective for the successful implementation of these policies.

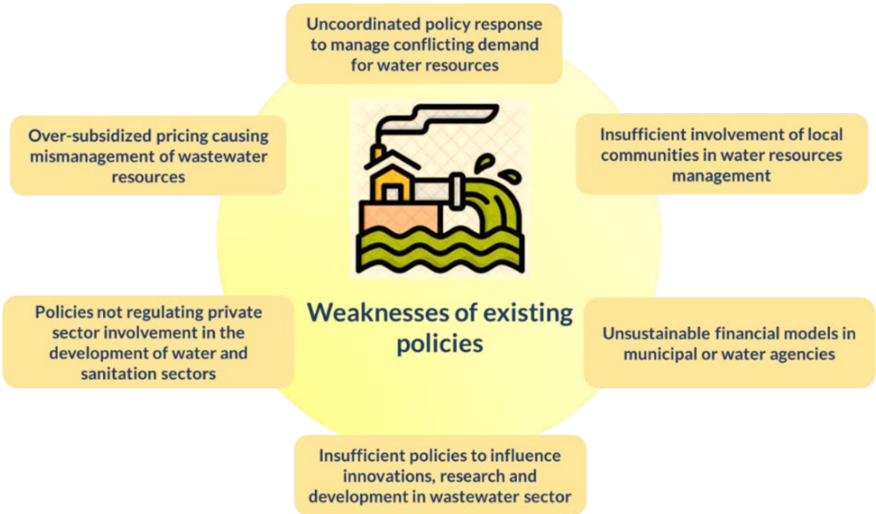


Figure 3.2.8-3: Weaknesses of the existing policies in Asia and the Pacific Region. Source: (ADB, 2016; ARCOWA, 2018; UNESCAP, 2015)

Domestic and industrial wastewater flows

Wastewater flows from the generation at the source to disposal by various pathways is shown in the ***Figure 3.2.8-4*** (Connor et al., 2017). Uncollected wastewater and the wastewater that is collected and disposed without treatment end up in the water ways. Wastewater treatment allows the separation of water and other valuable constituents which can be reused. This wastewater management cycle consists of the steps involving,

A) The prevention or reduction of pollution at the source
B) The removal of contaminants from wastewater streams
C) The reuse of treated wastewater
D) The recovery of useful by-products

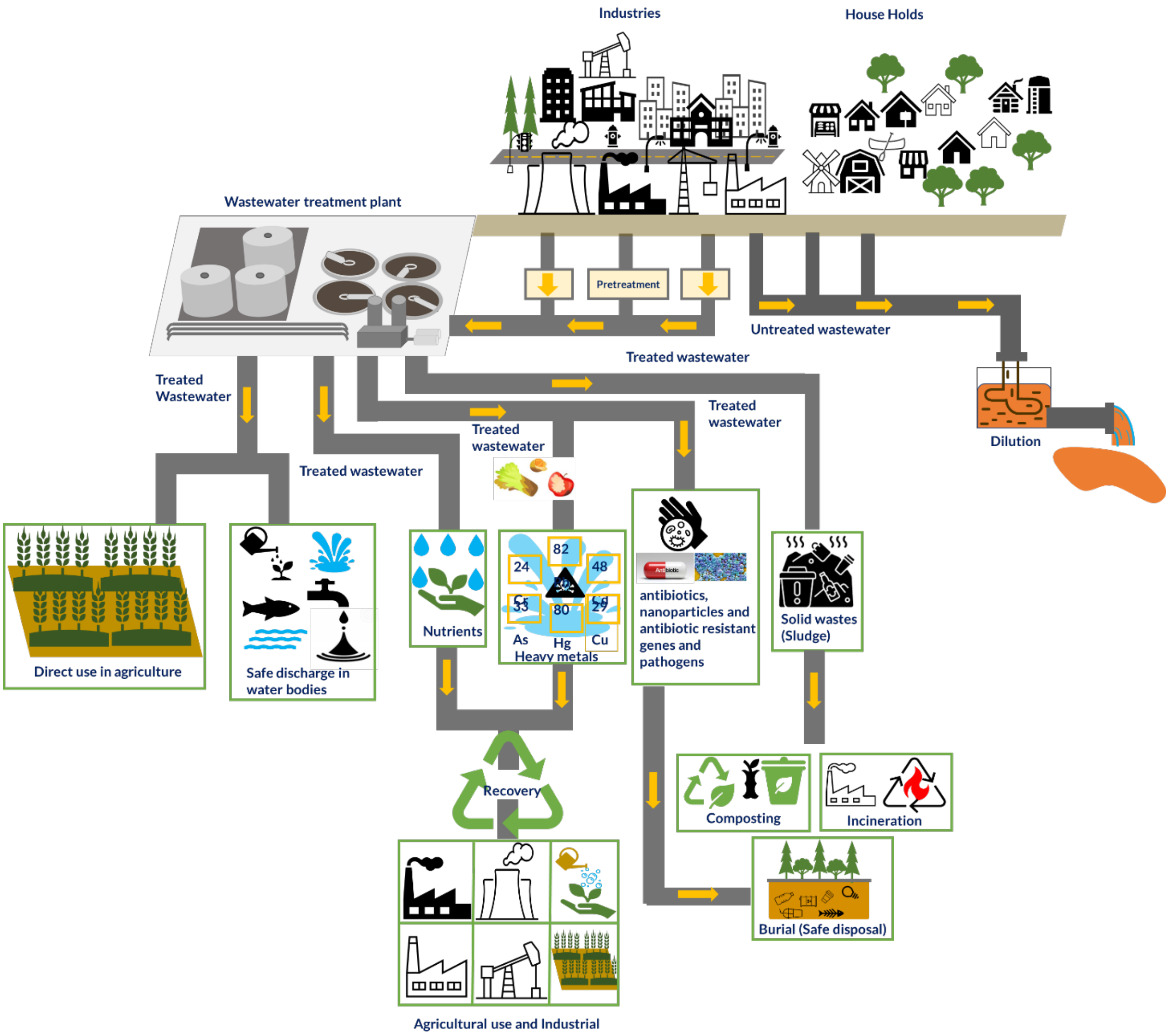


Figure 3.2.8-4: Domestic and industrial wastewater flows. Source: (Hegab et al., 2018)

Emerging contaminants related issues in wastewater

Since, the treated wastewater is planned to be re-used in the agricultural sector, it is necessary to consider the emerging contaminants related issues in wastewater. Especially, since Asia and the Pacific region is highly heterogeneous in terms of pollution status, remediation of the newly discovered emerging contaminants remains as the greatest analytical constraint for the development of an effective assessment and remediation strategy (Azoulay et al., 2013; Parsai and Kumar, 2020). These emerging pollutants include psychiatric drugs, steroids and hormones, personal care products, pesticides and herbicides, surfactants, nanoparticles, etc. Antimicrobial Resistance (AMR) is also one of the emerging issues. Advanced wastewater treatment technologies (membrane filtration, nano filtration, ultra-filtration and reverse osmosis) can partially remove some of the chemicals and pharmaceutically active compounds. Emerging contaminants can still be there in wastewater effluent depending on level of treatment provided. Micro-plastics are found in certain consumer products such as facial cleansers and toothpaste. After the utilization, these spherical particles made of polyethylene or polypropylene end up in wastewater. Once microbeads enter the wastewater, only few treatment facilities are able to remove them. PR China and Japan are the two leading countries with the highest plastic production in Asia (Wu et al., 2018). Some of the Southeast Asian countries such as Malaysia, the Philippines, Thailand, Vietnam, Brunei, Cambodia, and Lao PDR are facing the challenge of lack of research knowledge and information regarding these emerging pollutants compared to the developed countries such as the PR China and the Republic of Korea. Microbeads in personal care products are to be phased out from Australia by 2025 (Wahlquist, 2021). Since 2018, it was illegal to manufacture or sell some products containing microbeads in New Zealand (EPA NZ, 2018).

3.2.8.3 Wastewater treatment: Linear to Circular Economy management

The 2030 agenda for Sustainable Development is trying to gain more investment for improving the water efficiency and reusability of the water resources. Around 90 percent of the wastewater is discharged untreated and the implementation of SDG 6 on improving the water quality is urgent due to the growing requirement of fresh water in the region. SDG 6 and its' targets are dedicated to the water and sanitation sector for ensuring the availability and sustainable management of water and sanitation for all. SDG-6 stresses on the importance of looking at the entire water cycle from source to end, including the critical areas such as wastewater and excreta and septage management, integrated resource management, water use efficiency and conservation of ecosystems rather than just emphasizing on the on-site sanitation facilities. The increase of access to water supply, sanitation and hygiene (target 6.1, 6.2), is complemented by appropriate wastewater treatment and safe reuse (target 6.3).

Key Target and Indicators

SDG 6.3: By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater, and substantially increasing recycling and safe reuse globally SDG6.3.1: Proportion of domestic and industrial wastewater flow safely treated

SDG6.3.2: Proportion of bodies of water with good ambient water quality.

A robust follow-up and review mechanism for the implementation of the 2030 Agenda for Sustainable Development requires a solid framework of indicators and statistical data to monitor progress, inform policy and ensure accountability of all stakeholders. There are two indicators related to SDG 6.3 (SDG 6.3.1 and 6.3.2), and new progress updates by the UN-Water Integrated Monitoring Initiative for SDG 6 (IMI-SDG6) have been reported (UN WATER, 2021b).

Box 3.2.8-3: Highlights and Key Messages of Progress on Wastewater Treatment, Global Status and Acceleration Needs for SDG Indicator 6.3.1 in 2021

- Indicator 6.3.1 aims to track the percentage of wastewater flows from different point sources (households, services, industries and agriculture) that are treated in compliance with national or local standards (UN WATER, 2021b)
- Globally, 56 percent of household wastewater flows were safely treated in 2020 (extrapolated from data from 128 countries representing 80 percent of the global population). Wide disparities among the regional proportions of household wastewater safely treated were discovered (ranging from 25-80 percent by SDG region), indicating that progress remains uneven across the globe.
- Therefore, it is necessary to strengthen regulatory mechanisms (for example, national standards and discharge permits) for all sources of wastewater and to carry out monitoring and enforcement of local service providers and industry to drive improvements to both treatment and monitoring.
- A global standardized monitoring effort through indicator 6.3.1 will stimulate considerable progress in wastewater management and provide necessary and timely information to decision makers and stakeholders to make informed decisions.

Box 3.2.8-4: Highlights and Key Messages of Progress on Wastewater Treatment, Global Status and Acceleration Needs for SDG Indicator 6.3.2 in 2021

- In all world regions, in low, medium and high-income countries alike, there are water bodies that are still in good condition. 60 percent of water bodies (45,966 out of 76,151) assessed in 2020 were classified as having good ambient water quality (UN WATER, 2021a)
- Although low, middle and high-income countries also reported poor water quality, the underlying drivers are likely to be different and therefore require country-specific actions.
- Ambient water quality data are not routinely collected in most of the countries. This means that water quality for 3 billion people is unknown and these people could be at significant risk.
- To have the greatest impact, water quality data need to be embedded in management and policy actions and combined with improvements in outreach and communication aimed at all stakeholders to ensure water quality becomes everyone's business.
- Capacity development in data management is needed. Engagement with countries highlighted that, capacity development in data management was one of the greatest and most urgent needs. Targeting this area would help make better use of data already available and help activate these data for management.

Proportion of domestic and industrial waste water treated in Asia and the Pacific Region

Although, people have started looking at water as a resource, still a major share of wastewater is discharged without any treatment. Especially in the developing countries, more than 80-90 percent of the wastewater is directly discharged into the water bodies without any treatment. Singapore was the only country in 2015 to achieve 100 percent treatment of wastewater (UN ESCAP, 2018d). Percentages of wastewater discharged in some of the less developed countries in Asia and the Pacific region are shown in the ***Figure 3.2.8-5***.

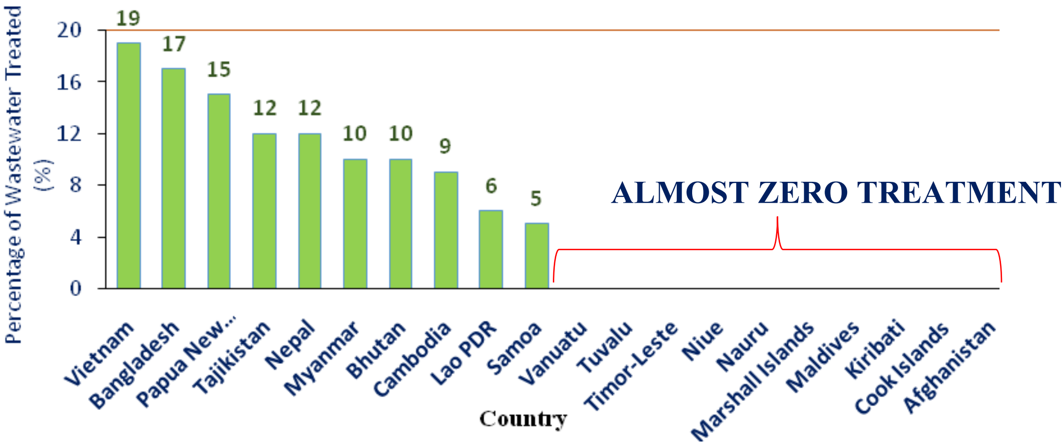


Figure 3.2.8-5: Percentage of wastewater treated in less developed countries in Asia and the Pacific Region. Source: (UN ESCAP, 2018a)

Improving the efficiency of wastewater management might contribute for the achievement of 2030 Agenda for Sustainable Development in the region. Indicators 6.3.1 and 6.3.2 are intrinsically related in that, ambient water quality is strongly affected by the discharge of wastewater produced by human activities into the aquatic environment (UN WATER, 2021a). For instance, as with many cities of Japan in the 1960s, the Dokaibay and rivers of Kitakyushu were extremely polluted, a situation comparable to the conditions currently found in cities of developing countries. However, pollution was greatly reduced because of the investment made by private factories in wastewater treatment facilities for industrial effluent, as well as the significant public investment made to develop the sewerage system. Below Figures illustrate these changes and improvements to water quality (ADB, 2016).

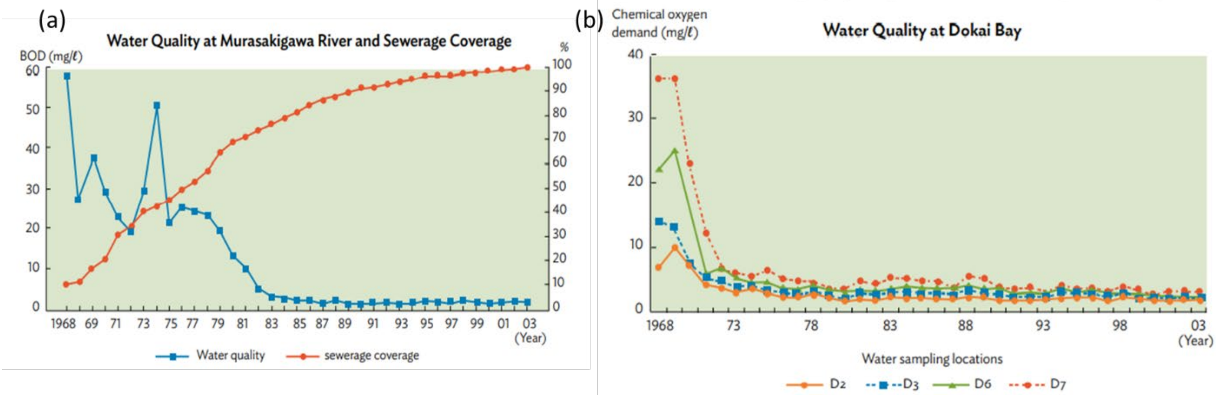


Figure 3.2.8-6: Changes in the Water Quality at (a) Murasakigawa River and (b) Dokai Bay. Source: (ADB, 2016)

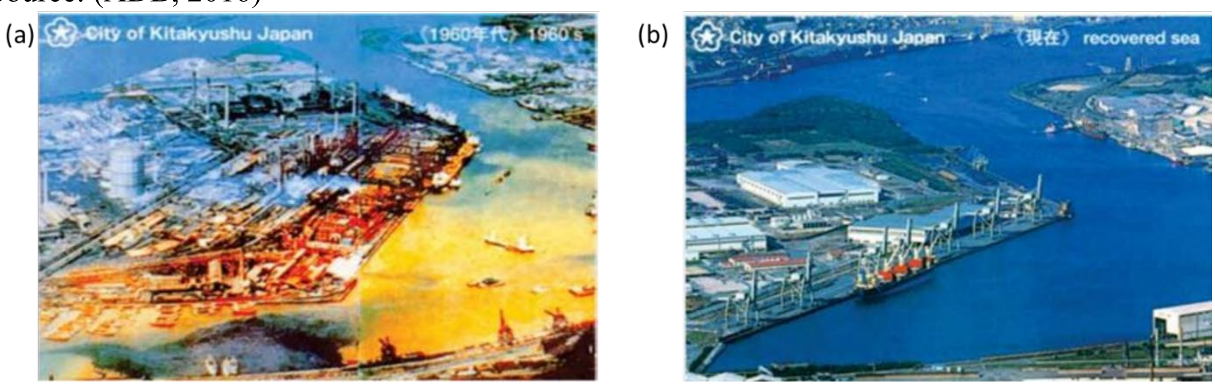


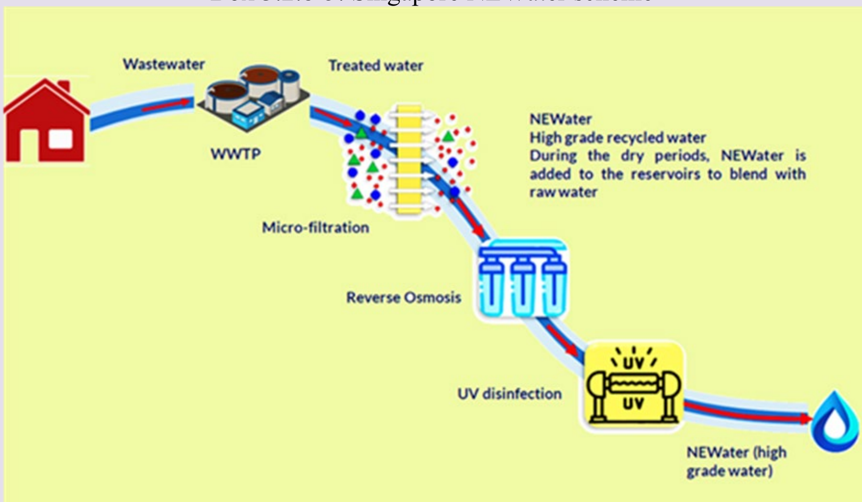
Figure 3.2.8-7: Water Quality at Dokai Bay and rivers of Kitakyushuin (a) 1960 before improvement and (b) in 2014after improvement. Source: (ADB, 2016)

Sewage works in Japan are promoted based on the sewerage law, which has the purpose to contribute to the sound development of cities and the improvement of public health, and to preserving the quality of water in areas of public waters. Comprehensive basin-wide plan of sewerage systems (related to SDG6.3.1) should be set forth in order to have its environmental conditions meet the Environmental Water Quality Standards (related to SDG 6.3.2) formulated in Basic Environmental Act (Japanese Law Translation, 2014).

Water and Sanitation Related Official Programmes

There are several water and sanitation related official programmes in Asia and the Pacific region. Singapore NEWater scheme is one of those successful implementations.

Box 3.2.8-5: Singapore NEWater scheme



NEWater produces high grade reclaimed water through regular treatment in a WWTP followed by additional 3 step purification process (Connor et al., 2017). An international expert committee has assessed and declared that NEWater quality is safe and high, and meets the standards of World Health Organization. However, NEWater cannot be directly used for the potable use. By 2060, NEWater is expected to meet 55 percent of Singapore's future water demand. Most of the NEWater is directly supplied for the industrial needs such as cooling water for air-conditioners and ultra-pure water for the semiconductor manufacturing.

The Republic of Korea had planned to increase the water reuse as a part of their green growth initiative where, water is called the "Blue Gold" (UN ESCAP, 2018d). In these countries, wastewater management and reuse have become integral parts of the water management cycle. As part of the wastewater treatment facility recovery programme, Japan Sewage Works Agency (JSWA) constructed Teijin's Multi-Stage Activated Biological Process technology (MSABP) to replace a sewage treatment system destructed by earthquake and tsunami on Japan's east coast.

Following is an example of water and sanitation related official programmes in India.

Box 3.2.8-6: Bangalore interventions and Project Nirmal for Water and Sanitation development in India

As a rapidly urbanizing country in South Asia, most of the Indians do not have access to safe sanitation facilities (UNESCAP, 2015). ECO-STP (ECO-Sewage treatment plant) is a sewage treatment technology based on gravity and natural processes in Bangalore. This works independent from power supply and daily monitoring while complying with the stringent pollution control norms. Grey water is treated using filtration and ozonation to bring it up to the drinking quality. Project Nirmal has aimed at developing sustainable sanitation services via the establishment of a fecal sludge treatment plant for Dhenkanal Municipality in India leading to the increased coverage of households. The project has focused on collection, transportation, treatment, disposal and reuse of fecal sludge. The treated dried sludge can be used as soil conditioner in the agricultural fields.

Development assistance for proper wastewater treatment

PR China, Japan, India, the Republic of Korea and Vietnam have increased their investments in the wastewater treatment (UNESCAP, 2016). The investments for water sector in Asia reached over 117.3 billion US$ in 2015. When considering the separate markets for wastewater treatment in Asia by technologies, it is observed that, the demand for mechanical equipment is highest and this trend will continue to be same in the future. The dominant countries providing investments in the Asia and the Pacific region are Japan, the Republic of Korea and PR China. Bangladesh and Thailand are also experiencing growth in the investments.

Partnerships for developing wastewater management

Goals of wastewater management could be only achieved by more effective partnerships. Japan has actively engaged in the improvement of the water environment in Asia and the Pacific region, via the establishment of a wide range of organizations as follows.

- Sewerage Business Management Centre (SBMC)
- Japan Sewage Works Association (JSWA)
- Japan Environnemental Sanitation Center (JESC)
- Japan Education Center for Environmental Sanitation (JECES)

Japan Sanitation Consortium (JSC) was established to promote the diffusion of basic sanitation (toilets) systems that will offer safe wastewater, night soil and sludge collection and treatment (JSC, 2021). As it considers both on-site and off-site sanitation, JSC is a unique organization that combines comprehensive knowledge and experience in policy making, system management, operation and maintenance through its' four member organizations (the agencies that have been successfully managing wastewater, sludge and night soil treatment in Japan for more than 40 years).

Two important organizations trying to improve the water sector in the region are, the Water Environment Partnership in Asia (WEPA), founded by the Ministry of the Environment in Japan (MOEJ) and Asia Wastewater Management Partnership (AWaP) founded by Ministry of Land Infrastructure and Transport (MLIT) and supported by the Japan International Cooperation Agency (JICA) (MLIT, 2008). These are the most active development aid ministries and agency in the area of water and sanitation in the Asia and the Pacific region. Water Aid India, is a prominent civil society organization, concerned about the water and sanitation sector.ADB programme has committed to the increase of the coverage of sanitation, hygiene and wastewater management in the region through the Water Operational Plan 2011–2020, supported by the World Bank's Water Financing Program (ADB, 2017). Initially, it was decided to cover 8 countries but later on expanded to two more countries based on the requests from regional departments. Targeted countries were Bangladesh, Bhutan, India, Indonesia, Mongolia, Myanmar, the Philippines, Sri Lanka, Uzbekistan and Viet Nam. These programs helped to identify the requirement of capacity building in these countries.

Official Development Assistance (ODA)

ODA provides the funding for the educational professionals to train water professionals in developing Asian countries. Following is an example for the ODA provided for wastewater sector in Japan.

Box 3.2.8-7: Improve local community wastewater treatment via subsidies and private financing in Japan

Private financing mechanisms are provided by the Government of Japan to establish the decentralized wastewater treatment systems (Kubota, 2021). One of the major purposes is to engage local small and medium enterprises in the decentralized wastewater treatment projects. National subsidies have been introduced to assist the establishment of Johkasou systems by covering the cost of installation. Cost that is passed on to the residents has reduced down to maximum of 10 percent of the total cost and the rest of the financial requirements are covered by the national government and local government taxes. To avoid the financial burden for the medium and small scale local projects, private finance initiative (PFI) mechanisms have been introduced. With PFI mechanisms, installation of Johkasou systems has been promoted by sales promotion by service providers.

Total amount of ODA into water sector in Asia and the Pacific has been around US$ 4.5 billion per year from 2010-2015 (UN ESCAP, 2018d). ODA flows into the categories of water supply, sanitation and water resource policy with an increasing trend from 2010 to 2015. Japan and the Republic of Korea are the major players in water and sanitation market of Asia and the Pacific region due to their significant investments in the sector in terms of ODA. However, low funding has been provided for waste management in the water sector, with compared to water supply and sanitation. At present, the existing amount of funding is not sufficient to cover the needs associated with achieving the 2030 Agenda and other water related SDGs. Achieving these goals might require large increases in investments with compared to Millennium Development Goals (MDGs).Blended finance is the strategic use of development finance for the mobilization of additional finance towards sustainable development in developing countries, and this innovative approach helps to enlarge the total amount of resources available to developing countries (OECD) (OECD, 2021).

Co-benefit of water saving and sanitation improvement by wastewater treatment

Wastewater treatment provides the co-benefits of water saving and sanitation improvement. ***Box 3.2.8-8*** presents a case study where a urine diversion toilet project had been implemented in PR China.

Table 3.2.8-1 shows the benefits of wastewater treatment and sanitation options used in Asia and the Pacific countries.

Box 3.2.8-8: Erdos Eco-Town Project (EETP) in the People's Republic of China

Under Erdos Eco-Town Project (EETP), the People's Republic of China designed an eco-san system with dry urine diversion toilets and solid waste treatment facilities (SuSanA, 2012). It was expected that, the separation of waste streams would increase the efficiency of treatment and recycling process. The system design focused on the separation of 4 main waste streams including urine, faeces, grey water and solid waste. This sanitation system consisted of urine diversion dry toilets, low flush urinals, faeces collection bins in the basements with ventilation systems, grey water treatment plants, composting plants and etc. The bins were sent to an on-site indoor thermal composting plant where the faeces were processed into an organic fertilizer product for the agricultural application.

Table 3.2.8-1: Benefits of Wastewater Treatment and Sanitation Options used in Asia and the Pacific Countries

Wastewater treatment and sanitation option	**Benefits**
Urine diversion toilets	Provides wastewater treatment Provides a green fertilizer and increases urban food security Reduces the nutrient content from wastewater effluent
Constructed wetlands	Provides wastewater treatment, storm water management, Aesthetic enjoyment and increase in urban green space Onsite treatment of grey water and storm water Creation of urban eco system
Waste stabilization ponds	Provides wastewater treatment, Provides a cheap source of irrigation water, source of local income through harvesting fish and plants
Biogas production from sludge	Provides wastewater treatment, Provides a cheap fertilizer for agriculture, Reduces cooking and heating bills
Grey water reuse	Reduces demand for potable water, Provides wastewater treatment, Creation of urban eco system, Provides a cheap source of irrigation water, Aesthetic enjoyment and increase in urban green space

Improving water resources and wastewater reuse related data coverage and data management issues for preparing effective national policy development in this sector

Asia and the Pacific region is very heterogenous, with each country having different types of infrastructures and capacities. Data on wastewater collection, treatment and reuse are sparse, particularly in the developing countries. Most of the countries do not have updated reliable statistical information on generation, treatment and use of wastewater and some of the countries had no information at all (UNEP, 2017a). The key challenge with data collection relates to the need of generating data at the national level that it is sufficiently detailed, consistent and able to compare with the data of other countries. Data gaps on infrastructure service pricing are significant. Most of the data available for water sector are of urban areas and pricing information in rural areas is largely unknown. The transport sector lacks the updated cross-country database on the wastewater tariffs and costs. Even International Benchmarking Network (IBNET) database, which is the most comprehensive water utilities data base fails to provide the accurate data, because utility services report them on a voluntary basis (World Bank Blogs, 2018). Utilities should be encouraged to publish the updated information on costs and tariffs. The World Bank could join other multilateral organizations in creating a comprehensive pricing dashboard which could be regularly updated.

A wastewater treatment system constitutes a long chain of interconnected components (pipes, pumps, treatment facilities). For assessing the risks involved in these components, data of the wastewater treatment systems is highly important. There should be inventories of the types of pollutants (physical, chemical bacteriological composition), their concentrations and the likely frequency of discharge. These details are essential for identifying the impacts throughout the chain of the components. Each link in the chain needs to be examined in order to determine how it should function, how it could interact with the pollutant, what are the impacts of the malfunction and so on. The database could also include options of different reuse activities and its' linkages with quality of wastewater effluent used and technology used.

Importance of water pricing structure and water subsidies on wastewater reuse

Water pricing is a regulatory option to reduce water demand and promote the sustainable water consumption. With the exception of Timor-Leste, where water supply is not priced, all other Asia and the Pacific countries are charging water tariffs. In Manila, the two main water utility companies have significantly different tariff levels (World Bank, 2017). Pacific islands, Fiji, despite of being the richest country in terms of GDP per capita, has the lowest tariffs, which is only a quarter of what is paid in Port Moresby (Papua New Guinea), the city with the highest tariff in the Pacific Islands. Since the revenue generated by water and sewage charges are just a fraction of the operating costs, water authority of Fiji is reliant on grants from the government to finance their projects. Singapore is a good example of water pricing strategy to reduce the water demand. Water pricing structure includes water conservation tax, sanitary appliance fee and waterborne fee. The generated revenue is used to fund the governmental water conservation programmes such as research and development, operation and maintenance. PR China has undergone several water reforms to systemize water pricing for agricultural, residential and industrial purposes. At present, the water volume quota system and a block rate structure mechanism govern the rate of water consumption in industries and domestic houses respectively (Che and Shang, 2015). This water pricing includes resource value and wastewater treatment costs as well.

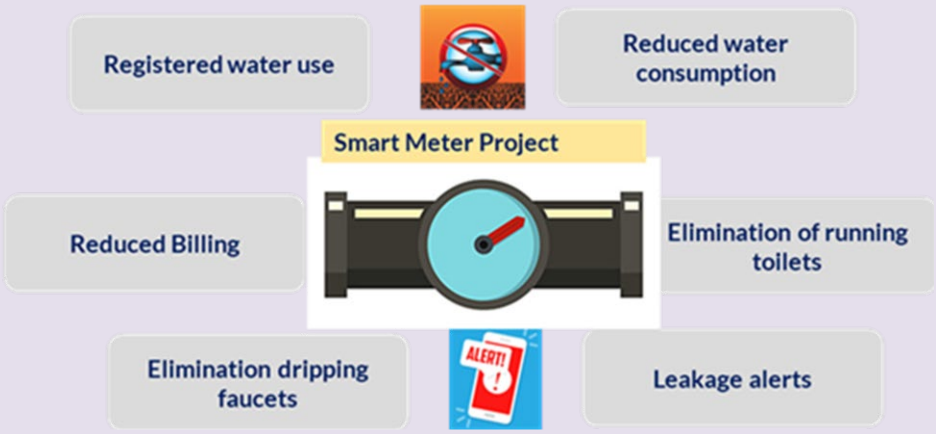
Wastewater collection tariffs are considered as a measurement for sanitation services. The number of countries which have tariffs for wastewater collection is significantly smaller than those regularly impose the water tariffs (World Bank, 2017). Unlike electricity and water services, wastewater services are often not priced. ASEAN low income countries such as Myanmar, Laos, and Cambodia do not charge tariffs for the wastewater collection services. Other countries such as Brunei, Indonesia, the Philippines and Thailand, have wastewater tariffs under the water bill (World Bank Blogs, 2018). In many cities in these countries, wastewater conveyance is not connected to centralized sewer systems and not collected by the utilities.

Vietnam has comparatively low prices and tariffs for water related services and generates low income in the water sector. In Vietnam, Decree No 88and2007andND-CP stipulated the requirement of collecting drainage fee from the households to cover the operation and maintenance cost of the drainage system (Horbulyk and Price, 2019). However, this drainage fee only covers 10-20 percent of operation and maintenance cost for wastewater collection system. From 2017, a wastewater discharge fee has been introduced for specific industries and they have to pay a fixed annual fee plus variable charges that are based on the concentrations in the discharged effluent of six listed contaminants (mercury, lead, arsenic, cadmium, chemical oxygen demand and total suspended solids). However, this fee plays a different role than a price for wastewater treatment. The industries are responsible for treating their own discharges and this fee is intended to encourage the firms to improve the quality of the effluent.

Water saving features at domestic levels in Asia and the Pacific countries

Water demand management is one of the most obvious options to tackle the increasing water demand and pollution of water resources. Water demand management emphasizes on changing practices and attitudes to improve the efficient use of water while lessening its' misuse. It is also more economical than building water infrastructure as well. Water demand management could be both short and long-term measures depending on the needs of the community. There are several solutions for saving water and managing the wastewater at the household level. They usually include the installation of water conserving appliances and water efficiency labelling schemes. Attention is being focused on reusing the grey water for various purposes. Toilets are being retrofitted with low-flow sanitary equipment such as low-dual flush toilets. Similarly, households are using showerheads and faucet aerators to reduce the flow of water in the taps. Wash basins in Japan are connected to commodes where, the water from hand wash is used to flush the toilets. Singapore has embraced this concept by mandating the people to install flow regulators for the non-domestic sector and private apartments. Also, mandatory water labelling of the products has been introduced since 2009 to indicate their water use efficiency (UNCRD, 2018b).

Box 3.2.8-9: Smart meters for water loss control in India



Shirpur Warwade is the first town in India to implement smart water meters and automatic meter reading system for 100 percent connections (KAMSTRUP, 2021). With the data received from 13500 smart meters installed, daily water supply has reduced by 33 percent and time spent on the entire billing process has become one-third than earlier. Previously, Shirpur citizens were worried that their bills would increase once the meters were installed but, after seeing their exact consumption readings, they are committed to conserving water. Even with the scarcity of water and depleting rainfall, they are assured that, they would have an equitable water supply since, they are paying as per consumption.

Centralized VS decentralized treatment (DEWATS) in circular water systems

By sewerage systems, wastewater is properly treated, and treated wastewater can be reused for irrigation, etc. In addition, these systems are effective for sound water environment, and creation of clean and healthy cities. However, it has been considered that, the sewerage systems are expensive, need long time for construction and not compatible for the developing countries in Asia and the Pacific region. Therefore, decentralized wastewater treatment has been successfully implemented in many Asia and the Pacific member countries.

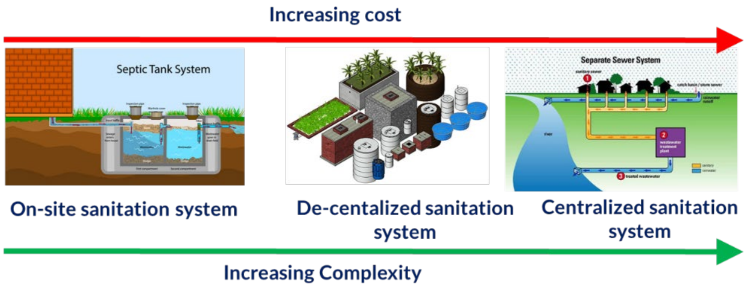


Figure 3.2.8-8: Differentiation between decentralized, on-site and centralized sanitation. Source: (NetSol Water, 2018)

Following is an example for the decentralized wastewater treatment in Indonesia.

Box 3.2.8-10: Community based sanitation systems in Indonesia

Since the issuing of "Development of Community-based Water Supply and Environmental Services" as a national policy in 2003, Indonesian government tried to make the efforts for the development of community-based sanitation systems (SANIMAS). This concept was initially aimed at developing community managed simplified sewer systems as a cost effective medium term solution for wastewater management in high density residential areas (UNESCAP, 2015; World Bank, 2016). 3 types of basic SANIMAS systems were constructed including community sanitation centers comprising public toilets, bathing and washing facilities, shallow sewerage systems connected to a communal anaerobic digester and combined systems with both shallow sewers for house connections, and a public facility at the digester site.

Decentralized systems could be built house-by-house or cluster in cluster, in a just in time fashion. This is obviously more economical than building a centralized treatment system. Also, spreading out the capital costs means that, a community needs to incur less debt compared to the borrowing requirements of a large upfront capital investment, which can reduce the financial burden off the society. Some potential financial disadvantages of the decentralized systems are that, the large number of systems could increase the design, financial and other transaction costs. Also, the financial risks of individual system failures on individuals, in contrast to the insurance like spreading of risks of failure across large number of users is a major concern. Despite of some dis-benefits, DEWATS could fill the gap between on-site treatment systems (septic tanks) and centralized treatment. However, effluent quality of the anaerobic type DEWAT systems should be improved. In this respect, effluent quality of Johkasou system (Aerobic type decentralized system) is as same as that of sewerage systems, though construction cost is higher than anaerobic type DEWATS (MOEJ, 2019). **Table 3.2.8-2** provides a comparison between Decentralized and Centralized Sanitation Systems.

Table 3.2.8-2: Comparison between Decentralized and Centralized Sanitation Systems

	On-site sanitation Systems and Decentralized Systems (Anaerobic type DEWATS)	Centralized System (Sewerage Systems)
Cost	Inexpensive Compared with Sewerage system	Higher cost is required
Construction Period	Short period compared with Sewerage System	Long period is required for construction of sewer network (Long time is needed to obtain the effect)
Improvement of Hygiene	○ SDG6.2	◎ SDG6.2
Improvement of Water Quality	△and× SDG6.3	◎ SDG6.3 Good Water Environment Reuse of Treated Wastewater

However, on World Toilet Day in November 2016, development agencies led by the World Bank declared the Citywide Inclusive Sanitation (CWIS) Initiative, which has been described in the Box below. CWIS has a clear goal of achieving SDG target 6.2 and 6.3, that were adopted in September 2015.

Box 3.2.8-11: Citywide Inclusive Sanitation Initiatives (World Bank, 2018)

- Everybody benefits from adequate sanitation service delivery outcomes
- Human waste is safely managed along the whole sanitation service chain
- Effective resource recovery and re-use are considered
- A diversity of technical solutions is embraced for adaptive, mixed and incremental approaches
- Onsite and sewerage solutions are combined, in either centralized or decentralized systems, to better respond to the realities found in developing country cities.
- Cities need to develop comprehensive approaches to sanitation improvement that involves long-term planning, technical innovation, institutional reforms and financial mobilization.
- Cities should demonstrate political will, technical and managerial leadership to focus on durable drivers for innovation, and to manage funding for sanitation in new and creative ways.

CWIS is aiming to implement the appropriate and comprehensive wastewater management in response to each country's characteristics and situation, based on the proper combination of these systems considering the necessity, effectiveness and limitation of Fecal Sludge Management (FSM) or Septage Management (SM), and disadvantages and advantages of centralized system. **Table 3.2.8-2,** provides the comparison between Decentralized and Centralized Systems. Currently, ADB has been promoting wastewater management based on CWIS concept (ADB, 2021c). JICA is beginning a new initiative “JICA Clean City Initiative”, comprehensive approach for water pollution, solid waste, and air pollution. In the field of wastewater management, JICA is aiming the establishment of healthy and hygienic living condition, the sound development of cities and the good water environment in order that citizens can benefit inclusively and equally by the holistic approach based on the CWIS concept.

Advanced wastewater systems VS nature-based wastewater systems

Although, advanced wastewater treatment systems provide high treatment efficiency, nature based treatment systems including constructed wetlands and fish ponds have also been used in some of the developing countries in Asia and the Pacific region for the removal of pollutants from wastewater and achieved satisfactory treatment performance up to some extent. Following is an example of wastewater treatment and reuse through fish ponds in Asia and the Pacific region. The EU-funded Thatuang Marsh wastewater management project was designed to improve wastewater treatment and drainage for the central Vientiane area (UNESCAP, 2015). The project designed and built a system of stabilization ponds at Thatuang Marsh to serve an estimated population of 44,590 with a per capita BOD discharge rate of 45gand capita/day, assuming 50 percent of the pollutant load would reach the treatment plant. EU-ponds restoration could be seen as an example of an approach to build a larger treatment system that would not require the installation of household septic tanks.

Box 3.2.8-12: Wastewater treatment and reuse through fishponds in Vietnam, Indonesia and the People's Republic of China

In the countries like Vietnam, Indonesia and the People's Republic of China, toilets are often placed above the fish-ponds (Vansintjan, 2021). Human and livestock waste may also be collected manually and put into the fish-ponds. Stimulated by the added nitrogen, phosphorous and carbon, algae and phytoplankton grow rapidly and start breaking the nutrients and bacteria and produce oxygen. As oxygen levels go up, fish are able to swim in the water and eat algae and phytoplankton. Then these fish are caught and sold to the market. Finally, when the pond is drained, fish droppings and any remaining sediments could also be used to fertilize surrounding crops like rice or fruit trees.

Role of NGO in creating public awareness on promoting wastewater reuse

Wastewater management issues must be socially and culturally appropriate and accepted since water and sanitation issues are linked to the local practices, cultures and traditions. Many cultures and religions discourage the reuse of treated wastewater, which acts as one of the barriers for wastewater reclamation and reuse. Such social gap could be addressed by properly introducing the treated wastewater reuse concept to all city dwellers. For improving the social acceptance of water reuse, Singapore and Australia have taken some steps. Following is an example of NGO supported water reuse systems.

The development of innovative, educational and training approaches with NGOs are essential to ensure that the issues and challenges could be overcome with confidence. Before directly addressing the public, it might be good to discuss water reuse issues with relevant NGOs. This might ensure that, they understand the context of water reuse proposals and potentially obtain the support during the communication process as well. In Adelaide, the Viriginia Pipeline Project was supported by an extensive education programme including a marketing study, display of water reuse at public meetings and ongoing support of the local and health authority, resulting in a clear change of public perceptions (EU Water, 2016). NGOs were highly involved with the promotion of these water reuse systems among the general public.

Box 3.2.8-13: Reuse system in Residential School, Madhya Pradesh, India

Infrastructure facilities for ensuring proper wastewater and reuse was inadequate in Madhya Pradesh with no wastewater drainage systems for majority of the households. There was the necessity of implementing proper wastewater reuse system in the state. A grey-water reuse system has been initiated in one of the Girls' boarding schools in Madhya Pradesh, which generates around 4000-6000 L of grey water (IIT, 2011). NGOs and UNICEF also promoted this grey-water reuse scheme to provide sufficient water for flushing the toilets, cleaning the floors as well as small scale irrigation. The public perception study of the reuse system revealed that, the grey-water reuse system was acceptable to them.

New business models to be adopted to promote wastewater reuse

There are several options to move from a revenue model to a business model, with cost and value recovery in the wastewater sector. Inter-sectoral water transfers or "water swaps"

This aims to provide the treated water to farmers for irrigation, in exchange of freshwater for domestic and industrial purposes. This business model can be also applied to water intensive users such as golf courses. Water swaps do not increase the overall water availability, but can allow for the allocation of more freshwater to high value uses. This concept is based on benefit sharing, where the agency responsible for drinking water pays an amount to the entity responsible for partial treatment and medium storage. Secondary treatment will be conducted for the wastewater in this case (UNEP, 2017a). In Iran, there has been an agreement between regional water company and farmers' association for water exchange. Farmers' water rights for dams and ground water has been exchanged for treated wastewater. In Asia and the Pacific region also, it is possible to implement this business model as well.

On-site value creation

This concept is based on wastewater aquaculture. When fish production is being conducted within a pond-based treatment process, reuse can be integrated through the absorption of nutrients from the wastewater into biomass such as duckweed which could be used as the fish feed. The business model combines a low cost treatment solution with potentially high revenue generation (Rao et al., 2015). On-site value creation based on aquaculture has been followed in Mirzapur, Bangladesh. A partnership has been formed between Hospital Trust and NGO to treat wastewater for producing duckweed as fish feed and cultivate crops for local market. Tertiary treatment including nutrient removal through duckweed is conducted for the wastewater. High demand for fish in the region has been an opportunity for the success of this business model.

Marketing reclaimed water

This is the simplest business model, where partially treated (fit-for-purpose) wastewater is made available to the user at a lower cost than the fresh water. Although, low freshwater prices make it difficult to charge appropriate cost for the reclaimed water, several successful examples have been documented (Lazarova and Asano, 2013). The concept is aimed at matching the future water buyers with suppliers of treated wastewater for securing the investment capital beforehand for wastewater treatment projects (Rao et al., 2015). Here, wastewater treatment is pre-financed by future water sales via contractual agreements to secure water shares and finances.

Replenishing Natural Capital

Secondary treated wastewater could be used to recharge groundwater in the water stressed regions. A business model could be based on benefit sharing principles, where the drinking water company and local government pays the wastewater treatment entity. Private stakeholders neighbouring the groundwater re-charge zone gain the potential of selling the water through private tankers. An example of planned ground water recharge could be found in the city of Bangalore, India, where urban wastewater is used to refill depleted irrigation tanks in the rural vicinity, which in turn helps to replenish the groundwater level and improves farmer access to irrigation water through tube wells (Jiménez, 2008; Rao et al., 2015). More efforts are needed to properly characterize secondary or tertiary treated wastewater depending on location and treatment schematic and then to explore feasibility of recharging groundwater in water stressed regions without contaminating it.

Public Private Partnership (PPP) business models to promote wastewater reuse

As the new business models, Public-Private Partnership (PPP) are used for financing the infrastructure development in improved water management. These projects have added advantages in lesser time to service delivery as well as decreased finance. Sound business models or formulation of enabling environment including feasible financial mechanism, capable institutional arrangement, etc. are important aspects for PPP. Also, clear definition and understanding of the role of public and private sector, and rational responsibility sharing between public and private sector is needed. In most of these projects, the finances associated with the projects are recovered from the use of these services by the public through fees and tariffs. Private sectors are mainly interested in designing, implementing, funding and the completion of the project while public sectors are involved in defining and monitoring the progress. Design-Build (DB), Operation and Maintenance (O and M) Contract, Build-Own-Operate (BOO), Build-Own-Operate-Transfer (BOOT) and Buy-Build-Operate (BBO) Operation license are examples of these PPP business models. At present, the possibilities for nutrient and energy recovery are among the most advanced in terms of technical and financial feasibility. However, there is increasing potential for providing the further opportunities for cost recovery in wastewater management.

Box 3.2.8-14: Public Private Partnership business model for wastewater treatment in the People's Republic of China

Sustainable urban development in the People's Republic of China for wastewater treatment is an example of the PPP. The wastewater and drainage service in Shanghai falls under the Shanghai Sewerage Company with the objective of increasing the wastewater collection and treatment ratio to 90 percent by 2020 (UNCRD, 2018b). The PPP between Shanghai Water authority and the Youlian Consortium has provided wastewater treatment services with 35 percent funded by the private consortium and the remaining amount by the bank loans.

Role of rainwater harvesting in efficient water resources management

Rainwater harvesting could be applied at a household or community level, contributing to the demand management of main water supply as well as localized flood controlling. Only minor treatment is required prior to usage for the laundry and toilet flushing. However, rainwater can be treated to drinking water quality as well. Roofs and terraces provide catchment areas and the rainwater can be used for irrigation purposes and to fill a tank for emergency tap water. Rainwater harvesting also helps in reducing soil erosion and contamination of the surface water with pesticides and the fertilizers from rainwater run-off. Following is an example of rain water harvesting in Australia.

Box 3.2.8-15: Rainwater Harvesting in Sydney, Australia

The Building Sustainability Index (BASIX) State Planning Policy has employed rainwater harvesting technique in the new developments for the people of greater Sydney. Considering the business-as-usual scenario, by 2050, the demand for water supply in Sydney will be increased by 80 percent, increasing the water charges by over 100 percent (Smit, 2020). One in four households in Australia has a rainwater tank. Despite of this, there is not much implementation of rainwater harvesting by the mainstream water industries. There is a perception that, rainwater harvesting to be used onsite is more expensive than the infrastructure facilities required to deliver the water to the buildings. Rainwater harvesting is a demand management and at-source storm water management distributed solution that operates at the individual building scale. It does not fit with a water utility business model and does not contribute to the short-term revenue. Volume reduction of storm water through rainwater harvesting helps to address flood.

Sewage sludge as a new resource for energy production VS fertilizer production in circular wastewater treatment system

Biomass from the septage and wastewater could be used as a fertilizer in agriculture, as practiced in the countries of Central Asia, or could be converted into fuel for cooking or heating with biogas reactors such as in Cambodia, the PR China, Thailand and Viet Nam, thus reducing water pollution. They have shown that, the revenues from wastewater by-products such as fertilizer are significantly higher than the operational costs of wastewater systems that harvest by-products. This indicates that, resource recovery from wastewater is a profitable business model for the economic development as well. Following is an off-site energy recovery project from sludge incineration in Japan through thermal treatment processes.

Box 3.2.8-16: Comprehensive approach in Japan for recovery of energy from sewage

In Japan, although, more than 50 percent of bio-solids are recovered from the wastewater treatment, only around 15 percent of their potential biomass energy was being used in 2017 (UNEP, 2017a). The Japanese government wanted to increase this percentage by means of legislative approaches, financial aids, promotion of innovations, tax reductions and standardization of bio-solid by-products. The new sewerage act of Japan 2015 requires the sewage operators to utilize the bio-solids as a carbon neutral form of energy. In 2016, 91 plants recovered biogas for electricity and 13 produced solid fuels. A leading example is the city of Osaka, which provided wet sewage sludge for electricity generation and cement production. As a financial aid to support the sewage operators investing in the energy reuse from bio-solids, a feed in-tariff is paid for the electricity generated from bio-solids at a fixed price per kWh.

Sewage sludge recycling rates in Japan from 1989 until 2019 has been depicted from ***Figure 3.2.8-9.*** The recycling rate has decreased to around 55 percent in 2011, with the increase of number of landfills after the Great East Japan Earthquake. 'Other' in the graph represents the storage of sludge in wastewater treatment plant sites.

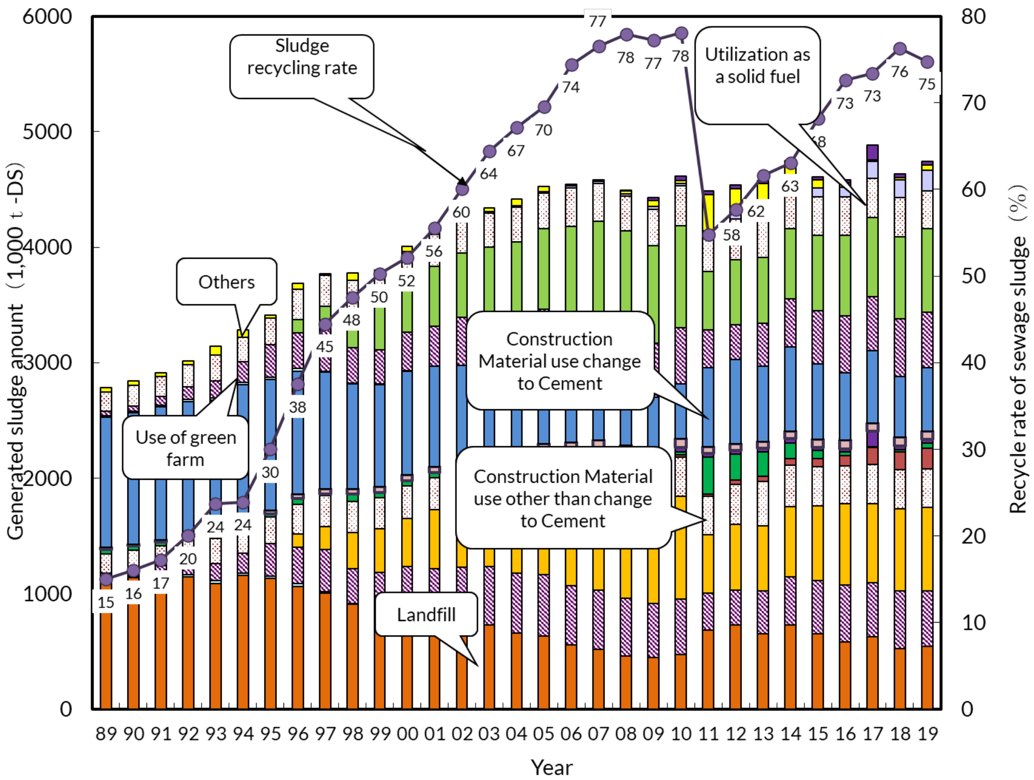


Figure 3.2.8-9: Sewage sludge recycling rates in Japan. Source: (MLIT, 2019b)

Utilization of Biomass in Sewage Sludge in Japan in 2019 is presented in ***Figure 3.2.8-10.*** In 2019, only 24 percent of the sewage sludge has been used for the energy while, 10 percent of the sludge has been used for agriculture as well. Around 65 percent of the sludge has not been utilized for any purpose and disposed. The plans have been made to achieve 40 percent of the sludge utilization rate by 2020**.**

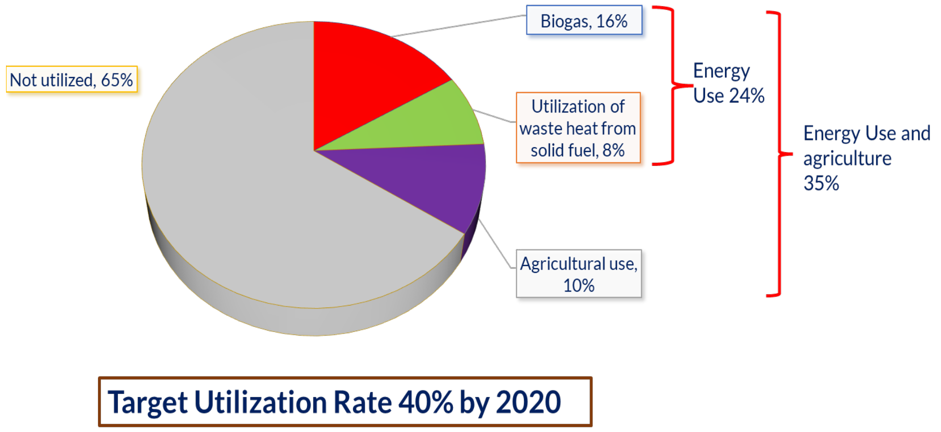


Figure 3.2.8-10: Utilization of Biomass in Sewage Sludge in Japan in 2019. Source: (MLIT, 2019b)

Ideal future sewage system towards the formation of the recycling society has been demonstrated in ***Figure 3.2.8-11.*** Consumption of sewage for the electricity and as biogas fuel in automobiles should be encouraged. Carbonization technologies such as the production of fuel tablets as well as the recovery of phosphate from sludge to be used as the fertilizer must be improved. Promotion of the collaboration and cooperating with the major organizations for the supply of resources and produced energy to districts is of significant importance.

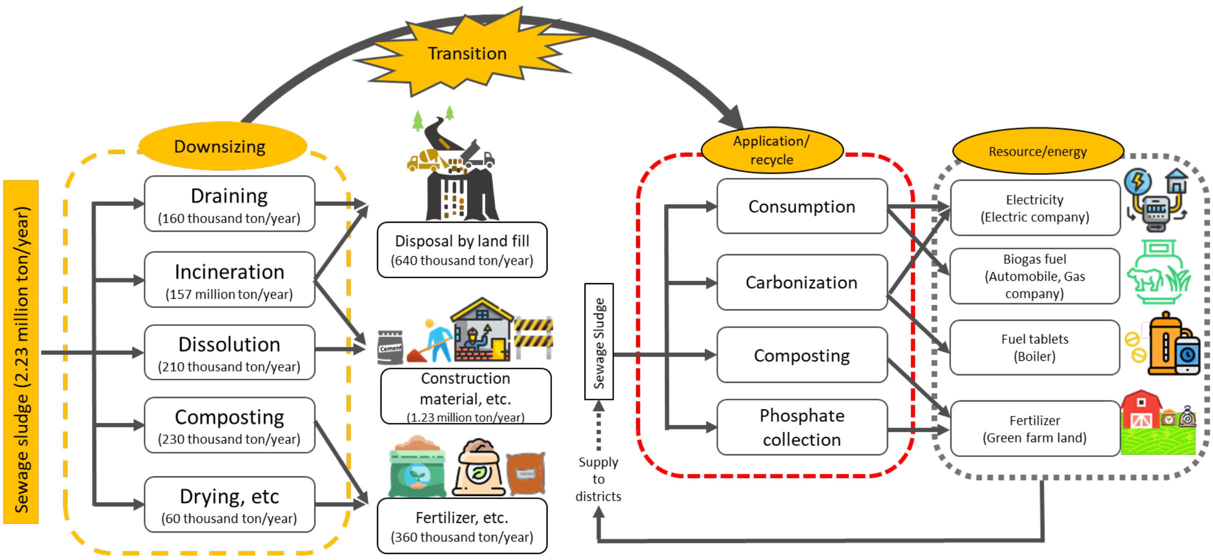


Figure 3.2.8-11: Ideal future sewage system towards the formation of the recycling society. Source: (MLIT, 2019c)

Recovery of nutrients from bio-solids

There are several studies from Asia and the Pacific countries such as Bangladesh, India and Sri Lanka where municipalities engage in septage sludge dewatering, safe composting and palletization (Nikiema and Cofie, 2014). Phosphorous recovery from on-site treatment facilities such as septic tanks could be technically feasible by converting septage into organic-mineral fertilizer. Since extractable phosphorous mineral resources are becoming scarce, phosphorous recovery from septage is becoming increasingly important. Around 22 percent of the global phosphorous demand could be satisfied via recycling of faeces and urine

(Mihelcic et al., 2011). Despite of the new research and advancements of the nutrient recovery from wastewater sludge, business opportunities are limited due to the low market value. Low nutrient content of the bio-solids (particularly nitrogen) does not allow for making a good market share with compared to chemical fertilizers. Although, it is possible to capture around 45-90 percent of phosphorous in wastewater, only 5-15 percent of the available nitrogen can be recovered.

3.2.8.4 Level of Achievement in SDG goals and targets of Ha Noi 3R Declaration in Asia and the Pacific Region

Ha Noi 3R Declaration discusses the critical importance of integrated waste management in the water sector. SDG-6 stresses on the importance of looking at the entire water cycle from source to end, including the critical areas such as wastewater and excreta and septage management, integrated resource management, water use efficiency and conservation of ecosystems rather than just emphasizing on the on-site sanitation facilities.

In most of the Asia and the Pacific countries, efforts have been taken for achieving the goals of Ha Noi 3R Declaration and SDG 6. Singapore NEWater Scheme, Bangalore interventions and Project Nirmal for Water and Sanitation development in India for the sludge treatment and reuse, Erdos Eco-Town Project (EETP) in PR China, Community based sanitation systems in Indonesia and Johkasou systems in Japan are examples for the effective wastewater treatment and reuse applications in the region. Japan established the targets of achieving the sludge utilization rates up to 40 percent by 2020 and made plans to develop the ideal future sewage system towards the formation of a recycling society. Also, Singapore is expecting to meet 55 percent of Singapore's future water demand via the reclaimed water with NEWater Scheme by 2060.

However, there is a significant investment gap to develop the water infrastructure in Asia and the Pacific countries. It has been mentioned that, more than $ 800 billion in investment through 2030 would be required for the development of water and sanitation infrastructure within the region. To achieve this target, countries in the region must develop effective policies to attract more private investment. In the countries such as Vietnam, the insufficient levels of investment in wastewater treatment by the government is a major constraint for the expansion of water service coverage. Low water and wastewater tariffs are barriers for encouraging the wastewater reclamation and reuse efforts. To rapidly develop new resource recovery systems, municipalities need to invest in the feasibility studies that include the production of bio-energy, water reuse and nutrient recovery. To enable the expansion of wastewater treatment and resource recovery, urban and industrial wastewater tariffs should be reformed. Sludge drying and dumping at landfills is one of the most common approaches to sludge treatment in Vietnam, even though, sludge contains valuable nutrients that can be used in agriculture. Some of the industries in Vietnam have tried to recover methane from their treated biological waste and wastewater effluent. Also, efforts have been taken to implement waste to energy projects such as the first full-scale Waste-to-Energy project with a capacity of 75 tons per day in Hanoi at the Nam Son waste-to-energy complex (ARCOWA, 2018). Although, major progress is being made in this sector, there is still further work needed to establish integrated water resources management in Vietnam.

More innovative technologies and approaches should be introduced for the water resource management to help diversifying water while at the same time reducing the costs. There are potential opportunities for making use of different water sources such as rainwater, grey and black waters in the region. However, these implementations would require technology transfer, social acceptance as well as adjustment of the regulations, policies as well as market-based instruments. Some of the Southeast Asian countries such as Thailand, Vietnam, Brunei, Cambodia, and Lao PDR are facing the challenge of lack of research knowledge and information regarding safe water reuse applications. Therefore, technology and knowledge sharing by the developed countries in the region such as Singapore and Japan are of crucial importance. Also, Decentralized wastewater treatment systems (DEWATS) could be most suitable solutions to respond to the local needs and resource recovery in the underdeveloped countries as well.

3.2.8.5 Conclusion

Asia and the Pacific region is making efforts on achieving the SDG targets and the goals of Ha Noi 3R Declaration via successful wastewater and sanitation management practices. Although, efforts have been taken to achieve these targets in the region, yet the potential and requirement of reusing treated wastewater remains unappreciated. This is mainly due to the in-sufficient sanitation infrastructures, lack of tertiary treatment systems and inability of correctly estimating the wastewater production. Despite of all the regulations and policies, still a higher fraction of the produced wastewater is discharged into the water ways. Also, the countries such as Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Nepal, Sri Lanka, Thailand, and Vietnam are dependent on septic tanks and other low cost onsite sanitation facilities which provide only partial treatment for the black water.

Some of the Asia and the Pacific countries such as Japan, PR China, the Philippines, Singapore and the Republic of Korea have successfully implemented wastewater and sewage management systems in their countries. Singapore and Japan are ahead of most of the other countries in the region with their advanced wastewater and sludge treatment technologies. However, the countries such as Vietnam, Myanmar, Nepal, Sri Lanka and Thailand require access to the updated knowledge and financial resources from developed countries for achieving the targets of SDG and Ha Noi 3R Declaration.

3.2.8.6 Way forward

Several improvements are required for the development of wastewater sector in Asia and the Pacific region.

Public perception

Proper assessment of the public perception on reuse of treated wastewater is of high importance for the successful implementation of these projects. Especially, in the countries such as India, due to the lack of knowledge on the wastewater treatment, people are reluctant to reuse treated wastewater. Therefore, it is essential to educate them on the technologies that are expected to be used and the importance of these projects prior to the implementation. Consideration on the public perception would be highly important for the initiation and operation of these projects in long term in most of the Asia and the Pacific countries such as India and Sri Lanka.

Policy, legislative and institutional reform

It is obvious that, most of the countries in the Asia and the Pacific region have developed national water and sanitation policies for achieving SDG goals and the goals of Ha Noi declaration. India’s policy for treated wastewater reuse, integrated wastewater management policy in Shenzhen, the PR China, the Sewerage Law of Japan are some of the examples in the region. However, the potential for the safe reuse of treated wastewater and sludge is not yet fully identified, except for Singapore which uses latest technologies to treat wastewater for reuse. Also, in India, lack of proper sewerage systems and onsite treatment facilities is a challenge for reusing treated wastewater. There is a need of developing the policies to support innovative processes for resource recovery from wastewater. Also, incentives should be introduced for the initiation of these projects as well.

Infrastructure and technology

There are latest technological developments in the region such as Singapore's NEWater scheme which produces high grade reclaimed water through additional 3 step purification process including micro-filtration, reverse osmosis and UV disinfection. ECO-STP (ECO-Sewage treatment plant) in Bangalore, India is based on the gravity and independent from power supply and daily monitoring while complying with the stringent pollution control norms. DEWATS are also successfully being implemented in several Asia and the Pacific countries including Indonesia. DEWATS could fill the gap between on-site treatment systems (septic tanks) and centralized treatment. Development of infrastructure and technology is required for the successful implementation of these technologies in Asia and the Pacific countries.

Research and Development

Research and development for latest technologies is significantly important for the improvement of safe water and treated sludge reuse in the region. There are several studies from Asia and the Pacific countries such as Bangladesh, India and Sri Lanka where municipalities engage in septage sludge dewatering, safe composting and palletization. India's National urban sanitation policy has encouraged research and development via establishing a "State Water and Wastewater Training Centre". In the countries such as PR China, Japan and Singapore and Hong Kong, numerous research are being conducted for the safe reuse of water especially using membrane technology. However, some of the Southeast Asian countries such as Thailand, Vietnam, Brunei, Cambodia, and Lao PDR are facing the challenge of lack of research knowledge and information regarding safe water reuse applications. Transferring technology and other resources within the region (from the countries like Singapore and Japan to other member countries) is one of the best options to overcome these issues.

Alternate Financing

Public private participation (PPP) projects within the region are very important in the wastewater sector. Japan and the Republic of Korea are the major players in water and sanitation market of Asia and the Pacific region. At present, the existing amount of funding is not sufficient to achieve the 2030 Agenda and other water related SDGs. Achieving these goals might require large increases in investments with compared to Millennium Development Goals (MDGs). Blended finance schemes to provide the additional finance towards these projects in developing countries are of high importance.

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3.2.9 Data Issues on new emerging waste streams

There is a significant increase in quantity of waste generated from new and emerging waste streams. Quantifying them is difficult, as a number of studies globally as well as Hanoi 3R indicators reporting indicates that due to a grey-zone in material flow chain the waste generation, segregation, reuse, repurpose, treated and disposed are not available or scattered at local and national level. Further, data related to littering or illegal movement at local, national and global level is very scattered. Therefore, the real magnitude of problem remains unclear, though the impacts of informal treatment in some countries are unquestionably significant. Thus, countries keep on contributing to the issue of environmental and health impacts through informal treatment by domestically generating huge quantity of such wastes. The following sections describe the issues faced, need for data, sustainability reporting, successful and practical case studies. Monitoring such flows is critical for countries to become better prepared at controlling transboundary movements of hazardous wastes and advancing in the environmentally sound management of such wastes.

3.2.9.1 Data Issues (UNITAR, 2022)

The driving factor is compliance with existing national and global waste legislation. However, other drivers are given below.

i. Increasing volumes of new emerging waste. For example, it is estimated that the amount of E-waste generated will exceed 74 Mt in 2030, and as much as 110 Mt is expected by 2050 (Forti et al., 2020b; Parajuly et al., 2019b).
ii. Absence of waste-specific legislation, items covered in existing legislation and extent waste definition is not clear.
iii. Limitations of waste management infrastructure. For example, the recycling infrastructure for different new emerging waste streams is absent.
iv. Competition between formal and informal sectors for valuable items. The informal sector nowadays plays a key role in low - and middle income countries in Asia with no developed waste ecosystem.
v. Mixing of waste with other waste streams such as metal scrap.
vi. Complex nature of waste ex. E-waste, plastic waste.
vii. Hazardous extent and nature of waste.
viii. Emergence of concepts like resource efficiency, sustainability and circular economy.

Consequently insufficient information for conducting a comprehensive material flow analysis is limited for the following reasons:

i. Ambiguous definitions: Interpretation of definitions is different among the countries, which results in irregularities that impede aggregating and analyzing data. For ex. the difference between recycling rate and recovery rate.
ii. Different categorisation: The categorisations of wastes as hazardous waste is different among countries due to different definitions. For ex. hazardous waste mentioned in Annex I Annex VIII, or other type of waste and Annex IX of the Basel Convention.
iii. Incomplete reporting: Many countries do not prepare and disclose a national report every year for disclosure.
iv. Different methodologies for estimation of new emerging waste.
v. Discrepancies in reporting: The amount of waste generated segregated, repurposed, recycled, treated and disposed as reported in the national reports may be inexact due to partial coverage of material flow chain and lack of material balance.
vi. Data inaccuracies due to unharmonised geographical scopes of data collection, interpretation and data reporting.
vii. There is no local, national and global registry which could facilitate for harmonization, interpretation and reporting of data.

3.2.9.2 Need (UNITAR, 2022)

Therefore, there is a need for: (i) harvesting all possible datasets; (ii) harmonising the datasets; (iii) Applying estimation based on mass balances and similarities across countries to estimate for missing data; and (iv) Creating one detailed harmonised dataset

The biggest challenge is emergence of new compliance and control regime for emerging waste. At first, the majority of the countries in the region try to bring these emerging waste streams under the jurisdiction of either municipal solid waste or hazardous waste management. Depending on the magnitude of the problem and the need to control it given the national, regional, and international commitments different countries adopt different policy and waste regulatory approaches. This stage is followed by addressing each waste stream individually after national capacities are augmented to address it. For example, the emergence of EPR based regulation in PR China, India, Vietnam and other countries indicate this trends.

A possible approach to address these data gaps could be a combination of both systemic and systems approaches. Hanoi 3R goals have tried to address the data gaps in Asia and the Pacific using systematic approach. It has given the foundation and prepared the countries in the region for transition into a more systemic and systems reporting as demonstrated in SDG reporting.

3.2.9.3 SDG Tier 1 and Tier 2 Indicators as Applicable

Globally and in Asia and the Pacific region, sustainability reporting is being increasingly followed by local and national governments and corporates. It gives broadly the uniform reporting framework, which can be interpreted and followed. Different emerging waste streams and SDG goals and indicators are well established.

3.2.9.4 Case Studies

Box 3.2.9-1 demonstrates the monitoring of ban on single use plastics and implementation of EPR in India.

Box 3.2.9-1: EPR Portal for Plastic Packaging (CPCB, 2022a)

In order to monitor EPR implementation, Central Pollution Control Board, MoEFCC, Government of India has launched "Centralized Extended Producer Responsibility Portal" for plastic packaging in India. It gives the status of Producers, Importer, Brand Owners (PIBO) whose registration has been received, registration in process, registration on process, registration not approved, and registration issued. Further, it gives information about each of PIBO's target as per the category of plastics. It give such type of information at national level and state level. The disclosure of such information internalizes the transparency in the implementation, monitoring and compliance of plastic waste management rules. It also enhances the capacity of the regulations at national and state level to optimize their human resources while ensuring compliance at the same time.

Box 3.2.9- 2 demonstrate an attempt to fill the data gaps for E-waste reporting using harmonized approach at global level.

Box 3.2.9-2: E-waste Monitor (UNITAR, 2022)

E-waste is one of the fastest-growing waste streams. Monitoring such flows is critical for countries to become better prepared at controlling transboundary movements of hazardous wastes and advancing in the environmentally sound management of such wastes. It gives: (1) Global Statistics: (a) Global E-waste Flows of Transboundary Movements; (b) Global Statistics of Printed Circuit Board Waste; and (c) Global Import and Export Hotspots. (2) Regional Overviews: (a) Africa; (b) Americas; (c) Asia; (d) Europe; and (e) Oceania

According to e-waste monitor, it is expected to increase to 74.7 Mt in 2030 and reach as much as 110 Mt in 2050. Under Sustainable Cycles (SCYCLE) Programme United Nations University develops.

E-waste Monitors series (ewastemonitor.info), which has been developed since 2014. It has just completed its transition from UNU to United Nations Institute for Training and Research (UNITAR). Its closest partners, such as ITU, UNIDO, and UNEP, follow international guidelines on E-waste statistics, containing the most applied classifications as well as correspondence tables of those classifications.

In 2019, the world generated 53.6 Mt of E-waste – an average of 7.3 kg per capita.

The UNU-KEYS are a product categorisation comprised of 54 products, which are listed in ANNEX 1 and which can be further aggregated into following six e-waste categories, as derived from the European Union WEEE Directive.

It estimates that 5.1 Mt (just below 10 percent of the total amount of global E-waste, 53.6 Mt) crossed country borders in 2019.

- 1.8 Mt of the transboundary movement is shipped in a controlled manner.
- 3.3 Mt of the transboundary movement is shipped in an uncontrolled manner
- Only 2 to 17 kt of e-waste is estimated to be seized
- 0.36 Mt of printed circuit board waste is imported mainly into East Asia, Western Europe, North America, and Northern Europe, where specialist recyclers for printed circuit board waste are located.
- 3.3 Mt of uncontrolled transboundary movement exists as used-EEE4) or e-waste from high-income to middle-and low-income countries, further trickling down regionally toward the poorest within the region.

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3.3 Conventional and Frontier Technologies in Advancing 3Rs and Circular Economy in Asia and the Pacific

3.3.1 Waste-to-Energy

Waste-to-energy (WtE) refers to a variety of treatment technologies that convert waste to electricity, heat, fuel, or other usable materials, as well as a range of residues including fly ash, sludge, slag, boiler ash, wastewater and emissions, including greenhouse gases. In the waste management hierarchy, it can also be classified into disposal, other recovery or recycling operations, according to the energy products produced and recovery level (UNEP, 2019e). The critical benefit of WTE is that it reduces the amount of waste while recovering energy at the same time some countries in the region consider it as a renewable source of energy. WtE is broadly classified into four categories: thermal, mechanical and thermal, thermo-chemical and biochemical through different routes or their combination such as: (i) Incineration with energy recovery; (ii) Gasification; (iii) Pyrolysis; (iv) Composting; and Anaerobic digestion. **Table 3.3.1-1** gives the comparison of the usage routes in terms of technology description major products, waste inputs, volume reduction, pollution control requirement, scale of plant indicative cost.

Table 3.3.1-1: Comparison of WtE Routes. Source: (Beyene et al., 2018; Moya et al., 2017; UNEP, 2015b; World Energy Council, 2016)

Type of technology	Incineration with energy recovery	Gasification	Pyrolysis	Composting	Anaerobic digestion
Technology Description	Direct combustion of waste between 750 and 1100ºC in the presence of oxygen.	Partial oxidation of waste between 800 and 1200ºC in the presence of a controlled amount of oxygen.	Thermal degradation of waste between 300 and 1300ºC in the absence of oxygen.	Aerobic bioconversion of organic wastes.	Biodegradation of (readily degradable) organic wastes in the absence of oxygen, with anaerobic microorganisms.
Major Products	Produces steam for electricity and and or heat generation in a boiler or steam turbine. Can generate heat or electricity, or combined heat and power.	Produces synthetic gas for further combustion or conversion to chemical feedstock.	Produces liquid fuel for further combustion or conversion to chemical feedstock.	Produces compost which can serve as a soil conditioner, mitigate erosion, sequester carbon in soil, be used in land reclamation and as a final cover for landfills.	Produces biogas and digestate. Digestate can be composted for use as a soil conditioner or dewatered and used as a low calorific value refuse-derived fuel.
Waste Input	Mixed MSW or refuse-derived fuel.	Only suitable for relatively homogeneous waste streams, such as wood waste, agricultural residues, sewage sludge, and plastic waste.		Separated organic fraction of MSW, food waste, or other solid organic waste. Suitable to treat material high in lignin (woody).	Separated organic fraction of MSW, food waste, animal and human excreta, or liquids and sludges. Less suitable for high in lignin (woody) material.
Volume Reduction*	75–90 percent	75–90 percent	50–90 percent	95–100 percent	45–50 percent
Pollution control requirement	High	Medium	Medium	Low	Low-medium
Scale of Plant	Available from small to large scales. A centralized large scale plant is more common.	Available from small to large scales.	Available from small to large scales.	Available at the household scale (home composting), community scale (backyard,	Available in decentralized small scale digesters (including on-farm), and large scale

Type of technology	Incineration with energy recovery	Gasification	Pyrolysis	Composting	Anaerobic digestion
				vermicomposting), or at a centralized, large scale (window, aerated static pile, in-vessel).	digesters for the organic fraction of MSW.
Cost per tonne (in US dollars)*	95–190 For centralized facilities on a moderately large scale.	95–190 For centralized facilities on a moderately large scale.	95–190 For centralized facilities on a moderately large scale.	0 –70 For small scale composting. At a pilot site running in Phnom Penh, Cambodia, for example, the cost can be made-up by the value of the end product.	65–120 For centralized facilities on a moderately large scale. Cost depends on subsidies for renewable energy.

Note: The volume of waste reduction depends on its composition, the specific type of technology used, and the amount of bottom ash recycled. For incineration with energy recovery, gasification, and pyrolysis, the typical volume reduction is 75 per cent, while higher volume reduction can be attained through recycling of bottom ashes. * Cost per tonne (in US dollars) refers to the estimated net operation and investment costs minus revenues from resource recovery. The estimated cost depends on the income level of the country. The term "refuse-derived fuel" is used in this table to designate all processed fuel outputs.

i. Thermal WtE can reduce waste volume and mass by 75–90 per cent, thus reducing the demand for landfill space.
ii. Thermal WtE plants reduce greenhouse gas emissions by diverting waste from landfills and open burning and by replacing fossil fuels.
iii. The energy value in waste can be utilized to generate electricity and heat during the thermal WtE process.
iv. Shift to thermal WtE from open dumpsites could improve hygienic and environmental conditions in countries.

Extensive use of incineration with energy recovery is widely applied in Europe, Japan and the United States. Its application in developing countries is increasing as it is under utilized. It is suitable for mixed MSW depending on waste quality and composition in developing countries. Composting widely used in high income countries has high potential, particularly in developing countries with a high organic fraction of MSW. WtE is the most common way of creating energy as power or potentially heat from the essential treatment of waste, or the handling of waste into a fuel source. Gasification and pyrolysis is not widely used (Beyene et al., 2018).

Among all the waste treatment technologies in Asia and the Pacific region, about 29.2 percent is used as incineration with energy recovery while 51.2 percent is landfilled. The products from WtE are power or potentially heat or a burnable fuel, like methane, methanol, ethanol or engineered energizes (UNEP, 2015b; World Energy Council, 2016). The low calorific value, high moisture content of waste, and emissions like dioxins and furans from incineration remain critical technical challenges for thermal WtE in developing countries in Asia and the Pacific region.

Though thermal WtE is still used in developing countries as a waste management approach, in particular Asia and the Pacific countries such as PR China, India, and Thailand, it is located at the bottom of the waste management hierarchy There are about 1120 WtE plants in Asia and the Pacific, majority in Japan, Republic of Korea and PR China as shown in **Figure 3.3.1.1**. PR China has the fastest WtE market growth.

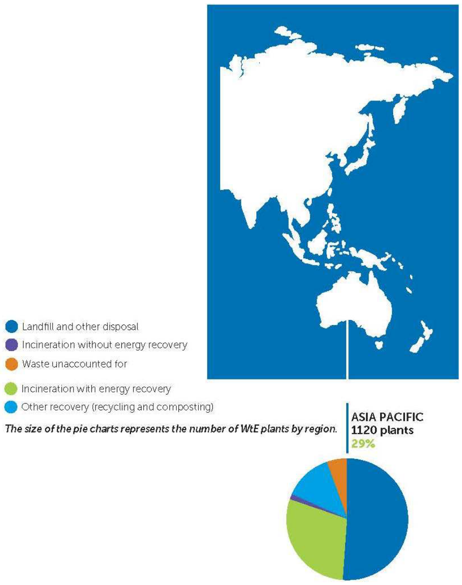


Figure 3.3.1-1: MSW incinerated with energy recovery and number of thermal WtE plants in Asia and the Pacific region. Source: (UNEP, 2019e)

Figure 3.3.1-2: Top 11 countries with the most thermal WtE plants, including amount of waste incinerated with energy recovery. Source: (UNEP, 2019e)

The implementation of thermal WtE in developing countries has technical challenges, such as waste characteristics, and governance challenges, which include social, financial and legislative aspects. Current pollution control technology has greatly reduced the level of dioxins from incinerators compared to 1990s levels.[6] Thermal WtE plants with advanced emission control technologies that are well-maintained have minimum public health impacts. Waste management strategies along with new technologies should be implemented based on local needs and subjected to periodic review and adjustment.

Thermal WtE requires significant investment for startup, operation and maintenance. A comparative investment cost versus waste capacity of WtE thermal plants is shown in **Figure 3**.

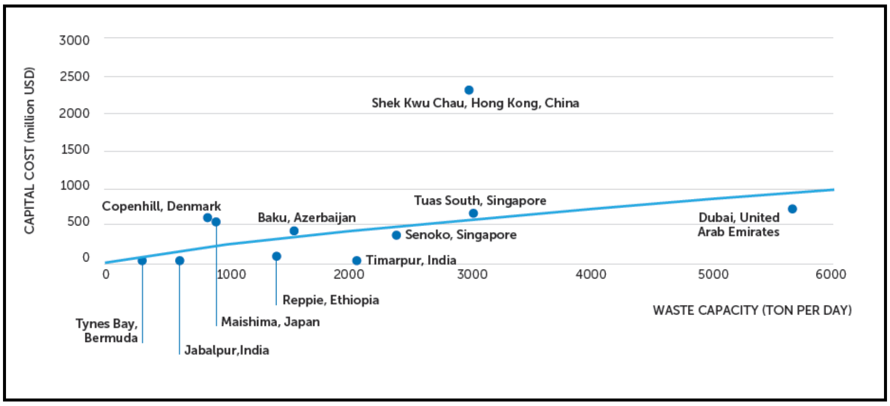


Figure 3.3.1-3: Comparison of investment cost and capacity of thermal WtE Plants. Source: (UNEP, 2019e)

Note: The blue line shows the formula adopted from literature describing the cost-capacity relationship of thermal WtE plants.

The breakup of estimated cost versus revenues is given in **Table 3.3.2-2**.

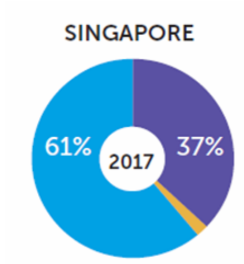
Table 3.3.1-2: Estimated costs of thermal WtE plants in developed and developing countries. Source: (UNEP, 2019e)

	Initial investment	**Capital costs**	**Operation and management costs**	**Total cost**	**Revenues from energy sales**	**Costs to be covered**
	In USD	**Euros per tonne**				
Developed country	132–181	78–112	176	255–289	58 (heat and electricity) 26 (electricity)	196–230
Developing country	30–75	22–55	20–35	42–90	2–10 (electricity)	40–80

Note: Figures shown are rough estimates and do not include land costs. The estimation assumes an incineration capacity of 150,000 tonnes per year. Thermal WtE plants in developed countries are assumed to have advanced technologies and two furnace lines. Plants in developing countries are assumed to have a basic technologies with one furnace line.

Box 3.3.1-1: TuasOne WtE Plant, Singapore (NEA, 2022b)

Singapore build its sixth waste-to-energy (WTE) plant in Tuas with the help of a consortium comprising Hyflux and Mitsubishi Heavy Industries (MHI). The TuasOne Plant is Singapore's sixth and largest waste-to-energy plant designed to process 3600 tonnes of waste per day and generate 120 MW of energy. It has minimum land foot print of 750 tonnes and day and hectare with a waste volume reduction greater and equal to 90% with net energy efficiency of 25%. Further, ferrous metals can be recovered from bottom ash. The project is the country's largest and most energy-efficient plant; the plant can produce 2,880 MWh of electricity per day from incinerating waste and the energy produced will then be used to run the plant and power Singapore's electricity needs. Moreover, the plant aids Singapore in waste disposal. It's one of the most efficient in terms of energy recovery per unit of waste incinerated globally.



MSW treatment methods in selected countries

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3.3.2 Biobased Plastics and Biodegradable Plastics

Bioplastics is not just one single material. They comprise of a whole family of materials with different properties and applications. According to European Bioplastics, a plastic material is defined as a bioplastic if it is either biobased, biodegradable, or features both properties (European Bioplastics, 2022b).

Biobased: The term 'biobased' means that the material or product is (partly) derived from biomass (plants). Biomass used for bioplastics stems from e.g. corn, sugarcane, or cellulose (European Bioplastics, 2022b).

Biodegradable: Biodegradation is a chemical process during which microorganisms that are available in the environment convert materials into natural substances such as water, carbon dioxide, and compost (artificial additives are not needed). The process of biodegradation depends on the surrounding environmental conditions (e.g. location or temperature), on the material and on the application (European Bioplastics, 2022b).

Benefits of bioplastics
Bioplastics are driving the evolution of plastics. There are two major advantages of biobased plastic products compared to their conventional versions: they save fossil resources by using biomass which regenerates (annually) and provides the unique potential of carbon neutrality. Furthermore, biodegradability is an add-on- property of certain types of bioplastics. It offers additional means of recovery at the end of a product's life (European Bioplastics, 2022b).

Most synthesised polymers are not biodegradable under normal environmental conditions, whether derived from fossil fuel or renewable biomass sources (UNEP, 2015a). Degradation will occur under favourable conditions, such as higher temperatures, physical abrasion and exposure to ultra violet (UV) radiation, with the rate dependent on the type of polymer and presence of stabilising compounds (UNEP, 2018b).

Starch-based polymers
Sources of starch are wheat, maize, waxy starch, Amylomaize and Potato.

It is composed of two types of macromolecule; amylose, (carbohydrate) and amylopectin. Different plant species and varieties tend have different proportions of amylose and amylopectin. The proportion of amylase and amylopectin, crystallinity and granule diameter affect the degree of processing required and the properties of the final product (UNEP, 2018b).

Starch-based bio-composites consists of starch based polymers as well as synthesised polymers. A simplified schematic diagram of this material is shown in **Figure 3.3.2-1**.

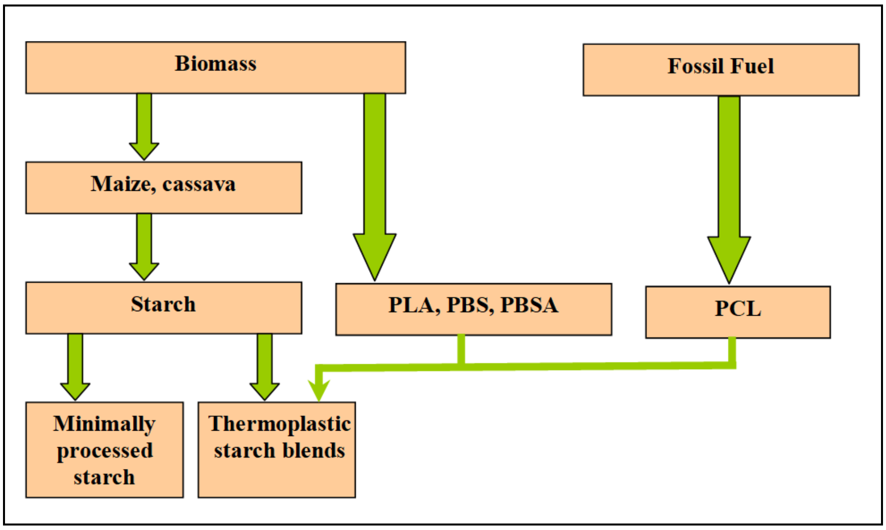

Figure 3.3.2-1: Simplified schematic of the production of starch-based polymers. Source: (UNEP, 2018b).

According to the latest market data compiled by European Bioplastics in cooperation with the nova-Institute, global bioplastics production capacities are set to increase from around 2.42 million tonnes in 2021 to approximately 7.59 million tonnes in 2026. Hence, the share of bioplastics in global plastic production will bypass the two percent mark for the first time (European Bioplastics, 2022a).

Currently, biodegradable plastics altogether, including polylactic acid (PLA), Polyhydroxyalkanoates (PHA), starch blends and others, account for more than 64 percent (over 1.5 million tonnes) of the global bioplastics production capacities. The production of biodegradable plastics is expected to increase to almost 5.3 million in 2026 due to a strong development of polymers, such as polybutylene adipate terephthalate (PBAT) and polybutylene succinate (PBS), but also a steady growth of polylactic acids (PLAs) (European Bioplastics, 2022a).

Bio-based, non-biodegradable plastics altogether make up for about 36 percent (more than 865 thousand tonnes) of the global bioplastics production capacities. These also include drop-in solutions like bio-based polyethylene (PE) and bio-based polyethylene terephthalate (PET), as well as bio-based polyamides (PA) (European Bioplastics, 2022a).

While production capacities for bio-based PET continue to decline, the focus has shifted to the development of PEF (polyethylene furanoate), a new polymer that is expected to enter the market in 2023. PEF is comparable to PET but 100 percent bio-based and is said to feature superior barrier and thermal properties, making it an ideal material for the packaging of drinks, food, and non- food products (European Bioplastics, 2022a).

Bioplastics are used in an increasing number of markets, from packaging, catering products, consumer electronics, automotive, agriculture and horticulture, and toys to textiles and several other segments. Packaging remains the largest market segment for bioplastics with 48 percent (1.15 million tonnes) of the total bioplastics market in 2021. However, the portfolio of applications continues to diversify. Segments, such as automotives and transport or building and construction, remain on the rise with growing capacities of functional polymers (European Bioplastics, 2022a).

With a view to regional capacity development, Asia further strengthened its position as major production hub with almost 50 percent of bioplastics currently being produced in the region. Asia is predicted to have pass the 70 percent production by 2026 (European Bioplastics, 2022a).

Biodegradation is a biologically-mediated process involving the complete or partial conversion to water, CO2andmethane, energy and new biomass by microorganisms (bacteria and fungi). Compostable industrial plastic waste is capable of being **biodegraded** at elevated temperatures under specified conditions and time scales. Compostable domestic plastic waste is capable of being **biodegraded** at low to moderate temperatures, found in a domestic compost system. The weathering, cracking, weakening and fragmentation of plastic waste will result in their size reduction (flakes or secondary micro plastics) as well as release of additives in the environment (UNEP, 2018b). Both degradation and **biodegradation** of plastics is extremely slow, and is delayed almost indefinitely in the marine environment (UNEP, 2015a). The three possible sources of chemical contamination due to plastic degradation include:

1. Monomers, or building blocks, making up the polymer. Some of the monomers are intrinsically hazardous but the degree of hazard varies substantially;
2. Sometimes additive chemicals are not strongly bound within the plastic matrix and so this tend to leach into the surrounding environment;
3. Absorbed contaminants – many persistent organic pollutants already present in the environment (e.g. PCBs, PBDEs, DDT) are preferentially absorbed by plastics, with the potential for being desorbed into an organism after ingestion. (Joint Group of Experts on Scientific Aspects of Marine Environmental Protection 2016).

Many countries in Asia and the Pacific region cover the bioplastic and biodegradable plastics as alternate to virgin plastic. Examples of some of the countries are given below.

Table 3.3.2-1: Regional Distribution of Countries with Thickness Requirements for Plastic Bags. Source: (UNEP, 2018d)

Country	Material Composition Requirement
Cambodia	Importation and production of bag or packaging material produced from **biodegradable** or bioplastic substances shall have preferential tax rates
India	Thickness requirement (50 microns) shall not be applicable to carry bags made up of compostable plastic in conformity with the prescribed standard
Pakistan	Ban on plastic products which are non-degradable. Disposable plastic bags must be made with **oxo-biodegradable** plastic technology from a registered supplier
Palau	Retail establishments shall not provide plastic bags except those that are **biodegradable** or compostable to their customers
Papua New Guinea	Ban is on **non-biodegradable** plastic bags. **Biodegradable** bags are allowed, and the use of bilum bags, made of organic woven material, is encouraged
Republic of Korea	**Biodegradable** plastic bags may be distributed for free
Samoa	Ban on all plastic bags except **biodegradable** bags
Vanuatu	Ban on import of **non-biodegradable** plastic single-use bags; local manufacturers of plastic bags to use only **biodegradable** plastics as of January 31, 2018.
Vietnam	Environmentally-friendly bags with bio-decomposition ability of at least 60 percent in a period of up to 2 years are exempt from the environmental protection tax

Malaysia: Investment tax allowance for use of **biodegradable** materials (UNEP, 2018d);

Maldives: Standards set for importers and local producers of **biodegradable** bags (UNEP, 2018d);

Pakistan: Prohibits not only the manufacture of conventional disposable plastic products in Pakistan, but also prevents them being imported into Pakistan. This means that all companies anywhere in the world exporting disposable plastic products to Pakistan made from or packaged in conventional or bio-based PE, or PP, or in PS must make and package them in future with **oxo-biodegradable** plastic technology from a supplier registered with the Pakistan Government (UNEP, 2018d);

Palau: Retail establishments shall not provide plastic bags except those that are **bio-degradable** or compostable to their customers at point of sale or prior to their exit for the purpose of transporting good (UNEP, 2018d);

Papua New Guinea: Ban on non-biodegradable plastic bags. **Biodegradable** bags are allowed, and the use of bilum bags, made of organic woven material, is encouraged (UNEP, 2018d);

Vanuatu: Prohibit the import of non-biodegradable plastic single-use bags. Obligation for local manufacturers of plastic bags to use only **bio-degradable** plastics as of January 31, 2018 and Prohibition of the Manufacture, sell, give or otherwise provide single use bags other than to contain, wrap or carry meat or fish, single use of plastic bags are shopping bags that are made out of polyethylene less than 35 microns thick (UNEP, 2018d);

Majority of the countries have opted for partial bans or restrictions, mostly in the form of thickness requirements and material composition. **Table 3.3.2-2** describes nine countries in the region which have imposed thickness requirement of plastic bags. This table also describes nine countries with requirement of material composition. This requirement is broadly based on bio and non **biodegradable** characteristics of the bags (UNEP, 2018b).

Box 3.3.2-1: Usage of Composite of PLA and natural fibres in a variety of usage (Ilyas et al., 2021)

Composite materials could be described as materials that consist of two or more phases separated by different interfaces that are chemically and physically dissimilar. The various systems are carefully integrated to attain structural or functional properties which cannot be obtained by either of the components when used individually. A combination of PLA and natural fibre has been established to deliver the required function properties of end usage.

PLA is a naturally resourced thermoplastic polymer produced globally with a capacity of approximately 211,000 tons in 2020. In addition, chitosan and chitin derivatives productions were about 107,000 tons, while cellulose and PHA were produced globally with a capacity of over 580,000 tons and 30,000 tons, respectively, in 2020. PLA is biodegradable brittle, sensitive to moisture and have low impact strength. Thus, a possible way to further reinforce the polymers is by hybridizing them with natural fibres to yield the enhanced mechanical properties of biocomposite. A combination of PLA and natural fibre is given below.

Table 3.3.2-2: Reported work on natural fibre reinforced PLA composites. Source: (Ilyas et al., 2021; UNEP, 2015a, 2018d)

Polymer	Natural Fibre	Mechanical Strength	
		Tensile (MPa)	Impact (kJandm^2)
PLA	Bamboo fibre; Wood fibre; Hard wood high yield pulp; Soft wood high yield pulp; Kraft; Wood fibre; Vetiver fibre;	16.17 – 253.7	1.8 – 46.17

	Coconut fibre; Kenaf fibre; Jute fibre; Sisal fibre; Elephant grass; Flax fibre; Wheat straw; Wheat straw; Rice straw fibre; Corn straw fibre; Abutilon fibre; Wowen jute fibre; Hemp fibre; Jute fibre; Ramie fibre; Hemp lyocell fibre; Lyocell fibre; Basalt fibre; Grewia optiva fibre; Palm fibre; Manicaria Saccifera palm fibre; Cordenka rayon fibres; Keratin based fibre Ramie, flax and cotton fibres; Plant fibres; Woven flax and jute fabrics; Abaca fibre; Bananaandsisal fibre; Lyocell fibre; Abaca fibres Coir, sisal and jutes fibres; Bamboo fibre, vetiver grass fibre and coconut fubre			

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3.3.3 Used Tyre for Roads Construction

The old, abandoned tyres from cars, trucks, farm and construction equipment and off-road vehicles are stockpiled throughout the region. They are openly burned, reused in a limited manner for other purpose. Generally, this leads to various environmental problems which include air pollution associated with open burning other harmful contaminants like (polycyclic aromatic hydrocarbon, dioxin, furans and oxides of nitrogen) and aesthetic pollution (Pasalkar et al., 2015). There is no estimates of waste tyre inventory in the region. Only official estimates are based on passenger car units, other automobile and off the road tyres estimates. There is a significant variation in average life cycle of tyres in developed and developing countries. The rising number of large-scale projects, including the development of roads, highways, power plants, industrial facilities, commercial complexes, etc., is primarily driving the tyre market in the Asia and the Pacific region (IMARC, 2022). Waste tyre rubber is used as binding material in bitumen, with aggregate in different layer. It also used on the top surface layer mixed with bitumen in percentage to increase in strength of road pavement (Pasalkar et al., 2015).

Waste rubber tyres in construction of bituminous road

Prof. Justo et al (2002), at the Centre for Transportation Engineering of Bangalore University compared the properties of the modified bitumen with ordinary bitumen. It was observed that the penetration and ductility values of the modified bitumen decreased with the increase in proportion of the plastic additive, up to 12 percent by weight. Therefore the life of the pavement surfacing using the modified bitumen is also expected to increase substantially in comparison to the use of ordinary bitumen.Shankar et al (2009), crumb rubber modified bitumen (CRMB 55) was blended at specified temperatures (Pasalkar et al., 2015).

Road base construction

In India, the 300 m long road embankment was constructed in July 1999. Initially five layers of the whole tyre sidewalls were manually placed on the subgrad in overlapping pattern to provide a clear working surface and to elevate tyre shreds above the ground water table. Then 300 mm tyre shreds were hauled to the site unloaded directly over the sidewalls and were spread to the desired thickness of 1500 mm with the backhoe in layers. The tyre shreds were compacted with five passes of small bulldozer, with passes perpendicular and parallel to the road, and were finally covered with 450 mm thick gravel fill (Pasalkar et al., 2015).

Addition of rubber aggregate

Waste rubber tyres were collected from roads sides, dumpsites and waste-buyers. The collected waste tyres were sorted as per the required sizes for the aggregate. The waste tyres were cut in the form of aggregate of sizes ranging from 22.4mm to 6.00 mm (as per IRC-SP20) in the tyre cutting machine. The waste rubber tyres can be managed as a whole tyre, as slit tyre, as shredded or chopped tyre, as ground rubber or as a crumb rubber product. The rubber of tyre usually employed in bituminous mix, in the form of rubber particles are subjected to a dual cycle of magnetic separation, then screened and recovered in various sizes and can be called as Rubber aggregate. It was cleaned by de-dusting or washing if required. The rubber pieces (rubber aggregate) were sieved through 22.4 mm sieve and retained at 5.6 mm sieve as per the specification of mix design and these were added in bituminous mix, 10 to 20 percent by weight of the stone aggregate. These rubber aggregate were mixed with stone aggregate and bitumen at temperature between 1600ºC to 1700ºC for proper mixing of bituminous mix. As the waste rubber tyres are thermodynamically set, they are not supposed to melt in the bitumen, at the time of mixing of rubber aggregate, stone aggregate and bitumen in hot mix plant (Pasalkar et al., 2015).

The waste tyres are either covered in solid waste management regulations or hazardous waste regulations in the Asia and the Pacific region. Further, the principles of extended producer responsibility (EPR) or product stewardship are applied in the region. In EU, Member States are free to set national initiatives to reach EU targets on the development of waste management policies at the national level. The Landfill Directive (EC Directive 1999and31) has been a major driver for regulating the waste management of landfills and shaping end of life tyre management systems in the European Union. In the EU, there are three different systems for managing end-of-life tyres (ERTMA, 2022).

i. **Extended Producer Responsibility (EPR):** Producer's full or partial operational and and or financial responsibility for a product extended to the post-consumer state of a product's life cycle.
ii. **Free market system:** The legislation sets the objectives to be met but does not designate those responsible. In this way, all the operators in the recovery chain contract under free market conditions and act in compliance with the legislation.

iii. **Tax system:** Tax system, as applied in Denmark and Croatia. It is financed by a tax levied on tyre producers and subsequently passed on to the consumer.

In Asia and the Pacific, Japan, Republic of Korea, Vietnam and India have regulatory systems based on EPR. In Australia, it is being regulated under product stewardship initiative. On July 22, 2022, the Indian Ministry of Environment, Forestry and Climate Change (MoEFCC) published the Hazardous and Other Wastes (Management and Transboundary Movement) Amendment Rules, 2022, which add extended producer responsibility (EPR) for waste tyres to Schedule IX of the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016. This regulation applies to producers, waste tyre recyclers and imposes obligations such as registration and meeting EPR targets. In addition, in the event that this regulation cannot be complied with, provisions for payment of environmental compensation have been established. As per this amendment, recycling targets for manufacturers or importers of new tyres (EPR obligations) are given in **Table 3.3.3-1** (Enviliance ASIA, 2022).

Table 3.3.3-1: Recycling Targets for Manufacturers or Importers of new tyres (EPR obligations)

Sl. No.	Fiscal Year	Recycling targets for waste tyres
(i)	2022-2023 (the year in which this Schedule comes into force)	35 percent of the quantity of new manufactured or tyres imported in year 2020-2021
(ii)	2023-2024	70 percent of the quantity of new manufactured or tyres imported in year 2021-2021
(iii)	2024- 2025	100 percent of the quantity of new manufactured or tyres imported in year 2022-2021
(iv)	After the year 2024-2025 (year Y), the recycling target shall be 100 percent of the quantity of new tyres manufactured or imported in the year (Y-2).	
(v)	Units established after the 1st April, 2022, the extended producer responsibility obligation shall start after two years (Y) and shall be 100 percent of the new tyres manufactured or imported in the year (Y-2)	

Note: The extended producer responsibility obligation for waste tyre importer in year (Y) shall be 100 percent of the tyre imported in year (Y-1). The import of waste tyre for the purpose of producing pyrolysis oil or char is prohibited.

Producers shall be deemed to have fulfilled their EPR obligation by purchasing an EPR certificate online from a registered recycler and submitting it through the dedicated portal on a quarterly basis. However, the producer may purchase EPR certificates for up to the limit of 10 percent of the EPR obligation for the year plus the residual liability for the past year. All recyclers shall submit on monthly basis the information regarding quantity of waste tyres used and end product produced, extended producer responsibility certificates sold and such other relevant information on the portal. (Trading and reporting must be done offline until the dedicated portal is established). PR China has drafted guidelines to tackle a mounting waste tyre problem. PR China will aim to scale up the tyre recycling business, improve recycling technologies like thermal cracking, and increase tyre retreading rates and encourage the recycling of tyres into rubber powder, the guidelines said (Stanway, 2019).

Road surfacing: Crumb rubber is used in significant volumes in road construction. It can be used as a replacement for traditional polymer modified binders (PMBs) in asphalt pavements and spray seals. The addition of crumb rubber increases the road’s resistance to surface cracking and can reduce traffic noise (Genever et al., 2017).

In Australia policy and regulation related to waste management, including management of End of Life Tyre (EOLT), is mostly devolved down to state and territory governments. However, from a national perspective, the EOLT market is influenced by several national and international policy settings, discussed below (Genever et al., 2017).

The tyre recycling industry, like most waste industries, is heavily reliant on collection fees or "gate fees" which are typically paid by waste generators to have materials collected and processed. The bulk of industry revenue is generated at end of the value chain, rather than by the sale of end products (Genever et al., 2017). Uses of rubber modified bituminous materials in road making are well developed and are supported by decade's worth of laboratory studies and field trials. When first introduced into Australia in the 1970s, crumb rubber bitumen mixtures were created on site with rubber added directly into the hot bitumen while being loaded into the bitumen sprayer. The addition of cold rubber into hot bitumen resulted in excessing foaming and odour issues and led many contractors to move away from rubber modified mixes completely (Genever et al., 2017).

At a national level, the use of these products is supported by the Austroads Specification Framework for Polymer Modified Binders (Austroads Test Method AGPTandT190-14). It includes requirements for the application of crumb rubber as well as properties of crumb rubber bitumen binders (Genever et al., 2017). The national specification framework in Australia supports the current market for sprayed seals. The use of pre-blended mixtures of bitumen and crumb rubber as binders for hot mix asphalt is commonly referred to as "wet mix" to differentiate it from the dry mix process. "Dry mix" refers to the blending of crumb rubber with asphalt aggregates in an asphalt mixer prior to addition of bitumen binder (Genever et al., 2017).

Crumb rubber seals tend to belong to the "Wet Mix" category and are generally used in the following products:

- High-Strength Seals (HSS) – Seal made with a PMB for high stress and high traffic loading areas, such as corners and high-speed road sections. Commonly use 5 percent – 10 percent crumb rubber by weight.
- Strain Alleviating Membrane (SAM) – Used as surface sealing for cracked pavements, bridges or anywhere that reflective cracking or waterproofing is an important consideration. Typically use 15 percent – 18 percent crumb rubber by weight.
- Strain Alleviating Membrane Interlayer (SAMI) – A highly modified version of a SAM seal used to greatly reduce reflective cracking and improve waterproofing. These products can contain high quantities of PMBs or crumb rubber. It can use up to 25 percent crumb rubber by weight (Genever et al., 2017).

Different types of asphalts using crumb rubber are given below.

Asphalt type	**Description**
Dense Graded Asphalt	Dense graded asphalt is the most widely used form of asphalt in both structural (base asphalt) and wearing course applications. PMBs, including crumb rubber, are particularly used in wearing course asphalt mixes for improved performance in heavy duty applications. Previous studies have shown that crumb rubber bitumen binders with properties comparable to competing SBS polymer modified binders translated into similar performance in terms of deformation resistance and fatigue but at higher total binder contents. This is also consistent with North American practice.

Asphalt type	Description
	However, whilst commercial blends of BCRA performed well in early trials, they required total binder contents of at least 8 percent to achieve the desired performance benefits, which resulted in significantly higher costs. This has been and remains the major prohibitor to the uptake of BCRA in Australia.
Open Graded Asphalt	Open Graded Asphalt (OGA) is a porous asphalt mixture that provides reduced tyre noise and reduced water spray, making it particularly suitable for use as wearing course on urban freeways and other high speed roads. Experience from the USA market suggests that usage of crumb rubber modified binder (wet mix process) in open graded asphalt can result in a significant increase in durability and potential improvement in resistance to heavy traffic. Whilst this may lead to a decrease in porosity and increase in water spray, such mixes would still be expected to retain suitable texture depth and hence good skid resistance. The increased durability of BCRA used in OGA mixes provides an opportunity for TDPs as maintenance and repair of high traffic roads is expensive and problematic in terms of traffic control. The potential reduction in noise (see below) from BCRA products adds to the compelling case for use in OGA mixes.
Low Noise Asphalt	The use of BCRA in high traffic areas can reportedly have benefits in noise reduction, a key consideration in constructing new or resurfacing existing urban roads. A 6-year study in Sacramento County on the degree to which rubberised asphalt can reduce traffic noise in open graded friction course found that: *The conclusions of the 6-year study indicate that the use of rubberized asphalt on Alta Arden Expressway resulted in an average four (4) decibel reduction in traffic noise levels as compared to the conventional asphalt overlay used on Bond Road. This noise reduction continued to occur six (6) years after the paving with rubberized asphalt. This degree of noise attenuation is significant, as it represents a 60 percent reduction in traffic noise energy, and a clearly perceptible decrease in traffic noise.* BCRA products manufactured in Australia have been tested for the same properties and have been shown in road trials in various Australian States to be effective in a measurable reduction in tyre road noise62.
Gap Graded and Stone Mastic Asphalt	The two existing standards for BCRA in Australia – by VicRoads and RMS NSW – are written around the dry mix process using a relatively high proportion of bitumen and crumb rubber additive in a coarse gap graded asphalt mix. The gap grading is employed to provide sufficient space (measured in VMA or voids in mineral aggregate) to accommodate the high proportion of bitumen and crumb rubber while maintaining sufficient air voids in the mixture to avoid instability at very low air void contents. Again, the high proportion of bitumen and crumb rubber have resulted in expensive products for these applications which speaks strongly to the current limited use of BCRA products.

Box 3.3.3-1 describes the case study of different countries using plastic waste in road construction.

Box 3.3.3-1: Used Tyre for Roads Construction (Sasidharan et al., 2019)

Ethiopia

Some data on the costs associated with the use of waste plastic for the construction of roads in Ethiopia are presented in Table.

Table 1: Road construction cost data using waste plastic in Ethiopia

Cost of Shredding Machine*	~$1,545
Cost of Plastic*	$0.15andkg

Optimum amount of waste plastic in the mix	11.5%
Cost saved by using waste plastic in road construction (per km)	10.06%

**The exchange rate at 2014 of 1 Ethiopian Birr = $ 0.05151 was used for this calculation*

Ghana

A Ghana based plastic recycling company, NelPlast Ghana Ltd, produces pavement blocks from waste plastic. These pavement blocks have been approved by Ghana's Ministry of Environment, Science, Technology and Innovation, and have been used to construct a road in Accra (AfrikaTech, 2018).

India

India is the nation where there gives off an impression of being the most involvement in involving waste plastics in street development. India has advanced the utilization of waste plastic in bituminous blends for the development of its public parkways and provincial streets, and has endorsed it as a default method of occasional recharging with hot blends for streets inside 50 km fringe of metropolitan regions with in excess of 500,000 populace. The Indian Street Congress (2013) has distributed rules for the utilization of waste plastic in hot bituminous blends while the Public Country Streets Advancement Organization (2019) gives direction on the utilization of waste plastic well defined for rustic streets development.

Starting around 2002, squander plastic has been utilized to build in excess of 2500 km of streets which were purportedly working great without potholes, tangling and rutting to a decade after the fact (Vasudevan et al., 2007) (Table 1). Unfortunate restricting between the totals and bitumen is one reason for such deformities in standard street development, however restricting between plastic covered total and bitumen is more grounded in contrast with standard development procedures (Mishra and Gupta, 2020). As per Vasudevan et al. (2012) a lot of waste plastic was utilized for each 1 km of street built, which diminished carbon dioxide emanations by 3 tons/km in contrast with standard development procedures.

Table 2: Road constructed in India using plastic

Road		**Year laid**	**Unevenness (mmandkm)**	**Skid number**	**Texture depth (mm)**	**Field density (kgandm^3)**	**Rebound deflection (mm)**
Design standard (acceptable values)		-	<4000	<65	0.6 – 0.8		0.5 – 1
Typical construction method: plain bitumen road		2002	5200*	76*	0.83*	2.86	1.55*
Roads constructed using waste plastics	Jumbulingam Street	2002	2700	41	0.63	2.55	0.85
	Veerabadhra Street	2003	3785	45	0.70	2.62	0.60
	Vandiyur Road	2004	3005	41	0.66	2.75	0.84
	Vilachery Road, Mai	2005	3891	45	0.50	2.89	0.86
	Canteen Road, TCE	2006	3100	45	0.65	2.86	0.86

*Values outside acceptable design parameters shown in red

Reproduced with kind permission of: International Journal of Pavement Research and Technology, 2010, p. 39 Some data on the costs associated with the use of waste plastic for the construction of roads in India are presented in Table 2.

Table 3: Road construction cost data using waste plastic in India

Cost of Bitumen*	~$670andton
Cost of Waste Plastic*	~$230andton
Cost of Shredding Machine and other equipment	~$955
Optimum amount of waste plastic in the mix	~11%
Cost saved by using waste plastic in road construction (per km)*	~$670andkm

*The exchange rate at 2012 of 1 Indian Rupee = $ 0.01909 was used for this calculation

United Kingdom

MacRebur, a UK based company, has developed a solution to use waste plastic within asphalt for road construction and surfacing (White, 2019). MacRebur's recycled waste plastic was incorporated into asphalt instead of traditional bitumen and 4 used by Durham County Council in the UK for resurfacing a section of A689 near Sedgefield and for resurfacing runways and taxiways at Carlisle Airport in the UK. MacRebur was also involved in the construction of plastic roads in the United States and Australia (UCSD Guardian, 2018) and is currently constructing South Africa's first plastic road (in Kouga Municipality). MacRebur products are the only technology for road construction using waste plastic which has made it to global commercial use. The UK government recently announced the investment of £23 million into plastic road technologies by setting up real-world tests across eight local authorities (Buckinghamshire, Bedfordshire, Cumbria, Staffordshire, Kent, Reading, Suffolk, Solihull and Birmingham) (Sasidharan et al., 2019). A portion of this funding, approximately £1.6 million, will be used to extend an existing road in Cumbria that is built from recycled plastic mixed with asphalt. This project also aims to produce a guidance document for the design and specifications of plastic asphalt (Sasidharan et al., 2019).

Construction Methods: (1) Dry Method (Wet Method)
Bituminous hot mixes using waste plastic for road construction are manufactured using either a 'dry' process or a 'wet' process . The dry process is considered to be simple, economical and environmentally friendly, while the wet process requires more investment and machinery, and hence is not commonly used.

Challenges: (1) Health and environmental Hazards; (2) Collecting and sorting waste plastic; (3) Training for construction workers; (4) Regulatory framework

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3.3.4 Plastics as Alternative Timber

Plastics is being increasingly used along with timber to give alternatives, which reduces the need for wood as well as save trees and forests. Both natural fiber and wood composite products can be made with either virgin plastic or post-consumer and industrial recycled material. There are two different types of plastic wood products the "composites" (wood products made from a mix of plastics and natural fibers) and the "wood-like" products made solely from plastics (Cirko, 2019). "Wood Plastic Composite (WPC)" a synthetic polymer made from wood dust and plastic composites, such as Polythylene (PE), polypropylene (PP), polyvinyl chloride (PVC), and recycled plastics is widely being used in a number of applications. Wood-plastic composites outperform traditional timber production in terms of durability, moisture content, shear strength, bending resilience, and water permeability. These properties have led to its use in guard rails, doors, flooring, exterior siding, windows, fencing, and inner molding, as well as increased demand in the building and construction industry (Acumen Research and Consulting, 2022).

Advantages of using Recycled Plastic Timber (Tangent Materials, 2023)

- Environmental friendly – Use of recycled plastic timber is an effective green approach. It is diverting plastics from landfills thus increasing landfill life.
- Durable – The properties of these materials of being water resistant, chemical resistant, and nonporous make it very durable. It is also resistant to insects and graffiti which make it very good for fencing systems. It does not crack or splinter which makes it good for playground equipment since it cannot splinter on hands or feet.
- Easy to maintain – It is easy to maintain with recycled plastic wood, maintenance is absent. Since it comes pre-colored, it does not require painting or staining.
- Economic – It is much more economical compared to timber. The higher purchase price is balanced by the low installation, replacement, disposal, and maintenance costs over lifetime.

Types of Recycled Plastic Timber and Uses (Tangent Materials, 2023)

1. High Density Polyethylene – the main characteristic of this type is that it is made up of 95 percent HDPE. It is very suitable for landscape and decking solutions.
2. Commingled Timber – It is made of recovered thermoplastic, which has 80 to 90 percent concentration of polyethylene. It is very used for landscaping solutions.
3. Wood Filled Timber – It is made up of recycled plastic mixed with sawdust. The plastic can also be mixed with other recycled fiber or polyethylene.
4. Fiber Reinforced Timber – The recycled plastic is mixed with strands of glass fiber that may be either chopped or continuous. It is used for making support structures because it is more firm than other types of plastic timber.

The Asia and the Pacific wood plastic composites market is growing rapidly with a CAGR of 13.28 percent in terms of revenue from 2020-2028. Further, in terms of volume the market is projected to register a compounded annual growth rate (CAGR) of 11.82 percent. PR China has, the largest market share of more than 61.87 percent, in terms of revenue in Asia and the Pacific and the Pacific Region. Other countries driving this growth rate are South Korea, India, Australia, ASEAN, Japan, and the rest of Asia and the Pacific. The infrastructure and the real estate sectors are driving this rapid growth. In the rest of the Asia and the Pacific, the growth in the construction and automobile industry will be the primary factors driving the market growth (Report Linker, 2020).

Product quality, product identification, consumer response, and success of research and development efforts, specifications and standards in a particular country determine the future usage of the products. The following are a list of active standards pertaining to composite products (Neograss, 2020):

- ASTM D 6108-03, Compressive Properties of Plastic Lumber and Shapes
- ASTM D 6109-03, Flexural Properties of Unreinforced and Reinforced Plastic Lumber
- ASTM D 6111-03, Bulk Density and Specific Gravity of Plastic Lumber and Shapes by Displacement
- ASTM D 6112-97, Compressive and Flexural Creep and Creeprupture of Plastic Lumber and Shapes
- ASTM D 6117-97, Mechanical Fasteners in Plastic Lumber and Shapes
- ASTM D 6341-98, Linear Coefficient of Thermal Expansion of Plastic Lumber and Plastic Lumber Shapes between [–34.3 and 60 C] –30 and 140 F
- ASTM D 6435-99, Shear Properties of Plastic Lumber and Plastic Lumber Shapes
- ASTM D 6662-01, Standard Specification for Polyolefin-based Plastic Lumber Decking Boards

Box 3.3.4-1 describes how recycled plastic is used as a material for manufacturing sleepers for railway track.

Box 3.3.4-1: Creating Railway sleepers out of recycled plastics in Australia (Ho, 2019)

Richmond Station in Melbourne, Australia has railway tracks where sleeper replacements are made of recycled plastic which is a composite of polystyrene and end of primary life agricultural plastics from Victoria region. Recycled plastic makes up approximately 85 per cent of the content of each sleeper. This includes both rigid and flexible plastics alongside polystyrene, combined with virgin materials carrying specific functions to enable the performance required. One kilometre of sleepers uses approximately 64 tonnes of recycled plastic. The sleepers provide a suitable alternative for timber sleepers and concrete sleepers in mainline track. They are manufactured in Mildura in northwest Victoria by Integrated Recycling. The sleepers have a lifespan of up to fifty years. Their life is three times longer than timber sleepers and operate at par with concrete sleepers. They require less maintenance than timber sleepers because they have low water absorption and are fire tolerant and resistant to termites, UV, fungal decay, rot and split. Their usage leads to environmental benefits which can be summarized as:

- Reduce the need for timber resources;
- Reduce concrete production (the second-largest carbon emitter in the world);
- Meaningful use of recycle plastic waste

Major constraints which were encountered while developing standards of the sleepers were: (i) the lack of standards for recycled plastic railway sleepers in Australia. The rail operators had no benchmark to compare the performance of this new material. (ii) The cost and time expenditure of testing, (iii) Formulating and approving a new product. The academia like Monash University provided technical assistance to overcome these constraints. A series of laboratory-based testing protocols were recommended by the university to overcome these constraints and design to provide a comprehensive assessment of the whole sleeper and rail fastening system. These tests included:

An Electrical Test to assess the capability of the sleeper system to provide adequate electrical insulation for use in circuited tracks in both dry and wet conditions.
A Fastener Pull-out Test to ensure that the fastening system used to secure either the rail or base-plate to the sleeper had adequate strength to maintain an appropriate clamping force once installed.
A Bending Moment Capacity Test to ensure that there was sufficient strength in the manufactured sleeper so it would not break or deform excessively under load during service.
A Fastener Repeated Load Test to ensure that the fastening system in combination with the sleeper

material was capable of resisting the repetitive vertical and lateral loads during service. This test was particularly important where sleepers were to be used in tight radius curves, as it provided confidence in the fastening system to limit lateral rail movement.
A Rail Seat Durability Test to measure whether the manufactured sleeper was capable of withstanding cyclic bending moments during service.
A Sleeper Lateral Stability Test was designed to compare the alternative sleepers against timber sleepers in terms of lateral resistance.
The testing confirmed that the plastic-composite sleepers' load bearing capabilities and durability made them a safe, cost-effective and sustainable alternative to timber sleepers.
Vioctorial government provided Sustainability Victoria a grant of $300,000 under its Research, Development and Demonstration (RDandD) grants program for this project.

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3.3.5 Application of Smart Technology

Waste disposal expenses are on the rise as well, with the World Bank predicting global garbage collection costs to top $375 billion in the next five years. Valued at just under $1.5 billion in 2018, the smart management market is projected to top $5 billion by 2025 (Tele2, 2022).

The rapid waste generation leads to littered waste due to area overflowing waste bins in a densely populated are the application of IoT and artificial intelligence (AI) in waste management system in an urban area has high potential to revolutionize the waste management system. It makes the system more efficient and results in clean cities. IoT powered systems equip waste collection in real time and inform the stakeholders of any waste overflows (Intuz, 2022). Combining IoT waste data analytics with modern internet of things (IoT) solutions helps identify challenges and improve. To save money from the operational inefficiencies of traditional methods of trash collection and disposal procedures, IoT-driven solutions are required (Intuz, 2022). More cities across the globe are implementing smart waste management solutions to more efficient and clean waste management system in order to save money and reduce the environmental impact (BigRentz, 2021).

Smart bins and IoT based smart sensors has become an essential part of the smart city ecosystem, with IoT enabled smart waste sensors enabling cities to optimize waste collection, reduce overflowing bins, and manage resources.

Smart bins are an essential component of smart waste management system. It is expected the number of smart bins will reach 2.4 million by 2025. The rapid adoption of smart waste sensors will result in 29.8 percent growth through 2025 (Tele2, 2022). The new smart bin technology helps keep streets clean by stopping overflowing waste bins. Smart trash bins to detect location, temperature, and fill level in real time, and this data is then used to plan optimal collection routes (Tele2, 2022).

IoT based sensors are used to alert garbage collection trucks in a smart city. Smart sensors gather data on waste generation patterns and send this information to the cloud. These data are translated into insights and made available via a smart waste solution (Tele2, 2022). The sensor sends real-time communication to streamline the filling and clearing of smart containers. It ensures that clean and empty dustbins are available to people. The routing algorithm smartly finds the shortest route based on routing plan and reduce truck fuel consumption by aiding the garbage truck driver (Intuz, 2022). They help detect full bins and assess segregation levels. Weight sensors and waste compactor-equipped bins can be used to track fill levels, allowing them to hold more garbage whenever required (Intuz, 2022).

RFID readers

RFID waste management solutions help hazardous and non hazardous in waste segregation leading to efficient separation of recyclable materials. They can identify and trace the flow of different streams of waste. RFID tags are attached to each garbage bin so that operators can monitor the sorting quality and weight of the bin and track the number of times it has been placed for collection (Intuz, 2022).

Smart Waste Management Platform

A smart waste management platform uses analytics to translate the data gathered in the bins into actionable items to achieve operational efficiencies. The collected data gives insights in the following issues.

- Locations prone to waste overflow.
- The number of bins to stop overflowing of waste.
- The number of collection services that could be saved through intelligent routing.
- The amount of fuel that could be saved through intelligent routing.
- Optimize the driving distance.

These data insights will help you transform your waste management to greener, cleaner, and smarter avenues (Nord sense, 2022).

Intelligent Routing and Route Optimization

Traditionally, waste management systems have used a pre-defined route based on historical patterns to schedule garbage collection and recycling point receptacle emptying, whether they were full or not (Tele2, 2022).

The data on the fill levels of bins also enables smart routing. With a digital overview of the fill levels of bins, waste collectors can use the smart waste management software to optimize their collection routes. Instead of driving along fixed collection routes, waste collectors can use the data insights to switch to dynamic routes and pick up the bins that are in need of service. It reduces long hours driving of pre-planned collection routes and picking up every single bin regardless of fill level (Nord sense, 2022).

Container Tracking

A digital overview of the bins, containers and waste inventory is an essential component and accurate data of smart waste management. Container tracking provides information on the location and movements of waste bins. Integrating container tracking enables to optimize waste container inventory so that schedule container maintenance, keep track of damaged bins, and security of bins (Nord sense, 2022).

Pneumatic waste pipes

Pneumatic waste pipe assist in transportation of waste under road or wherever space is available from originating point till destination. It eliminates the need of garbage transportation vehicles and waste bins and infrastructure. It works under negative pressure ensuring efficient transportation of waste. **Case study 3.3.5-1** describe application of smart bins in a city in India while **Case Study 3.3.5-2** describes truck free waste management system in Songdo, Republic of Korea.

Smart recycling

Machine learning and artificial intelligence (AI) can identify the type of material in the container, leading to better sorting, as well as an easier job downstream at recycling centers. The emerging smart bins are able to identify and sort waste into categories like glass, paper, plastic, and metal, compress it and notify sanitation workers of fill levels of each waste category, enabling a more sustainable society (Tele2, 2022).

Other existing smart waste management system are:

1. Solar-Powered Trash Compactors
2. Garbage Truck Weighing Mechanisms
3. E-Waste Kiosks
4. Recycling Apps

Box 3.3.5-1: Smart Dustbin for Khargone (MP) India Municipal Corporation (Softude, 2022)

A major step towards waste management with smart bin solutions.
Waste management and untreated garbage is the huge challenge for Khargone Municipal Corporation. There challenges included:

- How to get the waste bin Level status alerts?
- How to prevent their overflow?
- How to monitor their maintenance?
- How to control high logistics cost due to redundant trips?

The municipal corporation used the smart dustbin solution to take care of waste management. This application which is integrated with hardware automatically and it monitors waste management operations. The smart bin technology helped the municipal corporation in (i) Super quick Dustbin offloading; (ii) Garbage level notifications; (iii) Route plan; (iv) Notifications directly to drivers and Head Office; and (v) Clean and sustainable environment. As a result, Khargone (MP) India ranked the

15th cleanest city in India in Swachh Survekshan 2018, all India ranking of cities for cleanliness.

Box 3.3.5-2: Truck Free Waste Management System in Songdo, South Korea (BBC News, 2013)

Songdo, in Republic of Korea was one of the first cities to implement a truck-free waste management system. It installed bins connected to a series of underground pneumatic waste pipes that transport trash to a waste processing facility, where waste is automatically sorted and either recycled, buried or burned for energy. Songdo's system was the first to eliminate the need for collection trucks by connecting every building in the city to the underground pipe system. This not only cut down on carbon emissions but also saved the city money. By 2014, the system only required seven workers to operate.

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3.3.6 End of Life Batteries

The extensive use of batteries in a broad range from storing energy to operating various equipment's results in millions of tonnes batteries in operation in all countries.

Primary (single-use or "disposable") batteries are used once and discarded. For example, the alkaline battery used for a multitude of portable electronic devices. Primary batteries are designed to be used until exhausted of energy then discarded. Secondary (rechargeable) batteries can be discharged and recharged multiple times using an electric current (Dingrando and Barr, 2005). The main part of the battery is electrochemical cell, with varying chemical processes and designs. They include galvanic cells, electrolytic cells, fuel cells, flow cells etc. Depending on battery chemistry and usage, the primary and secondary batteries are classified in **Table 3.3.6-1**.

Table 3.3.6-1: Primary and Secondary batteries with composition and output and energy. Source: (Dingrando and Barr, 2005)

Chemistry	Max. voltage, theoretical (V)	Nominal voltage, practical (V)	Specific energy (kJandkg)	Shelf life at 25 °C, 80 percent capacity (months)
Zinc–carbon; Zinc–chloride; Alkaline (zinc–manganese dioxide); Nickel oxyhydroxide (zinc–manganese dioxideandnickel oxyhydroxide); Lithium (lithium–copper oxide) Li–CuO; Lithium (lithium–iron disulfide) LiFeS2; Lithium (lithium–manganese dioxide) LiMnO2; Lithium (lithium–carbon fluoride) Li–(CF)n; Lithium (lithium–chromium oxide) Li–CrO2; Lithium (lithium-silicon); Mercury oxide; Zinc–air; Zamboni pile; Silver-oxide (silver–zinc); Magnesium	1.5 – 3.8	1.1 – 3	130 - 1070	18 – >2000

Table 3.3.6-2: Secondary batteries with composition and output and energy Source: (Dingrando and Barr, 2005)

Chemistry	Cell voltage	Specific energy (kJandkg)
NiCd; Lead–acid; NiMH; NiZn; AgZn; LiFePO4; Lithium ion;	1.2 – 3.6	140 - 460

The comparison of different secondary battery of different chemistries in terms of size and weight is given in **Figure 3.3.6-1.**

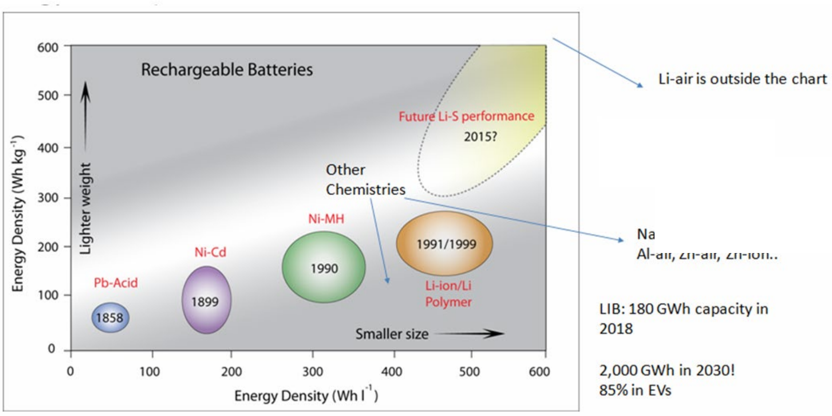

Figure 3.3.6-1: Comparison of different battery technologies in terms of energy density. Souce: (Kumar, 2022)

The development in the field of automobile, aviation and aerospace, marine hybrid propulsion, defence, telecommunication, micro-grid, etc. predict higher growth of battery market. The demand for automotive industry, which is one of the largest end users of lead acid battery across the countries including India, Indonesia, Sri Lanka and Vietnam, is likely to augment market growth.

Recycling of end of life batteries is very complex, while lead acid batteries recycling is well developed while the emergence of new varieties of batteries makes their recycling very difficult (Dingrando and Barr, 2005).

The global automotive battery recycling market is predicted to register a revenue of $19,222.3 million by 2028 and grow at 8.1 percent CAGR (Research Dive, 2022). Currently, lead-acid Battery Sub-segment is most dominant as the lead acid batteries are easy to handle. Since the automotive sector is the major consumer of the batteries, the automotive battery recycling market drives the recycling market. Higher operational costs in recycling of batteries is the major constraint in the growth of the battery recycling (Fortune Business Insights, 2022). Other constraints are: (i) Large quantities and range of strategic minerals needed to power renewable energy transition and digital tech including demand for battery metals (nickel, cobalt, copper, lithium). (ii) Needed only in small quantities, cannot be easily recycled using conventional technologies. (iii) About 3 percent of rare-earth materials are recycled world wide. Crude recycling targets mean that most valuable materials are not reclaimed in recycling processes.

The automotive battery recycling market in the Asia and the Pacific region is predicted to have the fastest growth rate of 8.5 percent CAGR in the current decade (2021-2030). Robust manufacturing and recycling base of lead acid battery in PR China, Japan and India alone is expected to increase lead acid battery market share in the future. Japan, PR China, ASEAN countries, India, Australia and New Zealand, South Korea and the Rest of Asia and the Pacific countries together constitute the Asia and the Pacific's battery recycling market (Triton Market Research, 2020).

Dumping of batteries in open space can cause serious environmental threats and contamination of groundwater (Fortune Business Insights, 2022). End of life batteries are considered as hazardous waste. They fall in the category of hazardous waste regulations and are controlled and regulated by these regulations in each country. They are increasingly covered under "Extended Producer Responsibility" regime in major countries. The European Directive to address the treatment and disposal of waste batteries was published to the EC Member States in September 2006. This Directive gave instructions to each Member State to implement National Regulations regarding the collection and treatment of waste batteries (Citroen UK, 2009). **Box 3.3.6-1** describes how operations of new generation batteries is optimized using Battery as a Administration (BaaS) model in China.

Box 3.3.6-1: Rechargable batteries Business Model using BaaS (Battery-as-a-Administration Case Study in PR China (NITI Aayog and GGEFTCF, 2022)

There is an increase in the demand for rechargeable batteries because of the increasing adoption of electric vehicles, and regulations in PR China. In addition, PR China has launched a national New Energy Vehicle Subsidy Program to augment the production of EVs. The charging infrastructure is also getting augmented at the same time. The target included 1200 charging stations for swapping batteries and 500000 publicly accessible chargers till 2020 (Triton Market Research, 2020).

Utilizing the circular economy model, Battery-as-a-Administration (BaaS) is augmenting resource effectiveness and associating the vehicle and energy areas. Under this model, produced batteries are rented to endusers, for example, vehicle proprietors and energy stockpiling projects. While approaching the end of life (EOL) of a battery, the supplier of BaaS renovates the battery and makes it reasonable for applications (Triton Market Research, 2020).

The Chinese automaker Nio, in partnership with CATL, a leading battery manufacturer, aims to separate the cost of the battery from the price of the vehicle purchase by 2020 through the BaaS business model. As a result of BaaS, Nio has been able to reduce its vehicle prices by about 70,000 yuan (US$ 8600). For the BaaS project, Nio, CATL and two other partners established the Battery Asset Company. Each partner invested 200 million yuan in the company (US$ 25.5). The Battery Asset Company is set up to buy batteries, and to lease them out using a BaaS model through CATL, which will supply the batteries.

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3.3.7 Carbon Neutralization Technology

In response to tackle GHG emissions and combat climate change the ever-increasing global greenhouse effect, all countries signed a historic agreement during COP21 in Paris on December, 2015. The countries agreed to keep warming below 2.0°C and make an effort to curb global warming to less than 1.5°C by achieving carbon (C) neutrality by 2050 (Chen, 2021; UNFCCC, 2015). Therefore, there is an urgent need to accelerate efforts to reduce atmospheric GHG emissions to reverse global climate change. This need requires reduction in fossil fuel and food missions in terrestrial and marine ecosystems to achieve carbon neutrality, support and sustain human activities (Cheng, 2020). The following sections describe different neutralization technologies in the region. This also includes their current status including adoption at the commercial level or at R&D level. A snapshot of the carbon neutralization is given in **Table 3.3.7-1** followed by description of each technology.

Table 3.3.7-1: Carbon Neutral Technologies in Asia and the Pacific. Source: (Wang et al., 2021)

Technology	Commercialization	RandD Stage
Technologies for renewable energy		
Solar Energy	□	□□(New cell chemistry)
Wind Energy	□	□□(New materials for wind turbines)
Ocean Energy		□
Bioenergy	□□(Partly)	□
Hydrogen Energy		□
Nuclear Energy	□□(Fission base)	□□(Fusion)□□
Geothermal energy	□	□
Energy Storage	□□(Small scale)	□
Technologies for enhanced carbon sink in global ecosystems		
Carbon sink in terrestrial ecosystems	□	□
Carbon sink in marine ecosystems	□□(Partly)	□
Zero waste biochar as a carbon-neutral tool.		□
Biochar for sustainable development.		
Other Technologies		
Carbon neutrality based on satellite observation and Digital Earth		

3.3.7.1 Technologies for renewable energy

Renewable energy, hydropower, such as solar energy, wind power, and ocean energy, are regarded as some of the most important and efficient means to achieve carbon neutrality along with other sources like nuclear and H_2 energy. The other technologies are at RandD stage.

Solar Energy: Solar energy, only constitute a small part of the energy consumption. It is harnessed through photovoltaic or solar thermal route.

Photovoltaic Technology: Conventional thin-film solar cells using inorganic semiconductors, such as silicon, gallium arsenide (GaAs), copper indium gallium selenide, and cadmium telluride (CdTe) materials, have been industrialized on a large scale, due to high power conversion efficiencies and salient operational stability. The major R&D is focussed on developing new solar cells with higher power conversion efficiencies ex. organic solar cells, perovskite solar cells, quantum dot solar cells, and other integrated devices (Aydin et al., 2020; Kılkış et al., 2020; Li et al., 2021; Sargent, 2012; Yoo et al., 2021).

The research studies have indicated rooftop solar panels may decrease GHG emissions by 57 percent due to fossil fuel combustion in the medium term (10 years) and achieve carbon neutrality in the long term about 30 years (Marchi et al., 2018). Solar thermal technologies such as concentrated solar power systems, are used in commercial and residential sectors to replace fossil fuel as a source of energy. It is on photothermal conversion to achieve heat, steam, and electricity production for C-neutral operations, unlike photovoltaic techniques (Di Leo et al., 2021; Zhou et al., 2021). Solar energy is widely used at a commercial scale and major countries in the Asia and the Pacific region has an active solar program.

Wind Energy: Wind energy plays a critical role in realizing carbon neutrality because of the replacement of fossil fuel. The harnessing of the wind energy is heavily dependent on site location, technical and financial feasibility.

Ocean Energy: Ocean energy is harvested through tidal energy, wave energy, ocean current energy, thermal energy, and osmotic energy. The tidal, wave energies are typically are on the verge of commercialization while all other forms are at R&D stage.

Bioenergy: Bioenergy is harnessed through thermochemical conversion, chemical conversion and biochemical conversion. The major feed stock are the agricultural and forestry residues, biogenic materials in municipal solid waste, animal waste, human sewage, and industrial wastes. Despite the presence of abundant biomass resources, in Asia and the Pacific region there is still a need for work on the use of biomass to produce energy (Yuzhong Liu et al., 2021).

H_2 Energy: H_2 energy has the potential to establish a fully renewable energy system similar to an electricity grid. And there is a need to develop hydrogen storage and transportation. The technology needs to be mature for establishing a hydrogen economy. India is actively considering to develop hydrogen road map to reduce its dependence on imported fossil fuel.

Nuclear Energy: Nuclear energy accounts for 40 percent of low-C electricity generation worldwide and avoids about 1.7 Gt CO_2 emissions a year globally. It is generated through nuclear fission. Nuclear fission technology is quite mature while nuclear fusion technology awaits commercialization. Gen IV reactor nuclear fission systems have been proposed in future nuclear energy development while “Thorium Molten Salt Reactor Nuclear Energy System” is at R&D stage.

Geothermal energy: Geothermal power generation technologies mainly include dry steam power, flash power, and binary power systems (Renault et al., 2009). It is at R&D stage of development. The major focus of technological development include ground source heat pumps, geothermal heating, geothermal refrigeration, geothermal greenhouse, and geothermal drying (Ahmadi et al., 2020). Turkey has a power generation capacity of 1,549 MW as of 2020 (Goldbrunner, 2020).

Energy Storage: The major renewable sources of energy except for nuclear suffer from low power conversion. Further, reliability and stability of the power generation is a major constraint in solar and wind energy systems (Yuan et al., 2019).

Major energy storage technologies can be classified into mechanical, electromagnetic, electrochemical, and phase change energy storage. The mechanical energy storage technologies and electrochemical storage technologies efficiency and stability are commercially successful. They include pumped hydro and battery technologies like (lithium, sodium, potassium)-based batteries, or advanced lead-C batteries for portable electronic devices and electric vehicles, and (2) flow batteries for renewable energy integration, microgrid, and power grid peaking.

One of the most mature technologies and is currently at the commercial demonstration stage are vanadium flow batteries.[18] The world's largest vanadium flow battery project (200 MWand800 MWh) is being built in Dalian, Liaoning based on the vanadium flow battery technology, developed by the Dalian Institute of Chemical Physics, Chinese Academy of Sciences (Deane et al., 2010; Rehman et al., 2015).

3.3.7.2 Technologies for enhanced carbon sink in global ecosystems

Major technological intervention for enhanced carbon sink can be classified into terrestrial and marine ecosystem. Research studies cite that removal of about one-third of anthropogenic GHG emissions has been attributed to terrestrial ecosystems (Feng et al., 2021). Forest ecosystems are one of the most important global C sinks and absorb 45 percent of anthropogenic GHG emissions (Feng et al., 2021). The ocean covers more than 70 percent of the Earth's surface and plays an important role in capturing CO_2 from the atmosphere. Currently, 22.7 percent of the annual CO2 emitted from human activities is sequestered into the ocean ecosystem (Yuan et al., 2018). The current requirement and focus of R&D is to develop from ecosystem (terrestrial and marine) and low GHG emissions without altering major usage of the ecosystem (Weaver, 2017; Zubrinich, 2020).

Carbon sink in terrestrial ecosystems

Nature based solutions (NBS) for mitigating GHG emissions rely on biomass carbon sequestration through reforestation and afforestation, sustainable forest management, soil carbon sequestration from increased inputs to soils, and biochar additions. A recent study suggests that there is a significant reduction of global CO2 emission from an increase in forest coverage, from a mean of 4.3 (between 1991 and 2000) to 2.9 (between 2016 and 2020) Gt CO2-eq year−1 (Ballantyne et al., 2012; Friedlingstein et al., 2020; X. Wang et al., 2020). Since the late 1970s, PR China has implemented six major ecological restoration projects, covering 44.8 percent of PR China's forests and 23.2 percent of its grasslands (Pikaar et al., 2018; Pikaar et al., 2017). The total annual carbon sink of the project area was 132 Tg C year−1 in 2001–2010, over half of which was attributed to the implementation of these projects (Pikaar et al., 2018). Some of the areas which can reduce GHG emissions are given below.

1. Crop production management. Optimization of fertilizer and water use in lands used to grow crops (Beerling, 2017).
2. Breeding crop varieties with a high N use efficiency (NUE) can reduce the N fertilizer application rate and reduce the emission of nitrogen oxides ex. by using transgenic and gene-editing technology, in rice varieties (Goll et al., 2021).
3. Development of inhibitors for methanogenesis or the addition of biochar in rice paddies (Bolan et al., 2012; Liu et al., 2019).
4. Animal production management.
5. Phytocompounds, ionophore antibiotics, and oil (Yongqiang Liu et al., 2021; Lu et al., 2018; Shang et al., 2021).
6. Manure management practices (Pratiwi et al., 2021).
7. Animal breeding techniques are being developed to genetically select highly productive animals with less GHG emission intensity (Rani et al., 2021).

Carbon sink in marine ecosystems

Several physical and biological processes determine the ocean carbon sink size. The "solubility carbon pump" removes atmospheric CO_2 as air mixes with and dissolves into the upper ocean. The "biological carbon pump" is the photosynthetic absorption of atmospheric CO_2 by ocean microorganisms (Zhang et al., 2019). The scientific understanding of ocean solubility C pump, biological C pump, and microbial C pump provides a practical and consistent foundation for the research and potential sustainable management of C cycling between land and ocean.

(i) Zero waste biochar as a carbon-neutral tool.
Generated globally the thermochemical conversion of solid waste into biochar can bring multifunctional benefits to the circular economy in addition to climate change mitigation and carbon sequestration. The thermochemical decomposition of feedstocks into biochar can be carried out by various methods, including pyrolysis, hydrothermal carbonization, torrefaction, gasification, and traditional carbonization. Among these methods, pyrolysis is widely employed to produce biochar (Wang et al., 2016; Wang et al., 2018).

(ii) Biochar for sustainable development.
Biochar offers tremendous potential to mitigate GHG emission by creating highly charged surface and multiple functional groups or hydrophobic surfaces (Zhang et al., 2021). It can absorb antibiotics, aromatic dyes, agrochemicals, polychlorinated biphenyls, and polycyclic aromatic hydrocarbons and inorganic contaminants such as phosphate, ammonia, sulfide, and heavy metals) from solid, aqueous, and gaseous media (Harindintwali et al., 2021; Knapp et al., 2014; Prentice et al., 2001; Wang and Wang, 2019). It improves the soil productivity as soil additive and can reduce GHG emissions and other air pollutants during the degradation of biomass in the soil. Box 3.7.4-1 describes a case study of one of the largest solar park in India.

Box 3.7.4-1: World's largest solar park in Bhadla, India (The Hindu net desk, 2021)

India's Bhadla Solar Park is the largest solar power park in the world. Bhadla Solar Park is located in Bhadla, in Rajasthan, India spans 14,000 acres with an operational capacity of 2245MW. It has an over 10 million solar panels at the park, which contribute to an (The Hindu net desk, 2021). The project has the potential of GHG reduction of 694,441 tonnes of CO_2e per year.

The project is being developed in four phases, with Rajasthan Solar Park Development Company Limited (RSPDCL) developing the first two phases, Saurya Urja Company of Rajasthan developing phase three, and Adani Renewable Energy Park Rajasthan developing phase four. The solar park construction was started in July 2015 and the first phase was commissioned in October 2018. April 2019, while phases three and four are expected to be commissioned by March 2019 (The Hindu net desk, 2021).

The total estimated investment on the project is Rs98.5bn ($1.4bn) (The Hindu net desk, 2021).
The first phase of the solar park has seven solar power plants with a combined capacity of 75MW, while phase two has ten solar power plants with a combined capacity of 680MW. Phases three and four will have ten solar power plants each, with combined capacities of 1,000MW and 500MW respectively (The Hindu net desk, 2021). National Thermal Power Corporation (NTPC) and Solar Energy Corporation of India (SECI) are the two organizations who have signed 25-year power purchase agreement with developers (The Hindu net desk, 2021).

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3.3.8 Technologies for CO_2 capture, utilization, and storage

CO2 capture, utilization, and storage (CCUS) technology comprises three different processes: separating CO_2 from emission sources, CO_2 conversion and utilization, transportation, and storage underground with long-term isolation from the atmosphere. These technologies mainly constitute technologies and CO_2 utilization technologies. They are at R&D stage.

3.3.9 Other technologies (Carbon neutrality based on satellite observation and Digital Earth)

At present, greenhouse gas observation methods include ground-based monitoring and satellite remote sensing. A global network of greenhouse gas observation stations was established in the early stage to provide accurate greenhouse gas concentration data. The Principle of Common and Separate Responsibilities was clearly stated in United Nations Framework Convention on Climate Change in 1992.

3.3.10 Assessment of world cases and best practices of circular economic utilization of food waste

Food waste utilization priorities in the Ha Noi 3R Declaration's Sustainable 3R Goals (3RGs) for Asia and the Pacific for 2013-2023 can be primarily attributed to goal 2 and goal 10 (UNCRD, 2013). In section 1 of the Declaration (3R Goals in Urban and Industrial areas), goal 2 refers to the full-scale utilization of organic components of municipal solid waste, including food waste, as a valuable resource, thereby achieving multiple benefits such as the reduction of waste flows to final disposal sites, reduction of GHG emission, improvement in resource efficiency, energy recover, and employment creation. This goal's indicators include 1) organic waste landfilled per capita, or per amount landfilled, 2) amount of organic component of MSW composted, 3) amount of organic waste component of MSW treated by anaerobic digestion, 4) number of cities that have introduced successful source separation programmes, 5) number of jobs in organic waste management (formal and informal), and 6) amount of organic waste component of MSW treated by waste-to-energy (UNCRD, 2013). As for rural areas, section 2's goal 10 refers to the reduction of losses in the overall food supply chain (production, post harvesting and storage, processing and packaging, distribution), leading to reduction of waste while increasing the quantity and improving the quality of products reaching consumers. This goal has one indicator, which is the percentage of food loss at each stage of food supply chain (UNCRD, 2013).

In 2019 in the agro-food sector alone, food loss and waste amassed to 1.3 billion tons, which cost more than 1000 billion dollars per year (FAO, 2019). Circular economy is the application of a basis of industrial economy that is restorative by design and mirrors natural cycles with the goal of the system being enhanced and its resources optimized (Jurgilevich, et al., 2016). Circular economy principles deviate from the take-make-dispose paradigm, which has been heavily criticized for its disregard for environmental sustainability as over-exploitation of resources and degradation of the environment are often observed with this paradigm (Esposito, Sessa, Sica, and Malandrino, 2020). Circular economy applications are now popularized by grass-root movements for plastics and the manufacturing sector committing to net zero plastics, zero-waste, and net circularity (Lee, 2021). Unlike more known applications of circular economy such as ones for plastics, those for food and food waste remain observed primarily in food production, food processing, wholesale and logistics combined with retail and markets, while applications remain few from consumer level and beyond (World Bank Group, 2020). Circular economy is yet to be widely observed in the consumer or household level, despite, as discussed in section 3.2.6, food waste is often most abundant at the household level, especially in more economically developed regions. Reluctance to transform practices to more sustainable ones could be an obstacle in integrating circular economy principles into the consumer and household levels (Lehtokunnas, Mattila, Naervaenen, and Mesiranta, 2020).

There is a plethora of benefits in adopting circular economy systems to resolve food waste problems. First of all, the food production sector's greenhouse gas (GHG) emissions can be estimated to be cut by 49% by a circular economy for food by 2050 (Robertson-Fall, 2021). Social benefits of circular economies for food include improve access to nutrition, supporting local communities, and creating value (Robertson-Fall, 2021). Circular economy is usually seen with applications of principles acquired from natural systems: production out of waste, resilience through diversity, reapplication of renewable energy sources, systems thinking, and cascading flows of materials and energy (Jurgilevich, et al., 2016).

Reduction of food loss and waste has been hailed as the primary focus in strategies to combat total food waste (FAO, 2011). However, it is also important to ask whether interventions to reduce food loss and waste would be the most effect ways to achieve environmental and natural resource conservation goals (FAO, 2019). Often times, there may be larger reductions of other negative environmental impacts from interventions that do not maximize the reduction of food loss (FAO, 2019). Through better utilization and valorization applications, food loss can be reduced when the organic material is repurposed and reintegrated into a supply chain. There are ample examples from the world where creativity, innovation, and technology have been applied to new methods to accomplish the utilization of food waste.

Solutions and interventions to combat food waste often revolve around the prevention and reduction of food waste, which is considered the primary focus to minimize total food loss. By definition, food loss is “all the crop, livestock and fish human-edible commodity quantities that, directly or indirectly, completely exit the post-harvest supply chain by being discarded, incinerated or otherwise disposed of, and do not re-enter in any other utilization (such as animal feed, industry use, etc.), up to, and excluding, the retail level.” (FAO, 2019). It is important to note that, although prevention and reduction of food waste generation are important, the utilization, valorization and re-integration of any food content in the supply chain is also critical in reducing food loss. In the definition itself, the applications of otherwise wasted food as animal feed and for other industry uses are highlighted as typical examples of utilization interventions to reduce food loss (FAO, 2019). In fact, numerous circular applications, utilization interventions, and valorization of food waste exist beyond these typical examples. Some of these interventions are highly effective in achieving circular food economies through reapplications.

Empirically, it is imperative to evaluate and monitor interventions by the success of reductions of total food loss by measurements and calculations. As discussed previously, focusing on the Food Loss Index (FLI), an indicator developed by the Food and Agriculture Organization (FAO) to monitor food losses on a global level for a basket of key commodities cover crops, livestock and fisheries products from harvest to retail, and subsequently the Food Loss Percentage (FLP), which represents food loss percentages measured over time, is essential to understand what interventions are most effective in reducing food loss (FAO, 2019). The FAO has also developed and applied a case study methodology, a useful tool for identifying critical loss points in a systematic and comparable manner, allowing for trends and common solutions in selected food supply chains to be identified (FAO, 2019).

Similar to other areas of production and consumption that requires more sustainable approaches, a systemic vision that considers a holistic perspective of the diverse nature of the system and their relationships with other stakeholders is essential for the integration of sustainability into business models of food systems (Hamam, et al., 2021). Deliberate interaction, formations of partnership, networking, and learning from many and diverse stakeholders are found to be some of the success criteria of achieving a balanced system when it comes to obtaining stakeholder acceptance of circular economy (Hamam, et al., 2021).

Furthermore, transition into circular economy models require consumers to take circular economy as their moral project and a conscious decision, and that wasting food is immoral (Lehtokunnas, Mattila, Naervaenen, and Mesiranta, 2020). Current researches of circular economy of food waste has been paying more attention to the technicality of applications, while less attention has been paid to consumer behaviour shifts and consumption patterns (Lehtokunnas, Mattila, Naervaenen, and Mesiranta, 2020).

3.3.10.2 World cases and best practices on circular economic utilization of food waste

Circular economy applications of food waste can benefit a multitude of social and environmental issues. Aside from Sustainable Development Goal (SDG) 12 “responsible consumption and production”, which has outlined specific food loss and food waste reduction targets, SDG 13 “climate action”, SDG 2 “zero hunger by improving food security”, as well as SDG 15 “promote sustainable ecosystems and halt biodiversity loss” can all see positive impacts from existing food waste circularity best practices (PACE, 2021). With the primary objective of incorporating food waste back into circulation, the added benefits of SDG 13, 2, and 15 can render a specific solution to be more worthy of consideration when the environmental and financial costs of the solution are incorporated into the calculation (World Bank Group, 2020). The World Bank has a holistic guideline – “Addressing Food Loss and Waste: A Global Problem with Local Solutions” with ample data of environmental and financial costs that assists with decision-making of adopting food waste circularity solutions (World Bank Group, 2020).

Policies and systems that enable best practices

To build effective circular economies for food, it is important to first recognize that policy systems that enable and support circular economies are often prerequisites. With supportive systems incentivizing and motivating the conception of ideas for reapplication, valorization, and diversion of food waste, ideas can be realized as real-life applications that result in positive environmental impact. **Table 3.3.10-1** lists out policy systems that enable circular economies for food from around the world.

Table 3.3.10-1: Policies that enable food waste circular economics from around the world

Geography	Policy and System
Australia	Circular Economy Policy released in New South Wales (NSW) in Feb 2019 – *Too Good to Waste*. The policy provides direction for circular with seven guiding principles, defines the State Government’s role in implementing circular economy principles across NSW and provides principles for implementing circular economy in the Government’s processes and decision making (KPMG, 2020).
	The State of Victoria has commenced shifting towards a circular economy and is currently developing a circular economy policy and action plan to be released in late 2019 through the Department of Environment, Land Water and Planning (KPMG, 2020).
	In 2019, the Queensland State Government defined its waste vision and strategy towards a zero-waste society that leverages circular economy principles. Earlier this year Queensland became home to Australia’s first Circular Economy lab with an aim to help drive the state’s transition to a new low-carbon and circular economy, delivering opportunities for industry and more jobs for Queenslanders. A key focus of the Circular Economy Lab is to consolidate industry, research and government partnerships and expertise to identify and deliver circular economy pilot projects, including two focused on the food supply chain.
	In June 2019, the Government of Tasmania released a Draft Waste Action Plan for consultation. The plan proposed, among other targets, the reduction of organic waste sent to landfill by 25% by 2025 and 50% by 2030 and the introduction of a waste levy by 2021 (KPMG, 2020).
	Through circular economy principles the state of South Australia is transforming the way the economy uses and values resources. Top of the agenda is reforming household waste, reducing food waste through developing industry solutions, reforming packaging and single use items, developing the circular economy in business and preparing for waste

Geography	Policy and System
	resulting from natural disasters (KPMG, 2020).
	These initiatives correspond to goal 2's indicators of reduction of organic waste landfilled per capita and reduction of amount of organic waste component of MSW treated by waste-to-energy, and number of jobs in organic waste management (formal and informal) and goal 10's indicator of reduction of percentage of food loss at each stage of food supply chain, as per the Ha Noi 3R Declaration (UNCRD, 2013).
European Union	EU Circularity Agenda 2024 – In 2015, the EU Action Plan for the Circular Economy was adopted and outlined plans to move towards circular economy, to improve competitiveness, create jobs, and enable sustainable growth (KPMG, 2020).
	Product Environmental Footprint – a methodology for measuring the environmental impact of products, as well as a includes a set of principles for communicating the environmental performance of products (KPMG, 2020).
	EU Monitoring Framework for the Circular Economy (2018) – 10 key indicators covering each phase of the lifecycle of products as well as competitiveness aspects (KPMG, 2020).
	Environmental Indicator Report of 2012 – first analysis of Europe's progress in achieving a more sustainable, regenerative economy, using six key indicators to assess resource efficiency and a further six addressing ecosystem resilience (KPMG, 2020).
	Sixty three legally binding targets and 68 non-binding objectives were set across nine environmental policy areas that the EU member states have to meet (KPMG, 2020).
	The EU has established resource-related policy goals extending as far ahead as 2050 as part of its Europe 2020 strategy. In many cases, these goals are accompanied by relevant targets and indicators to track implementation (KPMG, 2020).
The Netherlands	Goal for The Netherlands to be a completely circular economy by 2050. "A Circular Economy in the Netherlands by 2050", a government-wide programme for circular economy was released in September 2016. The document marks the start of a coordinated and focused effort towards circular with a shared vision and agreed pathway. Five economic sectors and value chains have been identified as priorities for the transition to circular, including biomass and food, and transition pathways have been developed (KPMG, 2020).
	In April 2017, PBL Netherlands Environmental Assessment Agency released a policy brief Food for the Circular Economy that focused on policy needs and opportunities presented by a circular approach to food production, waste and value from by-products (KPMG, 2020).
	Food Smart Facility – The Netherlands, Rabobank, the World Bank, IFAD, FAO and the Rockefeller Foundation are working together to develop a global framework to tackle food loss. This includes 'country heat maps', which show losses within the main food production chains in each country and which allows it to identify scope for action and investment (KPMG, 2020).
United Kingdom	UK Govt Food Waste Measurement Roadmap - to halve food waste by 2030(KPMG, 2020).
	The Courtauld Commitment is a voluntary agreement aimed at improving resource efficiency and reducing waste within the UK grocery sector. The agreement is funded by Westminster, Scottish, Welsh and Northern Ireland governments and delivered by the Waste and Resources Action Programme (WRAP). It supports the UK governments' policy goal of a 'zero waste economy' and climate change objectives to reduce GHG emissions (KPMG, 2020).
France	"National Pact to Combat Food Waste" in 2016, France made a commitment to reduce food waste by half by 2025 (KPMG, 2020).
	The first national law against food waste, known as the "LoiGarot", establishes a set of measures to reduce and manage this problem, particularly at the food retail level (KPMG, 2020).
Finland	In an effort to position Finland leader in circular economy, initiatives are focused on building capabilities in sustainable food systems, bio-based economies and digitisation (data and new technologies) (KPMG, 2020).
Scotland	The Government has a target to reduce food waste by 1and3 by 2025 (KPMG, 2020).
	In 2016, the circular economy strategy "Making Things Last" was published with a

Geography	Policy and System
	focus on waste prevention and four key areas: 1. Food and drink and the bio-economy, 2. Remanufacture, 3. Construction and the build environment, and 4. Energy infrastructure (KPMG, 2020).
Japan	The Japanese Government enacted the law entitled "Basic Act on Establishing a Circular Society" in 2000 (KPMG, 2020).
	In May 2019, the Government introduced the Food Loss Reduction Promotion Bill which will come into effect by the end of 2019. The Bill includes the establishment of a food loss reduction body in the Cabinet Office that will be responsible for policy development on the issue. The Bill establishes October as the annual Food Loss Reduction month and requires Government to investigate food loss and enable initiatives that support entities such as Food Bank (KPMG, 2020).
	The Japanese concept of "mottainai" refers to regret at allowing a resource to go to waste without using its full value (KPMG, 2020).
	The Japanese food industry recycles about 85 per cent of its food waste, which are turned into animal feed, fertilizer or methane (KPMG, 2020).
	These initiatives correspond to goal 2's indicator of reduction of organic waste landfilled per capita and goal 10's indicator of reduction of percentage of food loss at each stage of food supply chain, as per the Ha Noi 3R Declaration(UNCRD, 2013).
Cambodia	The 166-page "Waste Management Strategy and Action Plan of Phnom Penh" was adopted in 2018 with food waste positioned as a key component where the gradual development of resource utilization capacity and phased approach to the introduction of source segregation are planned (Dickella, et al., 2020; Phnom Penh Capital Administration, 2018).
	These initiatives correspond to goal 2's indicators of reduction of organic waste landfilled per capita, amount of organic waste component of MSW treated by anaerobic digestion, reduction of amount of organic waste component of MSW treated by waste-to-energy, number of jobs in organic waste management (formal and informal), and amount of organic waste component of MSW treated by waste-to-energy, and goal 10's indicator of reduction of percentage of food loss at each stage of food supply chain, as per the Ha Noi 3R Declaration (UNCRD, 2013).
United States of America	In 2013, US Department of Agriculture and the Environmental Protection Agency launched the U.S. Food Waste Challenge for stakeholders in the food value chain to share best practices on ways to reduce, recover, and recycle food loss and waste. The goal was to have 1,000 participants by 2020. By the end of 2014, the U.S. Food Waste Challenge had over 4,000 active participants (KPMG, 2020).
	In 2015, aligned with the UN Sustainable Development Goals, the United States government has set a national target to reduce food waste by 50% by 2030 (KPMG, 2020).
	Recognising that a shift to reducing food waste needs active participation from the whole value chain, the US Department of Agriculture has named 25 major food manufacturers, retailers and food service and hospitality organisations as Food Loss and Waste 2030 Champions. Each champion has committed to a reduction in food loss and waste within their own operations and is required to report on progress through their company websites (KPMG, 2020).
	In October 2018, a joint agency agreement titled Winning on Reducing Food Waste Initiative was signed by the U.S. Department of Agriculture (USDA), the U.S. Environmental Protection Agency (EPA), and the U.S. Food and Drug Administration (FDA). This is a formal commitment to a shared vision of reducing food loss and waste and an agreement to coordinate actions (for example research, policy discussion, public-private partnerships, and methodologies for measuring food waste) and leverage government resources (KPMG, 2020).
Singapore	Singapore introduced the Zero Waste Masterplan in 2019 with aims to achieve a 70 per cent overall recycling rate and to reduce the amount of waste sent to Semakau Landfill by 30 per cent per capita per day by 2030(MSE, 2019). Food waste is one of three priority waste streams identified under the Zero Waste Masterplan (MSE, 2019).
	The Resource Sustainability Act (RSA), which was enacted in 2019,gives legislative effect to the regulatory measures targeting the three key waste streams under the Zero Waste Masterplan. Under the RSA, it is mandatory, from 2021 onwards, for developers of new commercial and industrial developments, where large amounts of food waste

Geography	Policy and System
	are expected to be generated, to allocate and set aside space for on-site food waste treatment systems in their design plans. From 2024 onwards, it will be mandatory for the owners and operators of commercial and industrial developments, where large amounts of food waste are generated, to segregate their food waste for treatment(MSE, 2019).
	In 2021, the National Environment Agency (NEA) launched the Food Resource Valorisation Award to recognise companies in Singapore that engage in food waste valorisation to convert food waste into higher-value products and raise awareness on food waste valorisation(MSE, 2019).
	These initiatives correspond to goal 2's indicator of reduction of organic waste landfilled per capita and goal 10's indicator of reduction of percentage of food loss at each stage of food supply chain, as per the Ha Noi 3R Declaration(UNCRD, 2013).
Pakistan	The Disposal of Excess Food Regulation of 2019 rewards restaurants and hotels supporting the initiative of reducing food waste and proper disposal of excess food (Chiu, 2022).

In member countries of the Ha Noi 3R Declaration, there has been notable changes in legislations on agriculture biomass since the Declaration's implementation in 2013, explained by the expert panel at *The 2nd State of 3R and Circular Economy in Asia and the Pacific* virtual meetings. In **Table 3.3.10-2:** Legislation on Agriculture Biomass Waste since the Ha Noi 3R Declaration in 2013(Pariatamby**,** 2022; MOEJ, 2018). are regulations put in place in the respective countries of the Ha Noi 3R Declaration since the Declaration's implementation in 2013.

Table 3.3.10-2: Legislation on Agriculture Biomass Waste since the Ha Noi 3R Declaration in 2013(Pariatamby, 2022; MOEJ, 2018).

Country	Year						
	2013	2014	2015	2016	2017	2018	2019
Cambodia	National Strategi Plan on Green Growth 2013-2030						Cambodia Basic Energy Plan
India	Biogas Power (off-gride) Programme	National Biogas and Manure Management Programme	India 175 GW Renewable Energy Target for 2022			National Policy on Biofuels	Draft National Energy Policy
Indonesia	Biofuel Blending (Ministry Regulation No. 25and2013)	Feed-in-Tariffs for Biomass and Municipal Waste (Ministerial Regulation No. 27and2014 and No. 44and2015)			Government Regulation No. 50 of 2017 on Utilization of Renewable Energy Sources for Power Supply		
Japan	Act No. 81 – Act on Promoting the Generation of Electricity from Renewable Energy Sources Harmonized with Sound Development of Agriculture, Forestry and Fisheries	Basic Energy Plan(4th edition)				Basic Energy Plan (5th edition)	
Lao PDR					Law on Electricity		
Malaysia						Green Technology Master Plan Malaysia 2017 – 2030	National Renewable Energy Policy
Myanmar		National Energy Policy			Myanmar Climate Change Strategy and Action Plan 2016 –	Myanmar Sustainable Development Plan	

Country	Year						
	2013	2014	2015	2016	2017	2018	2019
					2030	2018 – 2030	
Pakistan	Framework for Power Cogeneration 2013 Bagasse and Biomass						
Republic of Korea			Framework Act on Agriculture, Rural Community and Food Industry				
Thailand		Alternative Energy Development Plan: AEDP2015					
Viet Nam		Decision on support mechanisms for the development of biomass power project in Vietnam (biomass feed-in tariff)	Vietnam Renewable Energy Development Strategy 2016 – 2030 with outlook until 2050 (REDS)	National Power Developmen t Plan 7 (PDPD7 – revised)			

Types of circular economic applications of food

Best practices of circular economy utilization of food can be found across the food supply chain. There is a diverse range of examples of best practices studied that serve a multitude of objectives and combats food waste from different angles through different principles of circular economy. The circular economy principles are:

1) Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows.
2) Optimize resource yields by circulating products, components, and materials at the highest utility at all times in both technical and biological cycles.
3) Foster system effectiveness by revealing and designing out negative externalities

These three circular economy principles carve out the framework of how solutions of food wastes circularity should look like, and how desirable they are as a solution. With these principles as underlying cornerstones of food waste circular economy, objectives pertaining to applying food waste towards circularity can be derived. Table 3.3.10-3 lists out the common objectives, strategies, and practices currently employed in the agro-food sector as approaches to a circular economy (Smart Prosperity Institute, 2021).

Table 3.3.10-3 Food circular economy objectives, strategies and practices

Objectives	Strategies	Practices
Reduced resource consumption	Ecodesign	Agroecology; Zero waste grocery delivery; Zero waste grocery stores; Energy efficiency
	Process optimization	Shorter supply chains; Agrimetrics yield tracking; Digital food waste tracking; Quality control
	Responsible consumption and procurement	Consumer awareness; Discounting soon expiring food; Sustainable food choices; Sustainable procurement
Intensified product use	Sharing economy	Cooperative supermarket; Food sharing
	Short-term renting	None found
Extending life of products and components	Maintenance and repair	None found
	Donating and reselling	Surplus food recovery; Re-appropriation of surplus food
	Refurbishing	None found
	Performance economy	Meal subscription service
Giving resources new life	Industrial ecology	Agricultural industrial eco-park
	Recycling and composting	Green bins; Nutrient recovery; Re-appropriation of food waste
	Energy recovery	Biogas and electricity; Biofuel

Box 3.3.10-1. Circularity with brewing

Beer-making with bread

Toast Ale, a startup that collects surplus bread from delis, bakeries, and sandwich makers, incorporates the bread to be brewed with malted barley, hops, yeast and water to create beer (Ellen MacArthur Foundation, 2021).

Coffee husks into tea

Dried coffee husks are not fit for human consumption as a part of the beverage. Cascara is a type of tea that is made by brewing the otherwise discarded dried coffee husks collected from the process after the usable parts of the coffee bean is extracted [Vuong, 2017]. The resulting tea contains a high amount of caffeine and imparts a fruity taste. Cascara tea is now available at global chain coffee shops [Vuong, 2017].

Targeted valorisation of food waste

Organic matter contains nutrients that can be used for various purposes, including nurturing people and animals and fostering growth of crops and consumable organisms. While food waste in general can be excellent fertilizers, different types of food waste have profiles of organic matter and nutrients that are more valuable and feasible for recovery than others (Cecilia, García-Sancho, Maireles-Torres, and Luque, 2019). *Table* 3.3.10-4 lists common plant and animal-based food wastes and the target ingredients that should be prioritized for extraction and reapplication into the food systems due to the ingredients ecological and economic values.

Table 3.3.10-4 Food waste origin, sources, and target ingredients for extraction

Waste origin	Selected sources	Target ingredients
Cereal	Rice bran	Albumin and globulin, hemicellulose B and fiber
	Wheat middling	Arabinoxylan
	Wheat straw	Hemicellulose
	Wheat bran	Glucuronoarabinoxylans
	Oat mill waste	β-Glucan
	Malt dust	Glucose, arabinose,and galactose
Roots and tubers	Potato peel	Carbohydrates and polyphenols
	Sugar beet molasses	Organic acids
Oil crops and pulses	Sunflower seed	Phytosterols
	Soybean seed	Phytosterols
	Soybean oil waste	Phytosterols
	Soybean wastewater	Albumin
	Olive pomace	Polyphenols
	Olive mill wastewater	Polyphenols and pectin
Fruits and vegetables	Cold hardy mandarin peel	Narirutin
	Orange peel	Hesperidin, apocarotenoid, and limonene
	Lemon by-product	Pectin
	Apple pomace	Pectin
	Apple skin	Polyphenols
	Peach pomace	Pectin
	Apricot kernel	Protein
	Grape pomace	Dietary fibre
	Grape skin	Phenols

Waste origin	Selected sources	Target ingredients
	Wine lees	Calcium tartrate and enocyanin
	Banana peel	Cyanidin-3-rutinoside
	Kiwi fruits	Dietary fibre
	Carrot peel	β-Carotene and phenols
	Tomato pomace	Lycopene
	Tomato skin	Carotenoids
	Cauliflower floret and curd	Pectin
Meat products	Chicken by-products	Proteins
	Slaughterhouse by-products	Proteins
	Bovine blood	Proteins
	Beef lung	Protein concentrates
	Sheep visceral mass	Protein hydrolyzates
Fish and seafood	Fish leftovers (skin, head, and bones)	Proteins
	Shrimp and crab shells	Chitosanandchitin, proteins
	Surimi wastewater	Proteins
Dairy products	Cheese whey	Lactose, β-lactoglobulin, α-lactalbumim

Assessment of value of utilization practices

There are numerous ways to assess a utilization practice that strives to achieve a circular economy for food systems. While certain systems aim to utilize the most amount of organic content to be consumed by humans or animals, some target the maximum amount of monetary value retrieved from the reapplication of the food material. Regardless of the prioritized goal of any theoretical circular food system, there are several criteria that need to be considered when judging whether the system is in fact circular (PBL, 2017):

- Natural resources must be utilized and managed effectively;
- Food material usage is optimized; and
- The system results in optimum use of residual streams to minimize biomass loss.

Figure 3.3.10-1 details the flow of different compositions of organic materials that address the criteria listed above.

Box 3.3.10-2. Decentralized food waste circular economies in city schools

Sapporo City elementary and junior high schools

Food waste from leftover lunch catering in schools are converted on-site as fertilizers for participating schools in Sapporo City, Japan(ICLEI, 2021). Within the school grounds and leveraging the fertilizer made from food waste, students participate in the cultivating of vegetables which are then procured by local caterers. The full cyclical model is in turn allowing for first-hand education of food system circular economics (ICLEI, 2021).

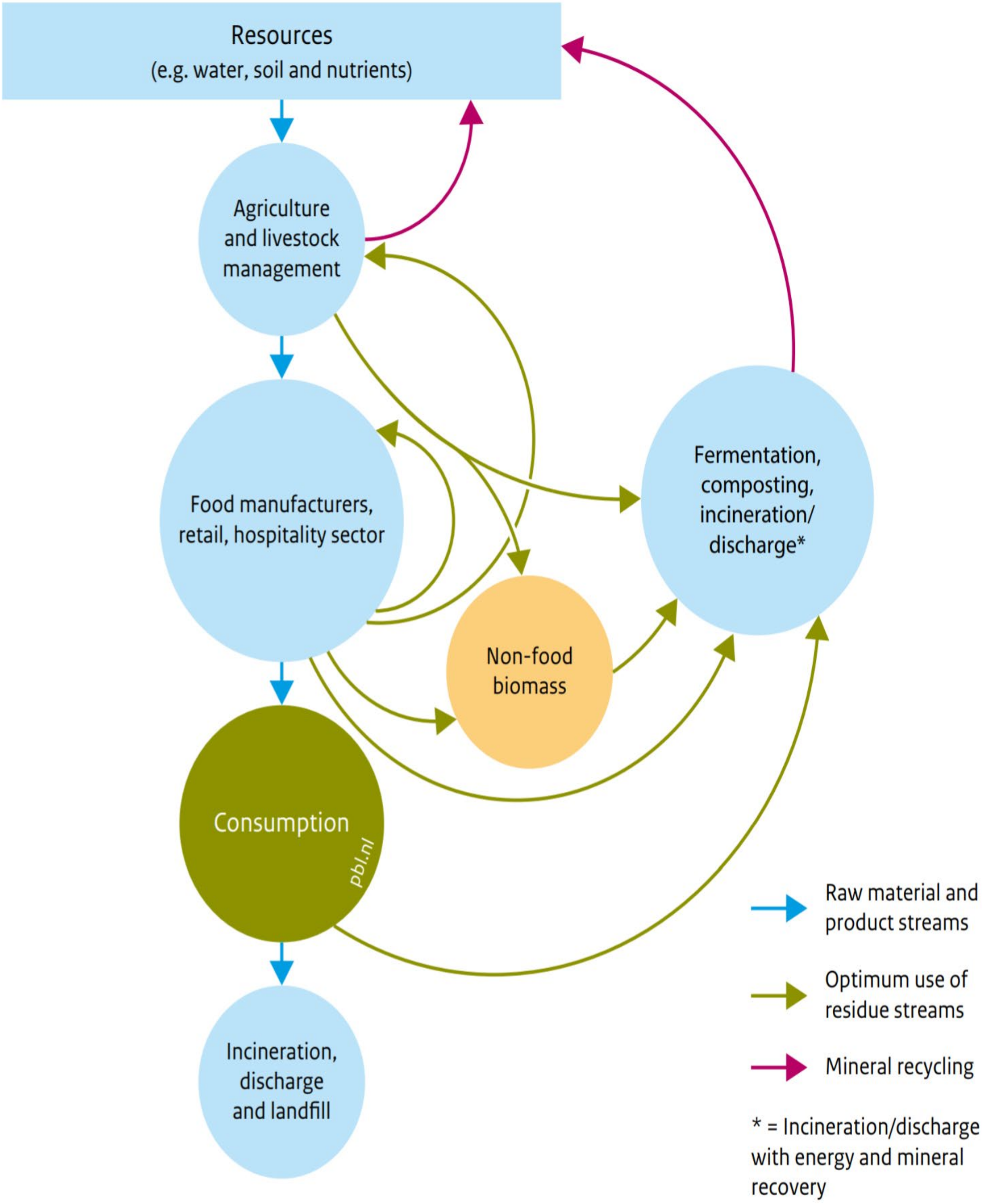

Figure 3.3.10-1: Flow of food in food production systems

Utilization of food waste as animal feed, one of the most common diversions of food waste for alternative circular applications, has been a practice descending from the ancient times. Despite this application being some of the most observed ones, it is important for the value of the food material to be preserved in order to have efficient retention of financial, nutritional, and environmental value of the food waste (World Bank Group, 2020). In , a model in the form of a hierarchy called Moerman's Ladder illustrates various common food recovery or diversion utilizations listed in descending order of preference according to the utilizations' value retention (PBL, 2017). This hierarchy can serve as a rule of thumb to guide decision-makers who are considering diversion as their primary choice of circular application of food waste.

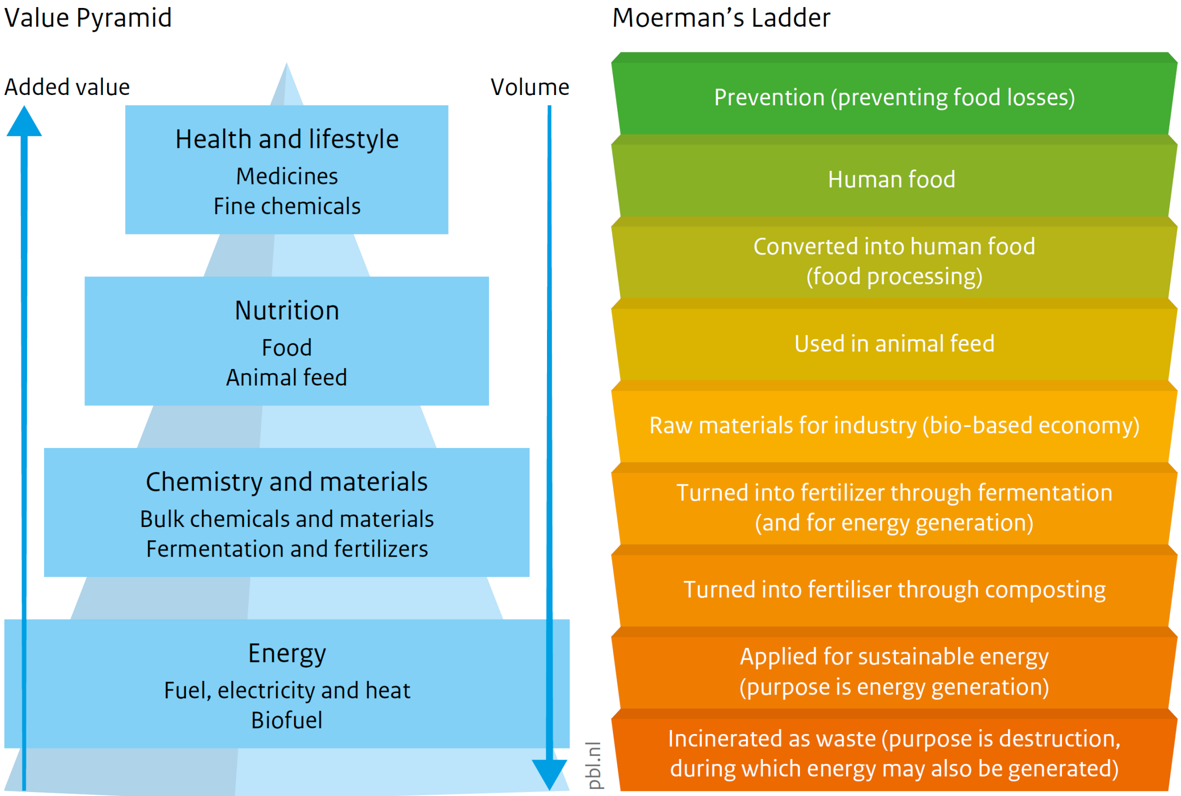

Figure 3.3.10-2: Conceptual frameworks for comparing the value of food waste diversion and utilization

When assessing circular utilizations of food waste, the economic and energy value are both key consideration factors (PBL, 2017). The Value Pyramid in outlines a similar hierarchy as the Moerman's Ladder, but prioritizing in its assessment of utilizations economic value over the conservation of resources (PBL, 2017). For instance, medicines usually have higher selling value than other consumables of the same biomass, hence medicines are placed on the top of the pyramid (PBL, 2017). Economic analyses for certain low value food waste in abundance across the world, such as spent coffee grounds, can bear high potential of generating high return on investment, thereby rendering the processes required to modify the food waste into a valorized product economically feasible (Topi and Bilinska, 2017).

More sophisticated and detailed analyses can help evaluate whether a particular circular application is optimizing the value retention of the food waste. For example, the application of life-cycle assessments (LCAs) can assist with improving the diversion of food waste to manufacture animal feed, as seen in the case of cruise ship food waste, often abundant, applied to the production of salmon feed (Strazza, Magrassi, Gallo, and Del Borghi, 2015). As a tool to measure overall impact, LCA was adopted to measure the application's impact on climate change, consumption of freshwater, and consumption of non-renewable energy resources (Strazza, Magrassi, Gallo, and Del Borghi, 2015).

Through considerations of the conditions of the food waste, the edibility of the material by humans and animals, and other factors such as the feasibility of processes that facilitate food waste processing, decision-makers can come to better-informed conclusions of how to utilize the food waste. As depicted in Figure 3.3.10-3, a collection of processes can render food waste from various parts of the supply chain valorized material for reintegration into other supply chains, therefore creating circular economies.

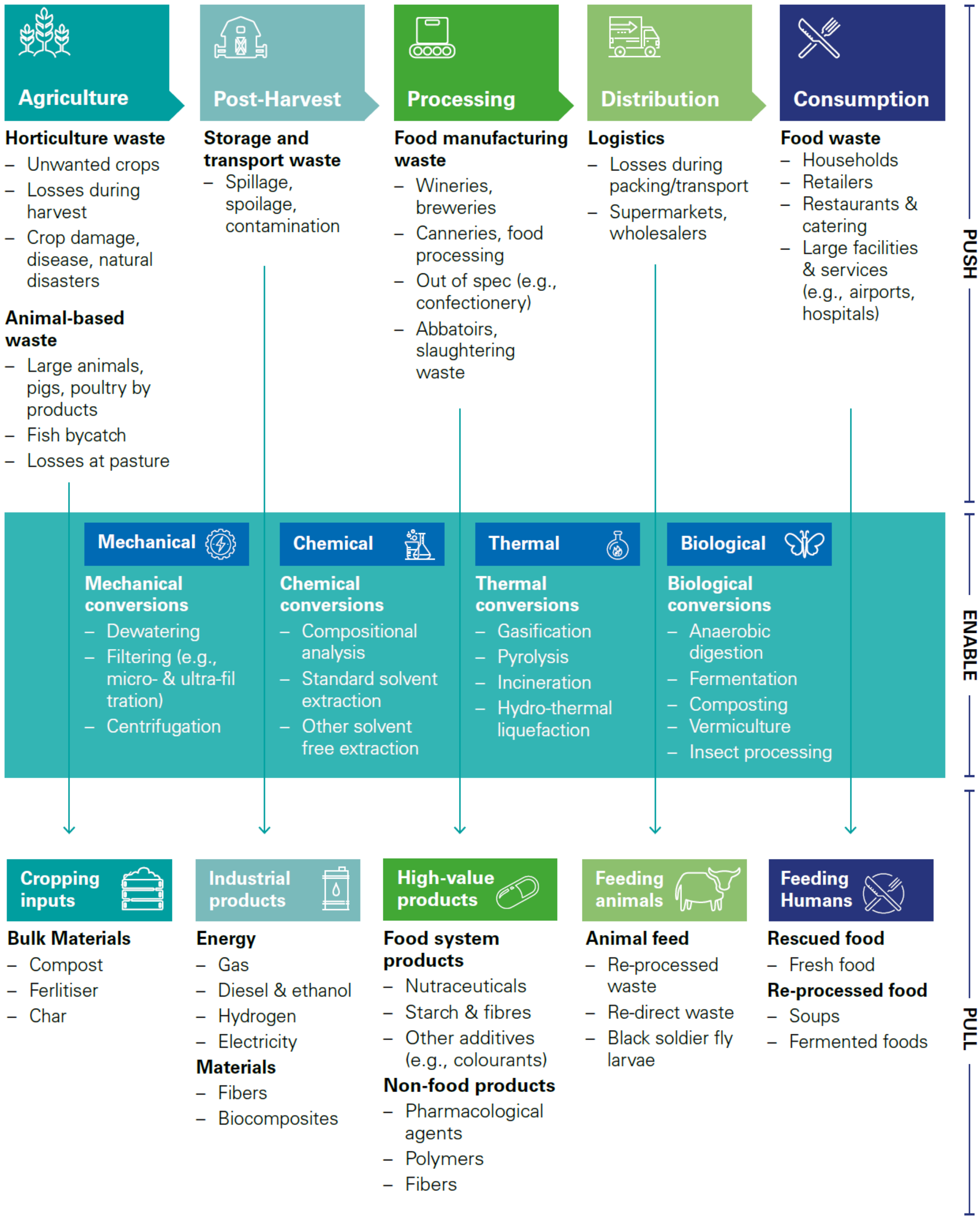

Figure 3.3.10-3: Food waste by origin and processes that transform them into circular products that maximize their potential

It is however, also important to note that these processes come at the price of environmental impact – detailed analysis of life-cycle impacts through LCAs should be adopted to assess the potential environmental impacts associated with all phases these processes when making decisions of circularity applications (Hamam, et al., 2021).

Box 3.3.10-4. Supermarkets' commitments to food circularity

Loblaw

Canadian retail chain Loblaw committed to reduce or divert their store-generated food waste by half by 2025 (Smart Prosperity Institute, 2021). The retailer's goals for food circularity include:

- Expanding their network of food banks, donating more than 8.5 million pounds of food in 2018
- Directing stale or expired grocery goods to use in the making of grain-based animal feed
- Feeding food trimming and inedible organics to anaerobic digesters to generate electricity that can be used locally or be fed back to electrical grids
- Converting used cooking oil into biodiesel (Smart Prosperity Institute, 2021)

3.3.10.3 Frontier technologies towards food waste management

Block chain has been active and disruptive as a secure ledger applied to innumerable areas within the past years – from financial markets to industrial supply chain applications (Kouhizadeh et al., 2020). Like other applications, food waste circularity applications of block chain offer transparent, decentralized, and secure transaction processes that offer many benefits (Kouhizadeh et al., 2020). Reduced overall costs, resource regeneration, improved efficiency, and responsiveness are some of the identified benefits of applying block chain to food waste circular economies(Kouhizadeh et al., 2020). Moreover, the reliable traceability of block chain-backed systems, equipped also with the option of transparency and scalability, can render the application of block chain ledgers to food waste solutions more attractive(Okorie et al., 2021). It is estimated that block chain-enabled traceability can amount up to a reduction of FLW of 30 million tons (Business, 2020)

Another technological innovation that greatly enhances food waste solutions is Internet of Things (IoT). Independent from human involvement, IoT is the vast network of devices communicating over the internet. Owing to the optimization of supply chains and more optimized and shorter distribution lines, it is theorized that IoT can enable a myriad of benefits that propel the food waste circular economy, including food waste reduction, food traceability improvement, food quality enhancement, and new food authentication capabilities (Andreopoulou, 2017). Electronic sensors paired with IoT technology can be helpful in collecting data for analyzing food waste types and therefore their potential for valorization(Jabbour et al., 2019). For example, there are sensors that can detect visual appearances and odours of food, which contribute to better monitoring and guidance on the application of the food.

It has long been known that spent coffee grounds has high potential to be repurposed into a wide array of products in agriculture, livestock keeping, and even construction applications such as sawdust and wood pellet production (Nosek et al., 2020)Recent studies have revealed a myriad of new applications and discoveries on how existing applications could be improved through advanced technology (Kueh, 2021). In Malaysia, there has also been studies done on agricultural biomass waste and livestock waste, more notably from fishery, food processing, and organic municipal solid waste.

Table 3.3.10-5: Applications of spent coffee grounds and recent discoveries related to their applications**.**

Application	Discoveriesandproducts
Biofuel	Ethanol production – 50 percent yield Ethanol production – 8.5 percent yield Ethanol production – 78 percent yield Biodiesel production – 10–15 percent yield Biodiesel production – 16 percent yield
Enzyme	Solid-state fermentation Substrate for cellulose production with *Paenibacilluschitinolyticus* –71 percent yield 8.6-fold Tannase using coffee husk β-fructo furanosidase andfructooligo saccharides production with *Aspergillus japonicus*
Mushroom	Biological efficacies between 125 and 138 percent 88.6, 85.8, and 78.4 percent efficacies, respectively, by the treated spent coffee grounds, coffee husk, and mixed substrates *Flammulinavelutipes* cultivation 73 percent of coffee husk for mushroom cultivation
Vermicomposting	Boost soil fertility and plant growth Microorganism inoculation enhances the composting quality and rate of SCG with low phenolic compounds(e.g., 120 percent barley germination index within 20 weeks)
Organic acid	10 g dry coffee husk yields 82 percent 1.5 g citric acid Optimal Cassava bagasse with 492.5 mgandkg coffee husk
Bioactive compound	Polyphenols extraction by coffee pulp 65–70 percent anti-oxidant activity from bioactive conserves of coffee by-products Phenolics – 3.6 percent yield
Biogas	Biomethanation with coffee husk cultivated with thermophilic *Mycotypha*
Dietary fibre	Fiber complex combined with anti-oxidant properties offer greater benefit 5-fold insoluble dietary fibre vs dietary fibre
Activated carbon and biosorbent	Phosphoric acid with coffee pulp inflicts great adsorbing capacity Heavy metals elimination from solutions
Toxin removal	Landfill leachate absorbent
Water treatment	Synthesis of silver nano particles
Lightweight clay ceramic aggregate	For draining and green roofing purposes
Pavement	Damaged or aged asphalt repair
Panel	Structural and non-structural panels with coffee husk– superior bending and bonding characteristics
Structural ceramic	Improve water absorption and apparent porosity Can be used as secondary material for bricks with good thermal insulation Improve mechanical strength by 15 percent coffee husk ash addition
Brick	Increase water absorption but decrease compression strength and thermal conductivity Lower mass but higher porosity, which provides greater insulation and good mechanical behavior. 3 percent spent coffee grounds optimum content enhances the compressionstrength17 percent spent coffee grounds provides a compression strength of >10 Nandmm2; spent coffee grounds combustion reduces bulk density, hence, enhances porosity but decreases thermal conductivity
Subgrade filler	Great water and organic contents, great compressibility but reduced shear strength and density; need stabilization for high traffic loads; spent coffee grounds as non-structural filler for embankment
Thermal insulator	Greater spent coffee ground content reduces thermal conductivity and thermal diffusivity
Sound absorbent	Sound absorption coefficient increases with frequency due to spent coffee ground porosity Rigid foams containing spent coffee ground offer good sound absorption Cold-pressed panels for soundproofing

3.3.10.4 Conclusion and Way Forward

As the Ha Noi 3R Declaration comes to an end in the next year, the member states of the Declaration come together to discuss next steps and the successor of the Declaration. As for trends and develops on relevant Ha Noi 3R Declaration goals and SDGs, PR China, Japan, Viet Nam, Malaysia, and Australia developed targets aligned with SDG 12.3, while Japan, Australia, and New Zealand measure food loss and waste (Lu et al., 2022).

Panel experts in the discussion recommended that efforts from all stakeholders are required to realize the maturation of technologies for maximum extraction of resources from agricultural biomass waste. Moreover, similar attempts must be made to scale up the new technologies to increase their capacity, advancing from laboratory scale to plot scale to commercialization. There is an urgent requirement for dedicated legislations for the management of agricultural biomass waste, and as of early 2022, only relatively developed countries of the Asia and the Pacific have specific laws for agricultural biomass waste.

An astounding majority of initiatives implemented for the reduction or circularity of food waste use the Ha Noi 3R Declaration goal indicators such as goal 2's indicator of "organic waste landfilled" and goal 10's "percentage of food loss at each stage of food supply chain". Increased practice of composting, or increased in organic waste management have not been widely discussed in published plans, reports or researches of food waste initiatives of Ha Noi 3R Declaration countries.

Current food systems are depleting our planet's resources while current practices pertaining to our consumption of food are resulting in global health and environmental crises (WBCSD, 2019). The current trajectory of population growth and increases in dietary consumption will further aggravate these crises (WBCSD, 2019). In the "Ha Noi 3R Declaration - Sustainable 3R Goals for Asia and the Pacific for 2013-2023", adopted at the 4th Regional 3R Forum in Asia and the Pacific in 2013, goal 2 (Full-scale utilization of the organic component of municipal waste, including food waste, as a valuable resource, thereby achieving multiple benefits such as the reduction of waste flows to final disposal sites, reduction of GHG emission, improvement in resource efficiency, energy recovery, and employment creation.) and goal 10 (Reduce losses in the overall food supply chain) can be achieved with the help of circular economy utilization of food waste. The SDGs 12 "responsible consumption and production", 13 "climate action", 2 "zero hunger by improving food security", and 15 "promote sustainable ecosystems and halt biodiversity loss" can all leverage circular economy principles on food waste (2021, PACE)

State-of-art technologies such as block chain, IoT, AI and other smart systems and devices can greatly assist the efficiency of food circular economies, also allowing traceability, transparency, big data analytics, and systemic studies of food circularity (de Souza et al., 2021). Coupled with LCA and holistic considerations of food waste utilization solutions, these technologies enable the optimization of the utility of food materials. By ensuring food systems making optimum use of natural resources, raw materials and products and reutilizing them as much as possible, total FLW can be reduced as circular economies for food waste are being built (PBL, 2017).Natural resources should be used in ways that bring maximum value to the economy while inflicting the lowest level of damage on the environment (PBL, 2017)

Moving forward, after the Ha Noi 3R Declaration's time frame ends in 2023, panel experts recommend several clear goals or targets to be set for agriculture biomass waste, including: 1) data collection, 2) quantitative targets of utilization, 3) quantitative targets of increase in installed capacity for bioenergy, and 4) encouragement of technology-sharing and capacity-building between developed and developing countries of the Asia and the Pacific. Specifically, SDG 12.3 and goal 10 of Ha Noi 3R Declaration can guide national goals to set food loss and waste reduction targets (Lu et al., 2022).

The causes of food loss and waste in the Ha Noi 3R Declaration countries vary and may be influenced by food habits, culture, consumer behaviour, and economic capacity (Lu et al., 2022). Practical, sustainable, inclusive and circular economy strategies and programs are needed to address the interrelated issues contributing to the challenges of food loss and waste (Lu et al., 2022). The goal of achieving food circular economies can be seen as the priority by many national, regional, and international agendas (PBL, 2017). Many food supply chains, organizations, and countries across the world are already implementing a variety of practices that support circular economy objectives and strategies, sometimes without having these practices explicitly labelled as circular (Institute, 2021). A turning point of the global food systems to achieve circular economies lie in the widespread adoption of such practices (Institute, 2021). In the Asia and the Pacific region, best practice examples bearing innovative and technologically-advanced approaches to circularity for food waste are abundant. Food waste circular economies are not only necessary, but are economically attractive when delivered with careful considerations of the processes and utilization methods involved (Topi and Bilinska, 2017). Key components of critical transformation of global food systems to become more sustainable, more equitable, and healthier for all, circular economies for food are the way of the future, where food production occurs in ways that regenerate nature, prevents food loss and waste, and utilize otherwise wasted resources (2021, PACE).

References Chapter 3.3.10

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3.4 Progress towards Implementation of the Ha Noi 3R Declaration (2013-2023)

The progress towards implementation of the Ha Noi 3R declaration in Asia and the Pacific region has been described in the following sections in terms of trends describing 3R policies and legislative framework, definition of MSW waste, hazardous waste including generation, policies and regulations and nationally implemented 3R projects programmes and master plan.

3.4.1 3R Policy Implementation in Asia and the Pacific

The major trends have been described in terms of policy and regulatory framework, definitions, related to MSW and hazardous waste, emerging of both waste streams and Extended Producer Responsibility (EPR).

National 3R-Related Policies and Legislative and Institutional Framework
Waste management exists in the basic environmental policy of all the countries, with the developed ones having specific legislation and framework for recycling, take-back schemes and e-waste management. **Table 3.4.1-1** is an indicative data giving waste management 3R related policies and strategies in Asia and the Pacific.

Table 3.4.1-1: Waste management and 3R-related policies and strategies in Asia and the Pacific. Source: (UNCRD et al., 2018b)

Country	Reference on waste management in its basic environmental policy	Waste management law	Framework strategy and law on resource circulation and the 3Rs	Law for recycling and take-back scheme for specific end-of-life products
Bangladesh	National Environment Policy 1992	--	National 3R Strategy 2010	--
Bhutan	National Environment Protection Act, 2007	Waste management and prevention regulation	National Solid waste management strategy, 2014 National Hazardous waste management strategy	Zero waste by 2030

Country	Reference on waste management in its basic environmental policy	Waste management law	Framework strategy and law on resource circulation and the 3Rs	Law for recycling and take-back scheme for specific end-of-life products
Cambodia	Law on Environmental Protection and Natural Resources Management 1996	Sub-decree on SWM (1999)	--	--
PR China	Environmental Protection Law of the People's Republic of PR China (2014 Revision)	Law of PR China on the Prevention and Control of Environment Pollution Caused by Solid Wastes (2015Amendment)	Circular Economy Promotion Law of the People's Republic of PR China (2008)	Regulation on the Administration of the Recovery and Disposal of Waste Electrical and Electronic Products (2009, Order of the State Council of the People's Republic of PR China (No. 551))
India	- Article 48A, directive principle, Part IV and Article 51 A(g), Part IVA, of the amendment of Constitution of India in 1976; - Environmental Protection Act 1986; - Factories Act 1948 and its amendment in 1987 - National Environment Policy (2006)	- Solid Waste Management Rules, 2016; - Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016; - Bio-Medical Waste Management Rules, 2016; - Construction and Demolition Waste Management Rules, 2016 - Plastic Waste Management Rules, 2016	Waste Management Rules are based on 5Rs strategies that include resource circulation and the 3Rs principles.	E-waste (Management) Rules, 2016
Indonesia	Environmental Protection and Management Act No. 32 (EPMA 32and2009)	Law no.18and2008 on MSW Management: 3R as the principle approach for waste management Law no, 32and2009 on Haz. Wastes	The government regulation no. 81and2012 on 3Rs and EPR President Regulation No.97and2017 on Policy and National Strategy of MSW	--
Japan	Basic Environmental Law and Plan	Waste Management and Public Cleansing Law	Basic act and fundamental plan for establishing sound material cycle society	Various recycling laws such as: Container Packaging Resource Recycling Act (1995) and Home Appliance Recycling Act (1998)
Malaysia	Environmental Quality Act 1974	Solid Waste and Public Cleansing Management Act 2007	There are 8 Regulations on 3R within the Solid waste Act	There are 8 Regulations within the Solid waste Act
The Philippines	PD 1152 –	Ecological Solid	Ecological Solid	--

Country	Reference on waste management in its basic environmental policy	Waste management law	Framework strategy and law on resource circulation and the 3Rs	Law for recycling and take-back scheme for specific end-of-life products
	Philippine Environment Code (1977) RA 8749 – Philippine Clean Air Act of 1999 RA 9275 – Philippine Clean Water Act of 2004 (2004)	Waste Management Act of 2000 (RA 9003)	Waste Management Act of 2000 (RA 9003)	
Singapore	Environmental Public Health Act	Environmental Public Health (General Waste Collection) Regulations; Environmental Public Health (Toxic Industrial Waste) Regulations Resource sustainability Act	Sustainable Singapore Blueprint setting waste recycling rate target of 70 percent in 2030 with a goal of becoming a Zero Waste Nation	Deposit refund scheme
Thailand	Enhancement and Conservation of National Environmental Quality Act B.E. 2535 (1992), Factory Act B.E. 2535 (1992), Public Health Act B.E.2535 (1992)	Maintenance of Public Sanitary and Order Act. B.E. 2535 (1992) and B.E.2560 (2017)	National Solid Waste Management Master Plan, Action Plan "Thailand Zero Waste, 2016"	Regulation on National Waste Management System 2007, Draft WEEE Act., Draft Waste Management Act, Draft Promotion of 3Rs and Utilization of Waste
Viet Nam	Law on Environmental Protection 2014 (amended in 2014)	Decree 38and2015andND-CP on management of wastes and scrap	National Strategy on Integrated Solid Waste Management to 2025, vision to 2050 (Being revised)	Regulation for take-back and treatment of discarded products: Prime Minister Decision 16and2015andQĐ-TTg dated 22 May 2015 (Small appliances, home appliances, lubricant oils, used tyres, ELVs)
Nauru	Chemical and Waste management policy	--	--	--
Myanmar	--	--	National waste management, strategy and action plan (2017-2030) Draft National Hazardous waste management master plan	--

Country	Reference on waste management in its basic environmental policy	Waste management law	Framework strategy and law on resource circulation and the 3Rs	Law for recycling and take-back scheme for specific end-of-life products
Russian Federation	Federal Law, EPR	--	Creating federal operator for extremely and highly hazardous waste classes waste management	--
Republic of Korea	Waste reduction Policy	Waste management law	--	Volume based waste free system
Nepal	Solid waste management Act, 2011	Local Government operational Act, 2017	National health care waste management guidelines	--
Sri Lanka	Cleaner Production Policy	--	--	Zero waste Concept
Mongolia		Waste law	--	Sustainable Development Concept
Pakistan	Pakistan Climate change Act	--	Framework for implementation of Climate Change Policy	--
Pacific Island Countries	Cleaner Pacific 2025 is a comprehensive long-term strategy for integrated sustainable waste management and pollution prevention and control in the Pacific Region.			

Definition and Classification of Municipal Solid Waste (MSW)

The definition and classification on MSW including associated waste streams vary across the region depending on the situation, context and the country's priority. Accordingly the quantity and the waste stream regulated varies across Asia and the Pacific. For example, Japan and Singapore define MSW as "general waste". However, whereas the category of "general waste" in Japan does not comprise "industrial waste", Singapore's classification of "general waste" includes this waste type. Similarly, "total MSW generation" often encompasses a range of recyclables (papers, bottles, metals, used electronic appliances, etc.) which are frequently considered waste in industrialized countries such as Japan. At the time same Indonesia, Vietnam and PR China consider "recyclables" as valuable goods. Therefore, it is difficult to suggest a single unified definition that could be applied to all countries. Examples of definition in different countries in the region are given in **Table 3.4.1-2.**

Table 3.4.1-2: Definition of waste and solid waste by laws. Source: (UNCRD et al., 2018b)

Country	Definition of Waste and Solid Waste
Bangladesh	According to the Bangladesh Environment Conservation Act, 1995: "Waste means any solid, liquid, gaseous, radioactive substance, the discharge, disposal and dumping of which may cause harmful change to the environment." The above act then specifies that: Municipal solid waste (MSW), commonly known as trash or garbage or refuse or rubbish, is a waste type consisting of everyday items that are discarded by the public. In Bangladesh, municipal solid waste includes not only household wastes but also other types of solid waste such industrial waste, hazardous wastes, E-wastes, agricultural wastes, etc."
Cambodia	In Solid Waste Management Sub-decree in Cambodia (established in 1999, Sub-decree No 36 ANRK.BK) "Solid wastes" comprise all the wastes arising from human activities, including

Country	Definition of Waste and Solid Waste
	animal wastes that are discarded as useless or unwanted. The sub-decree defines the key terms of "solid waste" and "garbage" as following: - Solid waste refers to hard objects, hard substances, products or refuse which are useless, disposed of, are intended to be disposed of, or required to be disposed of; and - Garbage is the part of solid waste which does not contain toxin or hazardous substance, and is discarded from dwellings, public buildings, factories, markets, hotels, business buildings, restaurants, transport facilities, recreation sites, etc."
PR China	According to the Law on the Prevention and Control of Environmental Pollution by Solid Wastes ("中华人民共和国固体废物污染环境防治法", adopted in 1995, and amended in 2004) and related regulations, "**solid waste**" refers to articles and substances in solid, semi-solid state or gas in containers that are produced in the production, living and other activities and have lost their original use values or are discarded or abandoned despite not having yet lost their use value, and articles and substances that are included into the management of solid wastes upon the strength of administrative regulations. "Solid waste" is classified into three types: industrial solid waste ("工业固体废物", IW), **municipal solid waste** ("生活垃圾", MSW), and hazardous waste ("危险废物", HW). **MSW** means solid waste discharged from everyday life or from services provided to everyday life as well as the solid waste that is regarded as municipal solid waste under laws and administrative regulations. It usually includes residential, institutional, commercial, street cleaning, and non-process waste from industries. In some cases, construction and demolition waste is also included.
India	According to the Solid Waste Management Rules, 2016 (MoEF and CC, 2016), "Solid Wastes" is defined as the solid or semi-solid domestic waste, sanitary waste, commercial waste, institutional waste, catering and market waste and other non-residential wastes, street sweepings, silt removed or collected from the surface drains, horticulture waste, agriculture and dairy waste, treated bio-medical waste excluding industrial waste, bio-medical waste and E-waste, battery waste, radio-active waste generated in the area under the local authorities. Wastes are materials that are not products or by-products, for which the generator has no further use for the purposes of production, transformation or consumption. (i) waste includes the materials that may be generated during, the extraction of raw materials, the processing of raw materials into intermediates and final products, the consumption of final products, and through other human activities and excludes residuals recycled or reused at the place of generation; and (ii) by-product means a material that is not intended to be produced but gets produced in the production process of intended product and is used as such. The regulated categories of wastes in India are as follows. - Solid Wastes are the Solid or semi-solid domestic waste, sanitary waste, commercial waste, institutional waste, catering and market waste and other non-residential wastes, street sweepings, silt removed or collected from the surface drains, horticulture waste, agriculture and dairy waste, treated bio-medical waste excluding industrial waste, bio- medical waste and E-waste, battery waste, radio-active waste generated in the area under the local authorities. - Hazardous Wastes are the wastes which by reason of characteristics such as physical, chemical, biological, reactive, toxic, flammable, explosive or corrosive, causes danger or is likely to cause danger to health or environment, whether alone or in contact with other wastes or substances, and shall include waste specified under column Schedule I, Schedule II and Schedule III of the Rules. - Biomedical Wastes are the wastes generated during the diagnosis, treatment or immunization of human beings or animals or research activities pertaining thereto or in the production or testing of biological or in health camps. - Electronic Waste are the electrical and electronic equipment, whole or in part discarded as waste by the consumer or bulk consumer as well as rejects from manufacturing, refurbishment and repair processes. - Demolition and construction waste comprising of building materials, debris and rubble resulting from construction, re-modeling, repair and demolition of any civil structure. - Plastic Waste is any plastic discarded after use or after their intended use is over. - Battery Wastes are the used Lead Acid batteries after their intended use is over.
Indonesia	**Wastes** are broadly classified as **domestic wastes** and **non-domestic wastes**. Domestic

Country	Definition of Waste and Solid Waste
	waste consists of household waste and household-like waste and wastewater. Non-domestic wastes, furthermore are grouped into non-hazardous wastes and hazardous wastes. There are two laws that regulate waste management namely Law no. 18and2008 concerning household and household-like waste (municipal solid waste), and Law no. 32and2009 concerning Environment Protection and Management, regulates industrial and HW. Law no. 18and2008 defines household and household-like waste as the residues of human daily activities and residues of natural processes in solid forms. Government Regulation (GR) no. 81and2012 explains more specific details regarding municipal solid waste management and its technical handling, 3Rs and EPR approach. Management of this type of waste is the responsibility of municipality or other governmental authorities. Wastes specified under this law are: - **Household wastes** which are generated by daily activities performed within households, but does not include feces and specific wastes; - **Household-like waste,** which are generated from commercial zones, industrial estates, special zones, social facilities, public facilities and any other facility; - **Specific wastes** are wastes which require special management due to their properties, concentrations and volumes, in forms of hazardous materials contained wastes, hazardous wastes, wastes generated by disasters, demolition wastes, un-processable wastes due to availability of technology and non-periodical generated wastes.
Japan	In Wastes Management and Public Cleansing Law (1970), "**Waste**" refers to refuse, bulky refuse, ashes, sludge, excreta, and other filthy and unnecessary matter, which are in solid or liquid state. "Waste" also refers to the things that cannot be used by the possessor or the things that cannot be handed over to others with compensation. Waste is widely divided into two types that are "**general waste (municipal solid waste)**" and "industrial waste". "Industrial waste" refers to the 20 types of waste material defined in Enforcement Ordinance of the Wastes Management and Public Cleansing Law among all the wastes generated from business activities and imported waste. On the other hand, general waste (municipal solid waste) refers to waste other than industrial waste. It consists of household garbage mainly generated from home other than human waste and business-related garbage generated from the offices and restaurants (household and business waste, and raw sewage).
Malaysia	The laws of Malaysia (Act 672 Solid Waste and Public Cleansing Management Act 2007) define "**solid waste**" as - Any scrap material or other unwanted surplus substance or rejected products rising from the application of any process; - any substance required to be disposed of as being broken, worn out, contaminated or otherwise spoiled; or - any other material that according to this Act or any other written law as required by the authority to be disposed of, but does not include scheduled wastes as prescribed under the Environmental Quality Act 1974 (Act 127), sewage as defined in the Water Services Industry Act 2006 (Act 655) or radioactive waste as defined in the Atomic Energy Licensing Act 1984 (Act 304). Solid wastes are generally categorized into five groups namely municipal wastes, industrial wastes, hazardous wastes, agricultural wastes and E-wastes. **Municipal waste** is part of solid waste, including the following; • any scrap material or other unwanted surplus substance or rejected products arising from the application of any process; • any substance required to be disposed of as being broken, worn out, contaminated or otherwise spoiled; or any other material that, according to Solid Waste and Public Cleansing Management Act 2007 (Act 672) or other written law, is required by the authority to be disposed of. This includes public solid waste, imported solid waste, household solid waste, institutional solid waste and special solid waste such as waste from commercial, construction, industrial and controlled activities.
The Philippines	**Municipal wastes** refers to wastes produced from activities within local government units which include a combination of domestic, commercial, institutional and industrial wastes

Country	Definition of Waste and Solid Waste
	and street litters; **Solid wastes** refers to all discarded household, commercial waste, non-hazardous institutional and industrial waste, street sweepings, construction debris, agriculture waste, and other non- hazardous non-toxic solid waste.
Singapore	According to the Environmental Public Health (General Waste Collection) Regulations, **General wastes** means - refuse or industrial waste, excluding any toxic industrial waste specified in the Schedule to the Environmental Public Health (Toxic Industrial Waste); - waste from grease interceptors; - waste from sewerage systems, including waste from sewage treatment plants, septic tanks and water-seal latrines; - waste from sanitary conveniences not part of a sewerage system, including waste from sanitary conveniences which are mobile or in ships or aircraft; - dangerous substances that have been treated and rendered harmless and safe for disposal [S 562and2008 w.e.f 01and11and2008]; - toxic industrial waste that has been treated and rendered harmless and safe for disposal and [S 562and2008 w.e.f 01and11and2008]; - recyclables waste [S 585and2016 w.e.f 01and12and2016].
Thailand	**Waste** means refuse, garbage, filth, dirt, wastewater, polluted air, polluting substance or any other hazardous substances which are discharged or originate from point sources of pollution, including residues, sediments or remainders of such matters, either in a solid, liquid or gas state [National Environmental Quality Act, B.E. 2535 (1992)] **Solid waste** means used paper, worn out cloth, discarded food, waste commodities, used plastic bag and food container, soot, animal dung or carcasses, including other matters swept from roads, market places, animal husbandry or other places including municipal infectious waste, hazardous or toxic waste [Section 3, Public Health Act, B.E. 2550 (2007)] **Municipal solid waste** means solid waste created by municipal activities e.g. residence, shop, business, service provider, marketplace, and institutes, i.e. organic and food waste, leaf and grass, etc., recyclable waste e.g. glass, paper, metal, plastic, aluminum, rubber, etc. and general waste e.g. fabric, wood, and material debris, excluding municipal hazardous waste [Pollution Control Department, Ministry of Natural Resources and Environment, B.E. 2550 (2007)] **Infectious waste** means body parts or carcasses of human and animals from surgery, autopsies and research; sharp items such as needles, blades, syringes, vials, glassware; discarded materials contaminated with blood, blood components, body fluids from humans or animals, or discarded live and attenuated vaccines and items such as cotton, other cloths and syringes; waste from wards [Regulation of the Ministry of Public Health, B.E.2545 (2002)] **Hazardous waste** means waste having hazardous constitutions, being contaminated with hazardous substance, or having hazardous characteristics as prescribed in annex 2 of the notification e.g. flammable, corrosive, toxic substances [Notification of the Ministry of Industry, B.E.2548 (2005) under Factory Act B.E. 2535 (1992)] **Marine waste** means a manmade product littered or washed into the sea, or waste from any production carried to the sea or marine environment by one way or another. Most types of marine debris are made of long lasting materials e.g. plastics, glass, wood, metal, and rubber [department of Marine and Coastal Resource, Ministry of Natural Resources and Environment, B.E. 2552(2009)]
Viet Nam	With regards to waste management, there have been definitions on different terms on waste and 3R such as: waste; scraps; discarded products; waste management and waste reuse, and recycling. These terms have been defined by the following legislations: - Law on Environmental Protection 2014 (LEP 2014); - Decree 38and2015andND-CP on waste and scrap management; - Decision 16and2015andQD-TTg on take-back and treatment of discarded products; - Circular 36and2015andTT-BTNMT on management of hazardous waste; - Inter-ministerial Circular 58and2015andTTLT-BYT-BTNMT on medical waste management. Based on a review of existing legislation it has been observed that **there is no clear definition of municipal solid waste (MSW)** in Viet Nam as is usually defined in other countries. Instead, **waste** has been classified into: (i) ordinary (non-hazardous) and; (ii) hazardous and can also be categorized as household and domestic, industrial or medical. In the national environment reports, however, the MSW has also been mentioned and

Country	Definition of Waste and Solid Waste
	addressed although there is not any clear definition. It is understood **unofficially** that **MSW** means waste generated from the urban area and includes: domestic and household waste; street waste; construction and demolition (C&D) waste; generated waste from office, hospital, industries, markets in the urban area. More often used is the concept of urban domestic waste (UDW), which means waste generated from urban households. It is estimated that the UDW accounts for around 60-70 percent of MSW in Viet Nam (MONRE, 2011).
Sri Lanka	**Municipal solid waste:** The discarded materials, substances or objects which originate (or refuse) from domestic, business and industrial sources, including household wastes which are typically disposed of in municipal type landfills, but not including industrial hazardous or 'special wastes'. **Agricultural waste:** Agricultural wastes are of two types, namely farm sector wastes and agricultural process wastes. Farm sector wastes are generated post harvest in the farm such as cotton stems, cereal straw etc; Process wastes are generated in the processing of agricultural produce such as bagasse from sugar mills, rice husk from rice mills, saw dust from saw mills, cotton fibre process waste from cotton fibre mills etc; **Special wastes:** Wastes (not hazardous) that require special handling considerations during disposal.
Nepal	"**Solid Waste**" means domestic waste, industrial waste, chemical waste, health institution related waste or harmful waste and this word shall also mean the materials which cannot be used presently, thrown away or in rotten stage or in solid, liquid, gaseous, thick liquid, smoke, or dust form emitted out damaging the environment or materials and equipments used for electrical or information technology or any other materials of such nature or posters, pamphlets posted unauthorized at public places or other substances prescribed as solid waste through publication of notice in the Nepal Gazette by the Government of Nepal from time to time.
Republic of Korea	"Waste" refers to substances unnecessary for residential, commercial, and industrial activities such as refuse, ashes, sludge, waste oil, waste acid and alkali, and carcasses. "Special waste" refers to sludge, waste oil, waste acid and alkali, waste rubber, and waste synthetic resins produced as a result of industrial and commercial activities. The Presidential Decree specifies these substances as detrimental to the environment and public health.
Pacific Island Countries	There is no generic consistent definition of wastes in most Pacific Island regulations, policies and strategy documents. The first Solid Waste Management Strategy for the Pacific Region (SPREP, 2005) defines solid waste as any solid or semi-solid garbage, refuse or rubbish, sludge and other discarded material including any contained liquid or gaseous material remaining from industrial, commercial, institutional activities and residential or community activities.

Hazardous Waste Generation and Disposal

The data from Basel Convention website and "State of 3R" reports from 2013 to 2022 indicate that many countries in Asia and the Pacific have enacted regulations on hazardous waste management. This includes both the definition and quantities. The Basel Convention, which has been ratified by most of Asian countries, defines hazardous waste as the category of wastes listed in Annex I of the Convention and exhibits one of the hazardous characteristics contained in Annex III such as possessing explosive, flammable, toxic or corrosive properties. Annex VIII also lists typical hazardous wastes. However, the classification of hazardous waste varies and difficult to compare uniformly. This individual classification depends on issues faced by each country for example polychlorinated biphenyl (PCB) in Japan. Though, latest datasets are yet to be updated on Basel Convention website, the comparison is difficult to make based on individual report of each country. Some countries such as Bangladesh, Cambodia and Pacific Island Countries do not have specific legislation, but follow Basel Convention guidance in their efforts to manage and treat hazardous waste. **Table 3.4.1-3** gives a snapshot of the quantities of hazardous waste.

Table 3.4.1-3: Amount of Hazardous Waste Generation. Source: (UNCRD et al., 2018b)

Country	Waste type	Data (year)	Reference
Bangladesh	Hazardous Industrial Waste (textile, hospital clinics, tannery, pesticides, fertilizer, oil refinery and paper and pulp)	(actual data in 2008) 109,470,000 m^3 (Wastewater) 113,000 tonne, (sludge) 26,884 tonne (solid waste) (estimation 2025) 2,472,470,000 m^3 (Wastewater) 2,810,000 tonne, (sludge) 53,874 tonne (solid waste)	Waste concern and ADB, 2008
	Medical Waste (infectious waste, sharp waste, recyclable waste, other)	2,720 kg (2008) 1,448 kg (2007) 426 kg (2006) 56kg (2005)	PRISM Bangladesh, 2009
Cambodia	Hazardous waste	11,000 m^3 (2011) 74,948 m^3 (2010)	DoPC (2011),
PR China	industrial waste generated as a by-product	31,570,000 tonne (2013)	PR China Statistical Yearbook
		34,652,400 tonne (2012)	
		34,312,200 tonne (2011)	
		15,870,000 tonne (2010)	
		14,300,000 tonne (2009)	
		13,570,000 tonne (2008)	
		10,790,000 tonne (2007)	
		10,840,000 tonne (2006)	
		11,620,000 tonne (2005)	
		9,950,000 tonne (2004)	
		11,700,000 tonne (2003)	
		10,000,000 tonne (2002)	
		9,520,000 tonne (2001)	
		8,300,000 tonne (2000)	
	Hazardous waste	63,586,235 tonne (2018) 70,146,300 tonne (2019)	Reporting Dashboard, Basel Convention
	Other waste generated	639,260 tonne (2018) 670,671 tonne (2019)	Reporting Dashboard, Basel Convention
India	Hazardous Waste	42795785.16 tonne (2020-2021) 7,467,000 tonne (2016) 6,232,507 tonne (2009) 7,243,750 tonne (2000)	CPCB Bulletin Vol.- I, July 2016, Govt. of India National Inventory of HW Generating Industries and HW Management in India, CPCB, 2009 Report of MoEF 2000
Indonesia	Hazardous Waste	65,970,612 tonne (2012) 50,000,000 tonne has been treated for three years after 2011	Press Release of Ministry of Environment (June 18, 2013), regarding the amount of hazardous waste treated
Japan	Specially controlled industrial waste	In total 2,261,000 (2012)	Data obtained from the Office of

Country	Waste type	Data (year)	Reference
		2,490,000 (2013) 2,821,000 (2014) Among them waste oil : 468,000 tonne (2012) 413,000 tonne (2013) 410,000 tonne (2014) waste acid : 467,000 tonne (2012) 533,000 tonne (2013) 606,000 tonne (2014) waste alkali : 241,000 tonne (2012) 293,000 tonne (2013) 390,000 tonne (2014) infectious industrial waste : 349,000 tonne (2012) 347,000 tonne (2013) 450,000 tonne (2014) Specific hazardous industrial wastes14 : 735,000 tonne (2012) 903,000 tonne (2013) 965,000 tonne (2014)	Sound Material Cycle Society, MoEJ
Malaysia	Heavy metal sludge, fly and	1,387,861 tonne (2013)	DOE Environment Report and Annual Report 2000 to 2012
	bottom ash, gypsum, glue,	1,708,708 tonne (2012)	
	petroleum, waste containing	1,659,537 tonne (2011)	
	formaldehyde, discarded	1,880,928 tonne (2010)	
	pharmaceutical product, ash of	1,705,308 tonne (2009)	
	paper sludge, spent mixed oil	1,304,899 tonne (2008)	
		1,138,839 tonne (2007)	
		1,103,457 tonne (2006)	
		548,916 tonne (2005)	
		469,584 tonne (2004)	
		460,865 tonne (2003)	
		363,071 tonne (2002)	
		420,198 tonne (2001)	
		344,550 tonne (2000)	
	Clinical Waste	19,500 tonne (2013) 18,100 tonne (2012) 17,800 tonne (2011) 16,800 tonne (2010) 16,600 tonne (2009)	ENVIRON Australia Pty Ltd, 2014
	Hazardous waste	2,355,085.21 tonne (2018) 4,013,189.03 tonne (2019)	Reporting Dashboard, Basel Convention
Pacific Island Countries	Healthcare waste	Average generation rate 0.8 (kgand occupied bedandday) in all Pacific islands Total estimation 76 tonne as	ENVIRON Australia Pty Ltd, 2014

Country	Waste type	Data (year)	Reference
		stock piled in all Pacific islands	
	Asbestos as asbestos containing materials such as cement water pipes, corrugated roof sheets, floor tiles, wall claddings, and insulation (e.g. boiler insulation)	285,784 m^2 and 267 m^3 of asbestos containing materials based on the pac waste estimation	Contract Environmental Ltd, Geoscience, 2015
The Philippines	Hazardous waste	833,174.9 tonne (2018) 1,712,505 tonne (2014) 8,976,959 tonne (2013) 780,523 tonne (2012) 4,979,340 tonne (2011) 1,346,506 tonne (2010)	Extracted from the Reports submitted by the EMB Regional Offices to DENR, Reporting Dashboard, Basel Convention
	Other waste	69.61 tonne (2018)	Reporting Dashboard, Basel Convention
Singapore	Toxic Industrial Waste (spent acids, spent solvents, spent etchants, waste oil and other waste sludge) Hazardous waste	1,136,240 m^3 (2014) 1,142,000 m^3 (2010)	NEA
	Hazardous waste	538,394 tonne (2018) 450,000 tonne (2019)	Reporting Dashboard, Basel Convention
	Other waste	3,160,000 tonne (2018) 3,150,000 tonne (2019)	Reporting Dashboard, Basel Convention
Thailand	Industrial hazardous waste,	2,065,000 tonne (2014) 2,690,000 tonne (2013) 2,810,000 tonne (2012)	PCD, MONRE, 2015
	Municipal hazardous waste	567,000 tonne (2014) 560,000 tonne (2013) 710,000 tonne (2012)	PCD, MONRE, 2015
	Infectious waste	52,000 tonne (2014) 50,000 tonne (2013) 40,000 tonne (2012)	PCD, 2015
	Other waste	27,000,000 tonne (2017)	Reporting Dashboard, Basel Convention
Viet Nam	Collected and treated hazardous waste which can be classified into 19 categories.	320,275 tonne (2014) 186,657 tonne (2013) 165,624 tonne (2012)	Hien et al, 2015
	Hazardous waste	800,000 tonne (2017)	Reporting Dashboard, Basel Convention
Bhutan	Other waste generated	521,736 tonne (2018)	Reporting Dashboard, Basel Convention
Afghanistan	Hazardous waste Generated	300 tonne (2016)	Reporting Dashboard, Basel Convention
Kyrgyzstan	Hazardous waste Generated	183,786,700 tonne (2018) 152,988,100 tonne (2019)	Reporting Dashboard, Basel Convention
	Other waste Generated	4,677,909 tonne (2018) 6,053,600 tonne (2019)	Reporting Dashboard, Basel Convention
Republic of	Hazardous waste Generated	994.5 tonne (2019)	Reporting

Country	Waste type	Data (year)	Reference
Korea			Dashboard, Basel Convention

Overall Assessment
Trends indicate positive movement towards policy and regulatory regime formulation, implementation and monitoring of the waste value chain in the region. This trends is reflected in **Table 3.4.1-4.**

Table 3.4.1-4: Specific policies and regulations (2018 to 2021). Source: (UNCRD et al., 2018b)

Sr. No.	Country	Municipal Solid Waste	Hazardous Waste Management	Emerging and Other waste stream (Metal, Construction waste, e-waste etc.)	
				E-waste	Agricultural Biomass
1	Afghanistan		Yes - Related		
2	Bangladesh	Yes - Related	Yes - Related	Yes - Related	Yes - Related
3	Bhutan	Yes - Related	Yes - Related	Yes - Related	
4	Cambodia	Yes - Related	Yes - Related	Yes - Related	Yes - Related
5	Cook Islands	Yes - Related	Yes - Related	Yes - Related	
6	Federated States of Micronesia	Yes - Related	Yes - Related	Yes - Related	Yes - Related
7	India	Yes - Related	Yes - Related	Yes - Related	Yes - Related
8	Indonesia	Yes - Related	Yes - Related	Yes - Related	Yes - Related
9	Japan	Yes - Related	Yes - Related	Yes - Related	Yes - Related
10	Kiribati	Yes - Related	Yes - Related	Yes - Related	
11	Kyrgyzstan	Yes - Related	Yes - Related		Yes - Related
12	Lao PDR	Yes - Related	Yes - Related	Yes - Related	Yes - Related
13	Malaysia	Yes - Related	Yes - Related	Yes - Related	Yes - Related
14	Marshall Islands	Yes - Related	Yes - Related		
15	Mauritius	Yes - Related	Yes - Related	Yes - Related	
16	Mongolia	Yes - Related	Yes - Related	Yes - Related	
17	Myanmar	Yes - Related	Yes - Related	Yes - Related	Yes - Related
18	Nauru	Yes - Related			
19	Nepal	Yes - Related	Yes - Related	Yes - Related	Yes - Related
20	Pakistan	Yes - Related	Yes - Related	Yes - Related	Yes - Related
21	Palau	Yes - Related			
22	Philippines	Yes - Related	Yes - Related	Yes - Related	Yes - Related
23	Republic of Korea	Yes - Related	Yes - Related	Yes - Related	Yes - Related
24	Russian Federation	Yes - Related	Yes - Related	Yes - Related	Yes - Related
25	Singapore	Yes - Related	Yes - Related	Yes - Related	
26	Solomon Islands	Yes - Related	Yes - Related	Yes - Related	
27	Sri Lanka	Yes - Related	Yes - Related	Yes - Related	Yes - Related
28	Thailand	Yes - Related	Yes - Related	Yes - Related	Yes - Related
29	Timor Leste	Yes - Related			

Sr. No.	Country	Municipal Solid Waste	Hazardous Waste Management	Emerging and Other waste stream (Metal, Construction waste, e-waste etc.)	
				E-waste	Agricultural Biomass
30	Tonga	Yes - Related	Yes - Related	Yes - Related	Yes - Related
31	Tuvalu	Yes - Related	Yes - Related	Yes - Related	Yes - Related
32	Vietnam	Yes - Related	Yes - Related	Yes - Related	Yes - Related
33	PR China	Yes - Related	Yes - Related	Yes - Related	Yes - Related
34	Australia	Yes - Related	Yes - Related	Yes - Related	
35	Fiji	Yes - Related	Yes - Related		
36	Maldives	Yes - Related	Yes - Related	Yes - Related	
37	Papua New Guinea	Yes - Related	Yes - Related		
38	Samoa	Yes - Related	Yes - Related		
39	Vanuatu	Yes - Related			
40	Brunei Darussalam	Yes - Related	Yes - Related		

Some of the emerging trends from the **Table 3.4.1-4** are given below.

- The majority of countries have specific policies and regulations for municipal solid waste management.
- The majority of countries have specific policies and regulations for Hazardous waste management.
- The majority of countries have specific policies and regulations for emerging waste streams particularly E-waste management. While Afghanistan, Kyrgyzstan, Marshall Island, Nauru, Palau, Timor Leste, Fiji, Papua New Guinea, Samoa, Vanuatu, and Brunei Darussalam are the countries that have not reported for the period of 2018 to 2021.
- The majority of countries have specific policies and regulations for Agricultural Biomass management.

Existence of Policies, Guidelines, and Regulations Based on the Principle of Extended Producer Responsibility (EPR) (Indicator VIII)

Extended Producer Responsibility (EPR) is considered as one of major policy approaches to promote take-back and recycling of end-of-life products that are usually considered difficult to be treated and managed by municipalities, including used plastic and paper containers, electronic wastes and batteries and other waste stream.

It is based on "Polluter Pays Principle" is defined by OECD as "an environmental policy approach in which a producer's responsibility for a product is extended to the post-consumer stage of a product's life cycle". Therefore, the both physical and financial responsibility for managing waste shifts to producer. Goal 15 of Ha Noi 3R Declaration emphasizes that "Progressive implementation of 'extended producer responsibility' by encouraging producers, importers and retailers and other stakeholders to fulfill their responsibilities for collecting, recycling and disposal of new and emerging waste streams, in particular e-waste". Combining various instruments, EPR-based legislation aims at achieving at least one of the following three distinct objectives:

1) Improved waste management and resource recovery

2) Changing allocations of cost for waste management and recycling
3) Design for the environment

Table 3.4.1-5 describes EPR based policies and regulations (2018-2021) and Important policies or programmes or projects or master plan (2018-2021).

Table 3.4.1-5: EPR Specific policies and regulations (2018-2021) and Important policies and programmes and projects and master plan (2018-2021). Source: (UNCRD et al., 2018b)

Sr. No	Country	Specific Policies and Regulations (Q1)	Important Policies and Programmes and Projects and Master Plan (2018-2021)
1.	Bangladesh		Yes - Related
2.	Bhutan	Yes - Related	Yes - Related
3.	Cook Islands	Yes - Related	Yes - Related
4.	India	Yes - Related	Yes - Related
5.	Indonesia	Yes - Related	Yes - Related
6.	Lao PDR	Yes - Related	
7.	Malaysia	Yes - Related	Yes - Related
8.	Mauritius	Yes - Related	Yes - Related
9.	Mongolia	Yes - Related	Yes - Related
10.	Nauru		Yes - Related
11.	Pakistan		Yes - Related
12.	Palau	Yes - Related	Yes - Related
13.	Philippines		Yes - Related
14.	Republic of Korea	Yes - Related	
15.	Russian Federation	Yes - Related	Yes - Related
16.	Singapore	Yes - Related	Yes - Related
17.	Solomon Islands	Yes - Related	
18.	Sri Lanka	Yes - Related	Yes - Related
19.	Thailand	Yes - Related	Yes - Related
20.	Tuvalu	Yes - Related	Yes - Related
21.	Vietnam	Yes - Related	
22.	PR China	Yes - Related	Yes - Related
23.	Australia	Yes - Related	Yes - Related
24.	Maldives	Yes - Related	Yes - Related

The approach to implement i.e. “Voluntary” or Regulatory for a particular waste stream is given in **Table 3.4.1-7.** About 11 countries and 1 sub region have implemented EPR based regulation. Japan leads the implementation of EPR based policy in the region followed by Korea, PR China, Malaysia, Indonesia and India. For example, PR China introduced the Rules on the Administration of the Recovery and Disposal of Discarded Electronics and Electrical Products (promulgated in 2009, effective in 2011). India introduced E-waste management and Handling Rules (promulgated in 2010, effective in 2012, revised in 2016, 2018 and 2022). Vietnam targets batteries, electronics, lubricant oils, tyre and end-of-life vehicles. Thailand has a WEEE policy as a part of National Integrated Strategies approved by the cabinet on 24 July 2007. **Table 3.4.1-6** describes the status of implementation of EPR-based legislations and policies in the selected countries in Asia and the Pacific.

Table 3.4.1-6: Status of implementation of EPR-based legislations and policies in the selected countries in Asia and the Pacific. Source: (UNCRD et al., 2018b)

Country	Fully implemented	Postponement period before full implementation	Specific legislations are under preparation	Existence of provisions supporting EPR principle	Based on voluntary approachand agreement
Bangladesh	National 3R Strategy 2010	--	--	Lead Acid Battery Recycling and Management Rules 2006	--
PR China	WEEE regulation (E. 2009, FI 2011) Recycling technology policy of automobile (E. 2006) Recycling method of scrap cement bag (E. 1989)			The 12th 5-year plan Law of prevention and control of environmental pollution caused by solid waste (E. 1995) Law of cleaner production promotion (E. 2003) The law of circular economy promotion (E. 2008)	
India	E-waste Management Rules (IT products and home appliances, E. 2011 revised in 2016, 2018 and 2022) Guidelines for environmentally sound management of ELV, 2016	--	Specific legislations on environmental ly sound management of ELVs are under preparation	E-waste Management Rules revised in 2016, 2018 and 2022) Guidelines for environmentally sound management of ELV, 2016 Batteries (Management and Handling) Amendment Rules, 2010 (lead acid batteries, E. 2010).	--
Japan	Law for promotion of effective utilization of resources (Revised 2000, FI. 2001) Container and packaging recycling act (E.1995. FI. 2000) Home appliance recycling act (E.	--	--	Basic Act for Establishing Sound Material Cycle Society	voluntary take-back under Law for promotion of effective utilization of resources

Country	Fully implemented	Postponement period before full implementation	Specific legislations are under preparation	Existence of provisions supporting EPR principle	Based on voluntary approachand agreement
	1998, FI. 2001) End-of-life vehicles recycling act (E. 2000, FI. 2005)				
Indonesia	--	GP101and2014 (Packaging) under Law 18and2008	Governmental regulation (E-waste) under Law 39and2009	Law on Rubbish Management (Law No. 18, 2008) "Article 15. Producers shall manage the produced package and products which could not decompose or difficult to decompose by natural process."	--
Malaysia	-- .	--	DOE and JICA has initiated another TC project from August 2015 through January 2018 to develop nationwide regulatory framework and the mechanism to channelize the household E-waste to the formal collection and recycling.	Environmental Quality Act (1974), Solid Waste and Public Cleansing Act (2007), Master Plan of National Waste Minimization (2006), 10th Malaysian Plan (2011)	National Strategic Plan for Solid Waste Management (2002)
The Philippines	-- .	--	The guidelines on the Environmen-tally Sound Management (ESM) of Waste Electrical and Electronic Equipment (WEEE)	--	Philippine Energy Efficiency Project (2009-2013) Lighting Industry Waste Management Guidelines (2013)
Singapore	--	--	EPR concept in the management of e-waste by 2021	--	Singapore Packaging Agreement (2007)

Country	Fully implemented	Postponement period before full implementation	Specific legislations are under preparation	Existence of provisions supporting EPR principle	Based on voluntary approachand agreement
Thailand	--	--	The draft act on the management of WEEE and other end-of-life products approved by cabinet on 19 May 2015 and on process of enactment and promulgation The draft Royal decree on product fees from used products e.g. electronic waste under draft Act on Economic Instruments for Environ- mental Management	The national integrated strategic 5 years plan (2014-2021) on management of WEEE approved by cabinet on 17 March 2015	WEEE Can Do campaign (2011-2012)
Viet Nam	--	16and2015andQD-TTg (batteries, electronics, lubricant oils and end-of-life vehicles)	Guiding circular is being developed	Law on Environmental Protection 2014	--
Pacific Island Countries	Container deposit legislation (Kiribati, FSM, New Caledonia, and Palau)	--	--	--	Informal agreement with a breweryand bottling company.
Bhutan	E-waste management (Waste prevention and management regulation 2012) Ozone regulation, 2008	--	--	--	--
Russian Federation	EPR,	--	--	Prohibition of Land filling	Liscensing of waste management activities
Republic of Korea	Act on “Resource Recirculation of electrical and electronic waste and End of life	--	--	Act on “Promotion on saving and recycling of Resources”	--

Country	Fully implemented	Postponement period before full implementation	Specific legislations are under preparation	Existence of provisions supporting EPR principle	Based on voluntary approachand agreement
	Vehicles"				
Sri Lanka	--	--	EPR Concept approved	--	--

E: Enactment year. FI: Fully implemented year

--.: Either policy does not exist or not under preparation as of September 2016

Note— voluntary approach and agreement shown in this Table is not an exhaustive list

Key Issues

Some of key issues associated with EPR adoption in emerging countries are overcoming constraints related to: (i) Physical responsibility i.e. collection, transportation, treatment and disposal of waste (ii) Financial responsibility i.e. type of instrument, where and when applicable and how much (iii) Infrastructure for treatment and disposal (iv) Development of ecosystem for waste value chain (v) Readiness of brands to adopt it (vi) transparent monitoring and reporting of the ecosystem.

The majority of countries have planned to develop specific policies and regulations regarding EPR for the period 2018 to 2021. However, countries like Afghanistan, Bangladesh, Cambodia, Federated States of Micronesia, Kiribati, Kyrgyzstan, Marshall Islands, Myanmar, Nauru, Nepal, Pakistan, Philippines, Timor Leste, Tonga, Fiji, Papua New Guinea, Samoa, Brunei Darussalam and Vanuatu have not reported for the year 2018 to 2021.

3.4.2 Nationally Implemented 3R- Related Programmes, Projects and Master Plans

Almost all the countries have planned to develop policies and master plans for Municipal Solid waste management for the year 2013 to 2021. The majority of countries have planned to develop master plans or plans or strategies for hazardous waste management for the period 2018 to 2021. However, countries like Afghanistan, Cambodia, Malaysia, Marshall Islands, Palau, Republic of Korea, Timor Leste, Vietnam, and Vanuatu have not reported for the year 2018 to 2021. The majority of countries have planned to develop Policies for E-waste management for the period 2018 to 2021. However, countries like Afghanistan, Cambodia, Indonesia, Kiribati, Kyrgyzstan, Marshall Islands, Mauritius, Mongolia, Nepal, Palau, Republic of Korea, Solomon Islands, Timor Leste, Vietnam, Fiji, Papua New Guinea, Samoa, Brunei Darussalam, and Vanuatu have not reported for the year 2018 to 2021. **Table 3.4.2-1** shows the status of programmes or projects and master plans from 2018-2021.

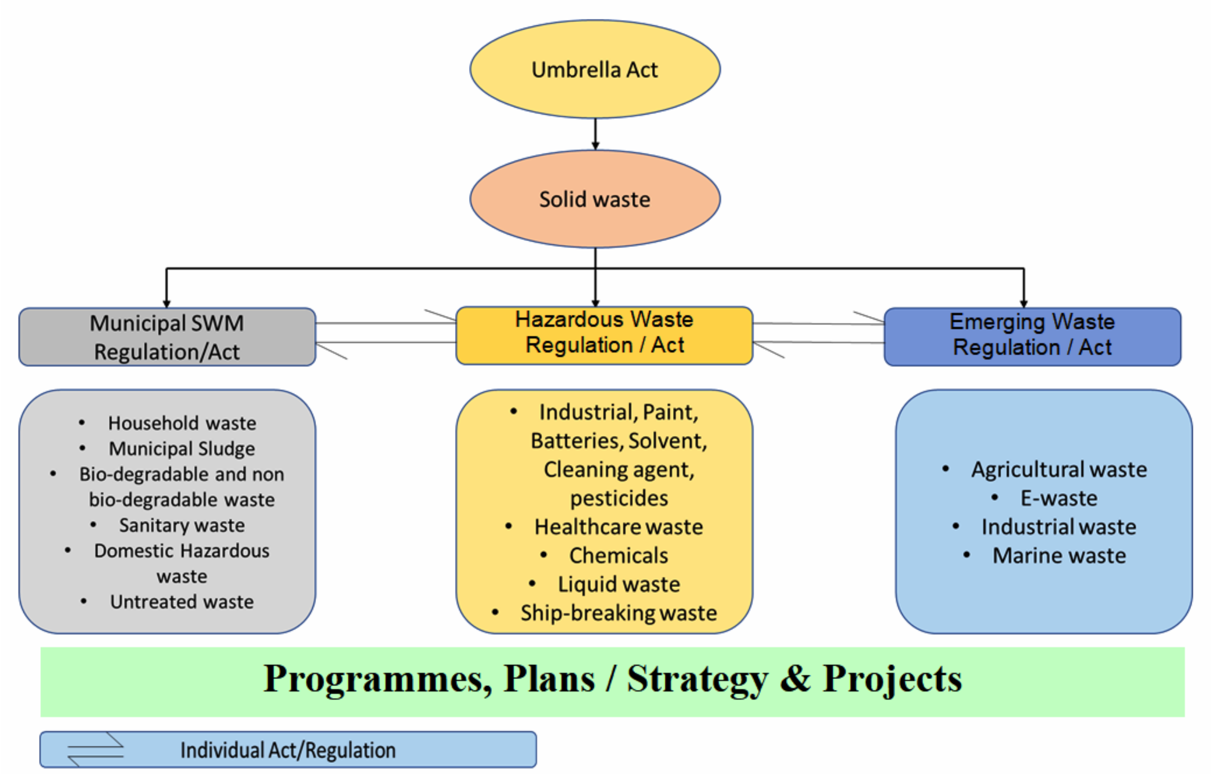

Figure 3.4.2-1: Overall Waste Management Eco System. Source (UNCRD et al., 2018b)

Table 3.4.2-1: Resource Efficiency and resource productivity Specific policies and regulations (2018-2021) and Important policies and programmes and projects and master plan (2018-2021). Source (UNCRD et al., 2018b).

Sr. No.	Country	Specific Policies and regulations (Q 1)	Important policies and programs and projects and master plan (2018-2021)
1.	Afghanistan	Yes - Related	
2.	Bangladesh	Yes - Related	Yes - Related
3.	Bhutan		Yes - Related
4.	Cambodia	Yes - Related	Yes - Related
5.	Cook Islands	Yes - Related	Yes - Related
6.	India	Yes - Related	Yes - Related
7.	Indonesia	Yes - Related	Yes - Related
8.	Japan	Yes - Related	Yes - Related
9.	Kiribati	Yes - Related	
10.	Kyrgyzstan	Yes - Related	
11.	Lao PDR	Yes - Related	Yes - Related
12.	Malaysia	Yes - Related	Yes - Related
13.	Marshall Islands	Yes - Related	
14.	Mauritius	Yes - Related	Yes - Related
15.	Mongolia	Yes - Related	Yes - Related
16.	Myanmar	Yes - Related	Yes - Related
17.	Nauru		Yes - Related
18.	Nepal	Yes - Related	
19.	Pakistan	Yes - Related	Yes - Related
20.	Palau		
21.	Philippines	Yes - Related	Yes - Related
22.	Republic of Korea	Yes - Related	Yes - Related
23.	Russian	Yes - Related	Yes - Related

Sr. No.	Country	Specific Policies and regulations (Q 1)	Important policies and programs and projects and master plan (2018-2021)
	Federation		
24.	Singapore	Yes - Related	Yes - Related
25.	Solomon Islands	Yes - Related	
26.	Sri Lanka		Yes - Related
27.	Thailand	Yes - Related	Yes - Related
28.	Vietnam	Yes - Related	Yes - Related
29.	PR China	Yes - Related	Yes - Related

The majority of countries have planned to develop specific policies and regulations regarding Resource Efficiency and resource productivity for the period 2018 to 2021. However, countries like Bhutan, Federated States of Micronesia, Nauru, Palau, Sri Lanka, Timor Leste, Tonga, Tuvalu, Australia, Fiji, Maldives, Papua New Guinea, Samoa, Brunei Darussalam and Vanuatu have not reported for the year 2018 to 2021.

3.4.3 Waste Management System Trends

The majority of countries have planned to develop master plans or plans or strategies for Agricultural biomass management for the period 2018 to 2021. However, countries like Afghanistan, Cambodia, India, Kiribati, Malaysia, Marshall Islands, Mongolia, Palau, Republic of Korea, Singapore, Solomon Islands, Timor Leste, Australia, Fiji, Maldives, Papua New Guinea, Samoa, Brunei Darussalam, and Vanuatu have not reported for the year 2018 to 2021.

The majority of countries have planned to develop important policies or programmes or projects or master plans regarding Resource Efficiency and resource productivity for the period 2018 to 2021. However, countries like Afghanistan, Federated States of Micronesia, Kiribati, Kyrgyzstan, Marshall Islands, Nepal, Palau, Solmon Islands, Timor Leste, Tonga, Tuvalu, Australia, Fiji, Maldives, Papua New Guinea, Samoa, Brunei Darussalam and Vanuatu have not reported for the year 2018 to 2021.

At institutional level, urban local bodies (ULBs) as well as private sector (formal and informal) are involved in collection, transportation, treatment and disposal of MSW in Asia and the Pacific region. Plan, program and projects are formulated by both nodal ministry and as well as local governments (ULBs) in respective country. An analysis of the solid waste institutional structure indicates that multiple agencies both at national and city level with strong presence of informal sector further exacerbate the existing regulatory compliance and management (segregation, treatment and disposal) issues in the region.

An example of policy formulation and financial instrument used for implementation is given in **Box 3.4.3-1**. An example of the fee based system on plastic bag in a developing country is given in **Box 3.4.3-2.**

Box 3.4.3-1: Plastic resource management policy, Japan

The Cabinet of Japan approved the Bill for the Act on Promotion of Resource Circulation for Plastics on March 9, 2021. The bill was submitted to the 204th ordinary Diet session and passed by the House of Representatives on May 21, 2021. The significance of further advancing the reusing of plastic assets in Japan is expanding because of the marine plastic waste issue, environmental change issues, and the fixing of waste import guidelines in different nations. Considering this, this bill plans to go to lengths to advance the reusing of plastic assets by all elements all through the existence pattern of plastic items, from their plan to Waste disposal. The following are the key points of policy Environment-friendly design that contributes to the reduction of plastic waste and its recycling

- Rational use of single-use plastics
- Sorted collection, voluntary collection, and recycling of plastic waste, etc.
- Guidelines for an environment-friendly design that manufacturers should try for and set up a system to certify the design.
- Decision criteria on which providers of single-use plastics (e.g., retailers and service providers) should work.
- Promotion of sorted collection and recycling by municipalities
- Promotion of voluntary collection by manufacturers and sellers
- Promotion of Discharge Control and Recycling of Plastic Waste by Business Operators

Japan has put forth attempts to eliminate plastic waste since it ordered a regulation in 1991 that put the obligation regarding reusing bundling on organizations. However, that may be going to change. In the year 2020, the Japanese government presented an obligatory expense of somewhere in the range of 3 and 5 yen (3 to 5 pennies) for every plastic sack, matching a move that has previously been made in the UK and the US.

The occupants of Kamikatsu in southern Japan, a town with a populace of 1,490, have been following a "zero-squander" strategy starting around 2003. The plan expects to focus on squander anticipation by teaching purchasers to put resources into reusable family things. Bigger cities are also trying to cut down on waste. In 2018, Kameoka city in Kyoto prefecture became the first Japanese city to announce plans to ban single-use plastics with a view to ending their use by 2030, according to a spokesman from the city's council.

Box 3.4.3-2: Fee on Plastic bags, Philippines

The Philippine Ecological Solid Waste Management Act of 2000, otherwise known as Republic Act 9003 (RA 9003) calls for a decentralized waste management system, at-source waste segregation, and regular segregated waste collection. The City of San Fernando in Pampanga is one of a handful of the city to have effectively implemented, with the direction of GAIA part Mother Earth Establishment, an NGO advancing Zero Waste.

In 2014, seeing that plastic bags were a major challenge in waste management, the city passed the Plastic-Free Ordinance of 2014. Executed by the City Climate and Regular Assets Office (CENRO), the statute expects to control the utilization of plastic sacks and polystyrene and energize the utilization of reusable packs with a unique spotlight on foundations, establishments, retailers, and families. They started with Plastic-Free Fridays. For three months, stores were prohibited from providing their customers with free plastic bags and polystyrene (styro) materials for their purchases every Friday. They charged customers PHP 4.00 (US$ 0.08) per plastic bag and PHP 1.00 (US$ 0.02) per paper bag regardless of size. For the next six months, plastic bags were no longer free, though still available for a fee. When the six months lapsed, the city prohibited all plastic bags and polystyrene packaging. Businesses found to be in violation of the ordinance were penalized for the first offense: a warning and compulsory attendance to a values formation seminar; for the second offense: a fine of PHP 1,000 (US$ 20); for the third offense, a fine of PHP 3,000 (US$ 60); and for the fourth and succeeding offenses: cancellation of business permit to operate.

The city likewise coordinated data drives to energize resident investment. They additionally offered reusable shopping sacks during exercises and occasions, coordinated rivalries on planning reusable packs, and facilitated television programs advancing Zero Waste.

References Chapter 3.4

UNCRD. (2018b). *Regional 3R Forum in Asia and the Pacific: State of 3Rs in Asia and the Pacific*. United Nations Centre for Regional Development. https:andandwww.uncrd.or.jpandcontentanddocumentsand6777[full%20document]%20State%20of%20the%203Rs%20in%20Asia%20and%20the%20Pacific.pdf

3.5 Key Messages: Chapter 3

Most countries have specific 3R policies or programs and projects in some form addressing the reduction in the quantity of MSW (Ha Noi Goal 1). The policies have been translated into specific regulations of municipal solid waste, which have been institutionalized at the national level to be implemented at the provincial and local levels. Though at the local level, participation of households in “source” segregation is low, trends indicate that more countries are approaching the “average to high” level (Ha Noi Goal 2).

The recycling rate of different items like paper, plastics, metal, construction waste, E-waste, and other waste streams show marked variation from “Poor” to “Very High” (Ha Noi Goal 13). Most countries systematically classify hazardous waste (Ha Noi Goal 9). Most countries have specific rules and regulations introduced to separate, store, treat, transport, and dispose of hazardous waste. Most countries have not quantified the amount of agricultural biomass and livestock waste grossly generated per annum (Hanoi Goal 11).

The majority of countries have policies to address the issue of plastic waste in the coastal and marine environments (Hanoi Goal 12). The majority of countries have addressed **the** issue of plastic waste as part of integrated coastal zone management. Several countries are adopting specific policies and regulations to manage E-waste through EPR schemes (Hanoi Goal 15). Most countries in the region have addressed climate mitigation in waste management policies, plans, and programs as part of national communication to UNFCCC (Hanoi Goal 18).

Chapter 4: Experts' Assessment of Policy Readiness for Related Ha Noi 3R Goals and Progress at National Level

A comprehensive overview of the progress achieved by participating countries of the Regional 3R and Circular Economy Forum in Asia and the Pacific on the Ha Noi 3R Goals (2013-2023) has been carried out at national level and regional level which find expression in existing and emerging waste management systems including 3Rs policies and practices, implementation of the circular economy.

4.1 Analysis of Progress of 3R Goals at National Level

The analysis of 3RGs at the national level during the timeframe of Ha Noi Sustainable 3R Goals from 2013 to 2023 is analyzed in **Table 4.1-1** and their status is depicted in **Table 4.1-2** as the submission of country reporting during the annual Regional 3R and Circular Economy Forum in Asia and the Pacific.

The majority of countries have reported subscription to 3Rs policy, programmes, projects and regulations related to twenty-two out of thirty-three 3RGs.. It indicates that 3RGs has triggered significant impact on the 3R policy, regulatory and monitoring framework in the Asia and the Pacific region. The implementation of 3R policies has resulted in conceptualizing, developing and implementing programmes, plans and projects at national level.

3RG 1, 3RG 2 and 3RG 3 related to municipal solid waste and its sub streams for example paper, metal, organic waste and their recycling aspects are widely reported in the region. However, the recycling activities are involved in both formal and informal sector. Majority of countries have their specific 3R policies, programs and projects.. The policies have been emphasized into specific regulations of municipal solid waste, which have been institutionalized and implemented at national level.. The recycling practices exists in the region however, paper recycling exists in majority of countries and unfortunately plastic recycling facilities are poor in majority of countries.

Metal recycling and recovery facilities are significant and activate by both formal and informal sectors. However, the recycling facilities of construction waste are poor in most of the countries. The institutional and financial challenges are reported significantly followed by policy and technical challenges. Due to growing urban extent and urbanization in Asia and the Pacific region, there is a need of "push" to build sustainable and green cities.

Most of the countries in the region have vibrant industrial sector and reported their initiatives as per 3RG 6, 3RG 7, and 3RG 8. Majority of the countries have systematic classification of chemical and hazardous waste. However, some countries like Kiribati, Marshall Island, Mauritius, Mongolia, Nauru, Palau, Solomon Island, Timor-Leste and Tuvalu do not have the systematic classification of chemical and hazardous waste. Indeed, most of the countries have their specific rules and regulation to separate, store, treat, transport and dispose off their chemical and hazardous waste. In addition, the institutional, financial and technical challenges are significantly reported followed by their policies.

Almost all the countries acknowledge high relevance of 3RG 9 as their national policy. Similarly, majority of countries have undertaken steps for prevention of illegal export and import of hazardous waste as per 3RG 14. 3RG11 (agricultural biomass waste and livestock waste), 3RG 12(coastal and marine waste) and 3RG 13 (e-waste) have been classified as highly relevant goals in countries' national policies.

Majority of the countries have policies to make compost from the agricultural biomass waste. They have stated specific policies that were introduced for efficient utilization of agricultural biomass waste and livestock waste as secondary material inputs. Indeed, the institutional and financial challenges are reported significantly followed by lack of technologies. The majority of countries have policies to address the issue of particular plastic waste in coastal and marine environment, either as part of solid waste, individual waste stream or integrated coastal management zone. The e-waste recycling exists in countries in both sectors such as formal and informal sectors. The majority of countries recycle their E-waste under the recycling policies by taking to recycling center, taking to landfill and taking to the retailer though there is dominance of informal sector. Most countries have specific policies and regulations in place to ensure their peoples' health and safety aspects of who are involved in E-waste management system from sorting, resource recovery and recycling. . However, the significant policy, institutional and financial challenges are reported include the lack of technical challenge. Indeed, 3RG 15 is evolving across Asia-Pacific region. Most countries have enacted Extended Producer Responsibility (EPR) based legislations provided a list of products and product groups targeted nationally from 2018. However, the institutional, financial and policy challenges are reported as significant. Almost all the countries acknowledge high relevance of 3RG 15 as their national policy. 3RG 17 (resource efficiency and resource productivity) have introduced specific policies and guidelines for product standard including towards quality, durability, environment and eco-friendliness and labour standards in most of the countries. While, Cambodia is the only country which has introduced a master plans, plans or strategy for product standard from the year 2018.

The majority of countries have introduced specific energy efficiency schemes for production, manufacturing and service sector. Some countries like Bangladesh, Cambodia, Japan, Lao PDR, Mongolia, Myanmar, The Philippines, The Russian Federation, Sri Lanka and Thailand have introduced specific policies to create green jobs in product service and waste management sector. Most of the countries acknowledge high relevance of 3RG 17 as their national policy. 3RG 18 on co-benefits for local air, water, oceans, and soil pollution and global climate change have addressed climate mitigation in waste management policies and programmes for maximize the co-benefits. The policy and institutional challenges are reported to be significant followed by financial and technical challenge. All countries except Bhutan and Lao PDR which have taken limited initiatives. Majority of the countries have undertaken step to enhance knowledge base and research network on the 3Rs and resource efficiency, through facilitating effective and dynamic linkages among all stakeholders, including governments, municipalities, the private sector, and scientific communities as per 3RG 19. Similarly majority of countries have reported to undertake steps to strengthen multi-stakeholder partnerships among governments, civil society, and the private sector in raising public awareness and advancing the 3Rs, sustainable consumption and production, and resource efficiency, leading to the behavioural change of the citizens and change in production patterns according to 3RG 20.

Table 4.1-1: Overall Hanoi 3R Goal Wise Implementation in Asia and the Pacific Region. Source: (UNCRD et al., 2018a)

Goals No.	Description	Ranges	Name of Country (Example)	Specific Interventions (Examples)
Goal 1	Reduction in the Quantity of Municipal Solid Waste Generated	M – H	Japan Republic of Korea	Policy, Technical and Financial
Goal 2	Full-scale utilization of the organic component of municipal waste, including food waste, as a valuable resource, thereby achieving multiple benefits such as the reduction of waste flows to final disposal sites, reduction of GHG emission, improvement in resource efficiency, energy recovery, and employment creation.	M – H	Japan	Technical and Collection on Mechanism
Goal 3	Increasing Recycling Rate of Recyclables (e.g., plastic, paper, metal, etc.)	M – H	Japan	Recycling Industry
Goal 4	Build sustainable cities and green cities by encouraging "zero waste" through sound policies, strategies, institutional mechanisms, and multi-stakeholder partnerships (giving specific importance to private sector involvement) with a primary goal of waste minimization	M – H	Japan, Singapore and Republic of Korea	Private sector participation and PPP Model
Goal 5	Encourage the private sector, including small-and medium-sized enterprises (SMEs) to implement measures to increase resource efficiency and productivity, creation of decent work and to improve environmentally-friendly practices through applying environmental standards, clean technologies, and cleaner production.	M – H	India	Energy Efficiency program in SME. Make in India Program
Goal 6	Promote the greening of the value chain by encouraging industries and associated suppliers and vendors in socially responsible and inclusive ways.	L	Japan, Singapore, PR China Republic of Korea	Examples of Major retailers in the region
Goal 7	Promote industrial symbiosis (i.e., recycling of waste from one industry as a resource for another), by providing relevant incentives and support.	M – H	Indonesia	Waste Bank Programs
Goal 8	Build local capacity of both current and future practitioners, to enable the private sector (including SMEs) to obtain the necessary knowledge and technical skills to foster green industry and create decent, productive work.	L	Thailand, Vietnam, Cambodia	Cleaner Production Program
Goal 9	Inventory of Hazardous Waste	M – H	India	Implementation of Rules on Hazardous waste
Goal 10	Reduce losses in the overall food supply chain (production, post harvesting and storage, processing and packaging, distribution), leading to reduction of waste while increasing the quantity and improving the quality of products reaching consumers.	M – H		
Goal 11	Agricultural Biomass Waste Management	M – H	Vietnam	Regulation, Strategy and Plans
Goal 12	Eliminating Marine Plastics	M – H	Japan	Programs andI infrastructure to prevent marine litter
Goal 13	E-Waste Management	M – H	Japan	Policy, laws and recycling ecosystem
Goal 14	Effective enforcement of established mechanisms for preventing illegal and inappropriate export and import of waste, including transit trade, especially of hazardous waste and e-waste.	M – H	Japan	Policy, laws and recycling ecosystem
Goal 15	Implementation of Extended Producer Responsibility	M – H	Japan, Republic of Korea, India	Regulations
Goal 16	Promote the 3R concept in health-care waste management.	M – H	India	Regulations and Waste Management System
Goal 17	Improving Resource Efficiency and Resource Productivity	L-M	Japan, Republic of Korea	Policy, Regulation and Ecosystem
Goal 18	Co-benefits for Local Air, Water, Oceans, and Soil Pollution and Global Climate Change	M – H	Japan, Republic of Korea	Policy, Regulation and Ecosystem
Goal 19	Enhance national and local knowledge base and research network on the 3Rs and resource efficiency, through facilitating effective and dynamic linkages among all stakeholders, including governments, municipalities, the private sector, and scientific communities.	M – H	Japan, Republic of Korea, Singapore	Policy, Regulation and Ecosystem
Goal 20	Strengthen multi-stakeholder partnerships among governments, civil society, and the private sector in raising public awareness and advancing the 3Rs, sustainable consumption and production, and resource efficiency, leading to the behavioural change of the citizens and change in production patterns.	L	Singapore	Policy, Regulation Implementation and Ecosystem Development
Goal 21	Integrate the 3Rs in formal education at primary, secondary, and tertiary levels as well as non-formal education such as community learning and development, in accordance with Education for Sustainable Development.	M – H	Japan	Sapporo city elementaty and Junior High School effort of conversion food waste into compost
Goal 22	Integrate the 3R concept in relevant policies and programmes, of key ministries and agencies such as Ministry of Environment, Ministry of Agriculture, Forestry and Fisheries, Ministry of Industry, Ministry of Trade and Commerce, Ministry of Energy, Ministry of Water Resources, Ministry of Transport, Ministry of Health, Ministry of Construction, Ministry of Finance, Ministry of Labour, Ministry of Land and Urban Development, Ministry of Education, and other relevant ministries towards transitioning to a resource-efficient and zero waste society	L	Japan	Different ministries following 3R concept
Goal 23	Promote green and socially responsible procurement at all levels, thereby creating and expanding 3R industries and markets for environmentally-friendly goods and products.	M – H	India, Japan, Republic of Korea	Changesx in government procurement policies
Goal 24	Phase out harmful subsidies that favour unsustainable use of resources (raw materials and water) and energy, and channel the freed funds in support of implementing the 3Rs and efforts to improve resource and energy efficiency	L	Japan	Policy and Regulation
Goal 25	Protect public health and ecosystems, including freshwater and marine resources by eliminating illegal activities of open dumping, including	M – H	Major countries in the region	Implementation of MARPOL

Goals No.	Description	Ranges	Name of Country (Example)	Specific Interventions (Examples)
	dumping in the oceans, and controlling open burning in both urban and rural areas.			protocols
Goal 26	Facilitate the international circulation of re-usable and recyclable resources as well as remanufactured products as mutually agreed by countries and in accordance with international and national laws, especially the Basel Convention, which contributes to the reduction of negative environmental impacts and the effective management of resources.	L		
Goal 27	Promote data collection, compilation and sharing, public announcement and application of statistics on wastes and the 3Rs, to understand the state of waste management and resource efficiency.	M – H	Japan, Singapore, India	Public disclosure ex. websites, annual reports of ministries
Goal 28	Promote heat recovery (waste-to-energy), in case wastes are not re-usable or recyclable and proper and sustainable management is secured	M – H	PR China, Japan and India	Waste to energy and RDF Plants
Goal 29	Promote overall regional cooperation and multi-stakeholder partnerships based on different levels of linkages such as government-to-government, municipality-to municipality, industry-to-industry, (research) institute-to-institute, and NGO-to-NGO. Encourage technology transfer and technical and financial supports for 3Rs from developed countries to less developed countries.	L	NA	NA
Goal 30	Pay special attention to issues and challenges faced by developing countries including SIDS in achieving sustainable development.	L	NA	NA
Goal 31	Promote 3R + “Return” concept which stands for Reduce, Reuse, Recycle and “Return” where recycling is difficult due to the absence of available recycling industries and limited scale of markets in SIDS, especially in the Pacific Region.	L	Palau	Take back program
Goal 32	Complete elimination of illegal engagement of children in the informal waste sector and gradually improve the working conditions and livelihood security, including mandatory provision of health insurance, for all workers.	L	NA	NA
Goal 33	Promote 3Rs taking into account gender considerations.	L	NA	NA

Note: M – H: Medium to High Implementation; L – Low Implementation based on 3R Country Reports (2013-2023); NA – Data not Available

Table 4.1-2: Country wide Policy, Programs, Plans and Projects Implementation as per Ha Noi 3R in Asia and the Pacific Region. Source: (UNCRD et al., 2018a)

Sr. No.	Country	Goal – 1	Goal – 2	Goal – 3	Goal – 4	Goal – 5	Goal – 6	Goal – 7	Goal – 8	Goal – 9	Goal – 10	Goal – 11	Goal – 12	Goal – 13	Goal – 14	Goal – 15	Goal – 16	Goal – 17	Goal – 18	Goal – 19	Goal – 20	Goal – 21	Goal – 22	Goal – 23	Goal – 24	Goal – 25	Goal – 26	Goal – 27	Goal – 28	Goal – 29	Goal – 30	Goal – 31	Goal – 32	Goal – 33
1.	Bangladesh																																	
2.	Bhutan																																	
3.	Cambodia																																	
4.	Cook Islands																																	
5.	Federated States of Micronesia																																	
6.	India																																	
7.	Indonesia																																	
8.	Japan																																	
9.	Kiribati																																	
10.	Kyrgyzstan																																	
11.	Lao PDR																																	
12.	Malaysia																																	
13.	Marshall Islands																																	
14.	Mauritius																																	
15.	Mongolia																																	
16.	Nauru																																	
17.	Nepal																																	
18.	Pakistan																																	
19.	Palau																																	
20.	Philippines																																	
21.	Republic of Korea																																	
22.	Russian Federation																																	
23.	Singapore																																	
24.	Solomon Islands																																	
25.	Sri Lanka																																	
26.	Thailand																																	
27.	Tonga																																	
28.	Tuvalu																																	
29.	Vietnam																																	

Data not available and not applicable **Policies and Regulations Implementation**

4.2 Analysis of Progress of 3R Goals at Regional Level

The majority of the countries in Asia and the Pacific region shows medium to high reporting for twenty-two out of thirty-three 3RGs. Individual reporting of these goals shows the focus areas of the countries in the region as the submission of Country reporting during the annual Regional 3R and Circular Economy Forum in Asia and the Pacific.

The evaluation of country reports indicate that resource productivity is steadily improving in many countries as 3RG 17, but total waste generation and material consumption is increasing across the region as 3RG 1 and 3RG 17. Though policy and regulatory framework exist in the region its actual implementation of progress varies across countries, 3RG1, 3RG 3, 3RG 9. Most countries subscribe to Basel Convention and have policies and guidelines to address hazardous waste management as a national waste management priority, the gap remains in reporting of proper inventories, 3RG9.

The new and emerging waste issues such as E-waste management has been prioritized and a number of countries have started to apply EPR-based policies as per 3RG 13 and 3RG 15. Whilst marine and coastal plastic waste has been given increasing regional attention, concrete actions taken by national governments are limited in most countries, 3RG12 and 3RG 15. Several countries are advancing greenhouse gases mitigation efforts through landfill diversion and the use of intermediate waste treatment approaches. However, more innovative interventions are needed to ensure that co-benefits from the 3Rs are more effectively realized in the region, 3RG19.

The waste from agriculture biomass, 3RG 11 is not reported significantly, however, the recycling practice exists in rural areas of the region. The e-waste and marine plastic ecosystem, 3RG 12 and 3RG 13 are under transition in the region primarily due to recognition of the problems and diffusion of policies and regulation on extended producer responsibility, 3RG15. Majority of the countries are trying to evolve elements of EPR based regime by integrating into their existing umbrella act and regulation or individual waste stream regulations. The countries grapple with the issues associated with defining the products and its age, fixing the physical and regulatory responsibility, the waste management system particularly collection versus recycling targets, and final treatment - disposal infrastructure.

Similarly, 3RG 17 on improving resource efficiency is driving the resource efficiency sector with major push on reducing labor and raw material intensities. The emergence of the integrated waste management system along with 3RG 15 and 3RG 17 will further drive 3RG 18. Most of the island countries are facing difficulty to implement ideal waste management systems which is operational system in Asia-Pacific region. These countries face policy, institutional and financial challenges in addition to logistics and availability of land and space constraints.

Majority of the countries like Cook Islands, Federated States of Micronesia, Kiribati, Tuvalu, Fiji, Solomon Islands, Palau, Solomon Islands, and Vanuatu have municipal solid and hazardous waste policies, strategies and plans either as part of standalone documents on integrated policy or strategy on 3R such as Beverage Recycling Law including container deposit legislation in Palau. this law helps to create recycle fund by an additional charge on the imported beverage container and these funds will use to finance the recycling value chain leading to sustainable waste management and recycling operations.

Though there is diversity of response for different goals across region the countries have undertaken different 3R policy and regulatory, strategies, plans and master plan or projects in the region. These response can be broadly classified under each new and emerging waste streams such as municipal solid waste, chemical and hazardous waste, and their recycling rates. The issues related to resource efficiency and institutional aspects like waste management, coordination at national and regional level, transboundary trade and associated macro- and micro- ecosystems have significant attention across Asia-Pacific region. The low response by countries has been observed for 3RG 6, 3RG 8, 3RG 20, 3RG 22, 3RG 24, 3RG 26, 3RG 29, 3RG 30, 3RG 31, 3RG 32 and 3RG 33.

4.3 Existing and Emerging Waste Management System Trends

The evaluation of 3RG gets reflected in the resource and waste management systems which exist in Asia and the Pacific region. These ecosystem can be broadly classified into three generic models based on resource and waste management system, technologies employed and practices across the value chain (UNCRD et al., 2018a). It is followed by an evaluation of emerging ecosystems in the light of global trends like circularity and sustainability. Further, the convergence of the emerging policy and waste management ecosystem as per 3RG in sync with global trends is described. Finally, the systemic assessment has been carried out based on the Driving-Pressure-State-Impact-Response (DPSIR) framework.

The three different types of models are:

(i) Model 1 – Linear and Simple Waste Management System
(ii) Model 2 – Resource Efficiency and 3R Waste Management System
(iii) Model 3 – Integrated Resource Efficiency, 3R Waste and Circular Economy System

These models have been evaluated based on the following criteria.

(i) Ha Noi 3R Goals wise implementation as per **Table 4.1-1** and **Table 4.1-2**.
(ii) Resource efficiency implementation
(iii) EPR Principles and
(iv) Circularity

These models are shown in **Figure 4.3-1, Figure 4.3-2** and **Figure 4.3-3** and the country wide assessment is shown in **Table 4.3-1**.

Table 4.3-1: Country wide Status of Waste Management System. Source: (UNCRD et al., 2018a)

Sr. No.	Country	Model 1	Model 2	Model 3
1.	Australia		□	□
2.	Bangladesh	□	□	
3.	Bhutan	□	□	
4.	Brunei Darussalam	□	□	
5.	Cambodia	□	□	
6.	Cook Islands	□		

Sr. No.	Country	Model 1	Model 2	Model 3
7.	Federated States of Micronesia	□		
8.	Fiji	□	□	
9.	India	□	□	□
10.	Indonesia	□	□	
11.	Japan			□
12.	Kiribati	□		
13.	Lao PDR	□	□	
14.	Malaysia	□	□	
15.	Maldives	□		
16.	Marshall Islands	□		
17.	Mauritius	□	□	
18.	Mongolia	□	□	
19.	Myanmar	□	□	
20.	Nauru	□		
21.	Nepal	□	□	
22.	Pakistan	□	□	
23.	Palau	□	□	
24.	Papua New Guinea	□		
25.	Philippines	□	□	
26.	PR China	□	□	□
27.	Republic of Korea		□	□
28.	Samoa	□		
29.	Singapore		□	□
30.	Solomon Islands	□		
31.	Sri Lanka	□	□	
32.	Thailand	□	□	
33.	Timor Leste	□		
34.	Tonga	□		
35.	Tuvalu	□		
36.	Vanuatu	□		
37.	Vietnam	□	□	

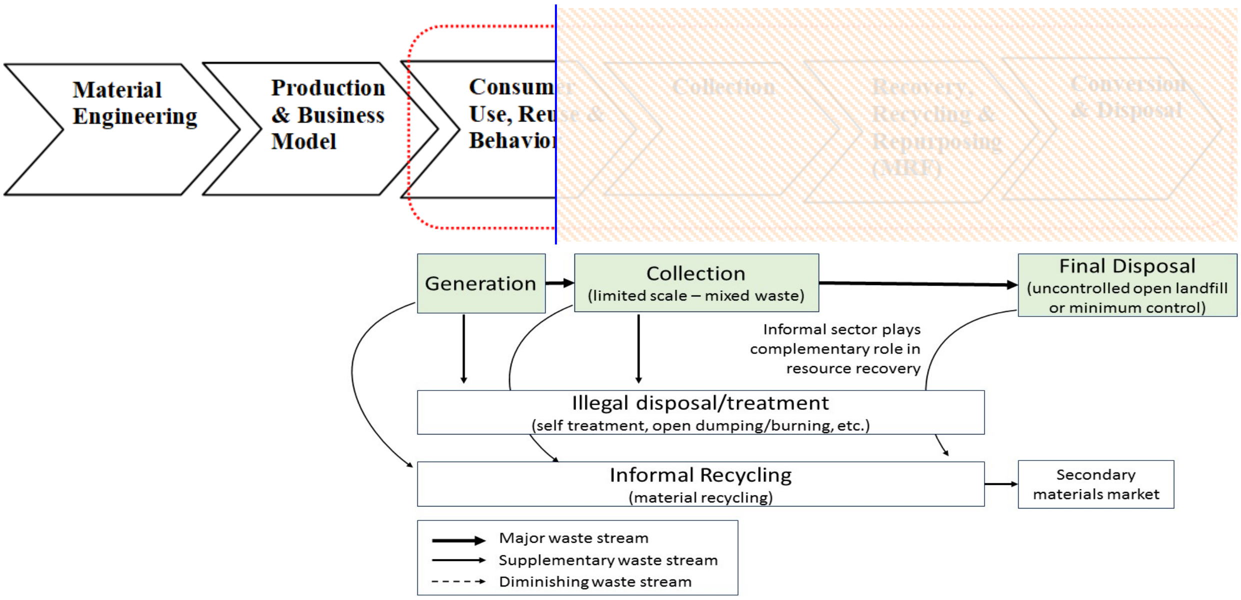

Figure 4.3-1: Model 1 - Linear and Simple Waste Management System

There are some salient features of model 1 as shown in Figure 4.3-1

- Limited segregation of waste in informal sector
- Minimum collection coverage in a geography
- Major valuable resources recovered by informal sector and very limited formal sector participation.
- Limited no options for intermediate treatment.
- Final disposal at dumpsite and open landfill and landfill with minimum control
- Rampant illegal disposal and treatment

Model 1 waste management broadly exist in all the countries except Japan, Australia, Republic of Korea and Singapore and in countries' rural areas. The different waste streams are often collected on a limited to wide scale. The source segregation practice based on the value items majorly done by informal sector till other items reach disposal sites with minimum or without control or engineering practices. The informal sector is taking care of resource circulation in an inefficient way that leads to causes land, water and air pollution and health issues. The resource efficiency or productivity is minimal and design for environment is virtually absent in this model.

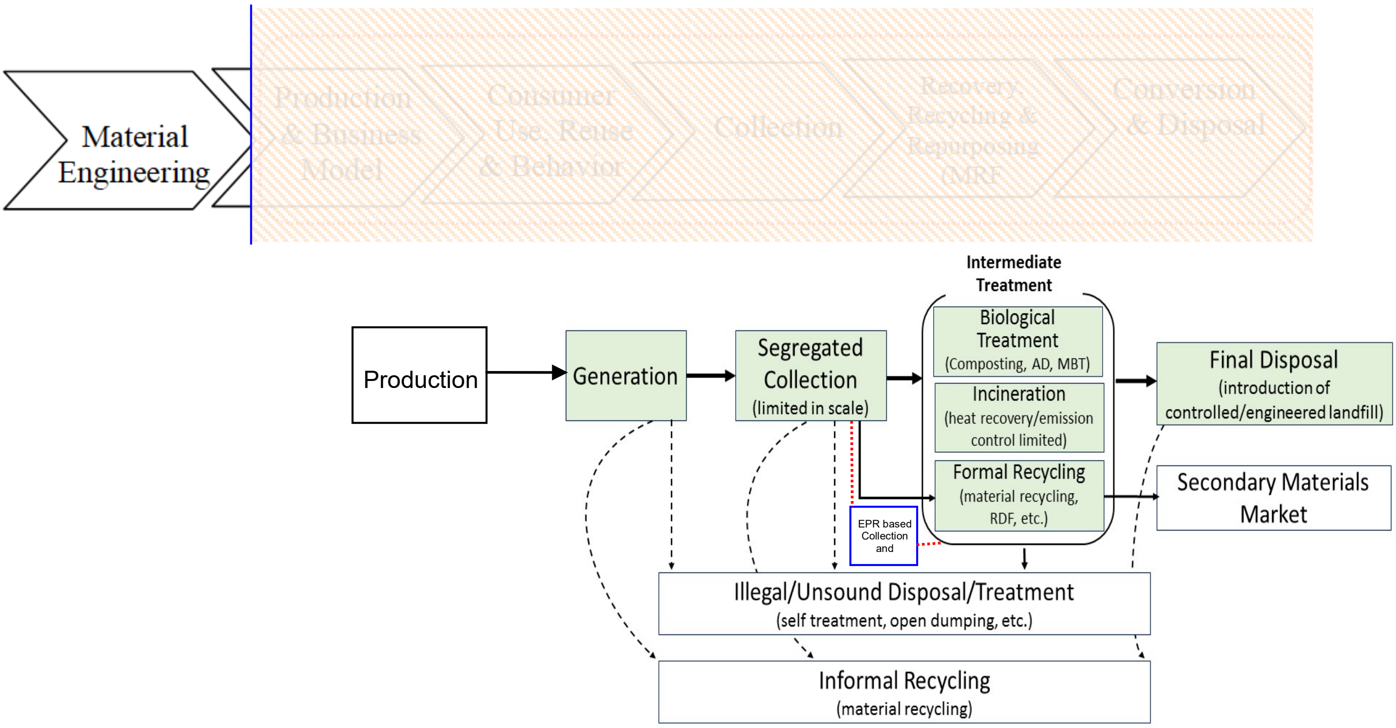

Figure 4.3-2: Model 2 – Resource Efficiency and 3R Waste Management System

There are some salient features of Model 2 as shown in figure 4.3-2

- Both formal and informal segregation of waste depending on appropriate treatment option
- Improved collection coverage across geography
- Items of value are collected through informal and formal sector.
- Different intermediate treatment options are explored and introduced, including incineration and other 3R technologies.
- Infrastructure for disposal such as controlled landfills are replicated across different geography
- Illegal disposal and treatment still exists while concepts like EPR and Product Stewardship and Circularity are introduced.

Model 2 represents emerging waste management systems which consists of existing waste management systems as well as systems which are emerging as a result of policy and regulatory interventions like EPR and product stewardship. Majority of the countries are adopting model 2 where formalization existing and emerging waste streams is happening simultaneously. In this model, the analysis of the waste value chain indicates that on the downstream side there is greater emphasis on the waste segregation, collection, intermediate treatment and disposal. The private sector is involved to assist the utilities in augmentation of services on the downstream side. On the upstream side, major brands are obligated to fulfill their physical and financial responsibilities. As a result, the concepts of circularity and resource efficiency are introduced in the waste value chain. The informal sector gets automatically introduced in the system and their scale starts getting reduced. The physical infrastructure constitutes material recycling facilities, recycling industry, incineration and controlled landfill.

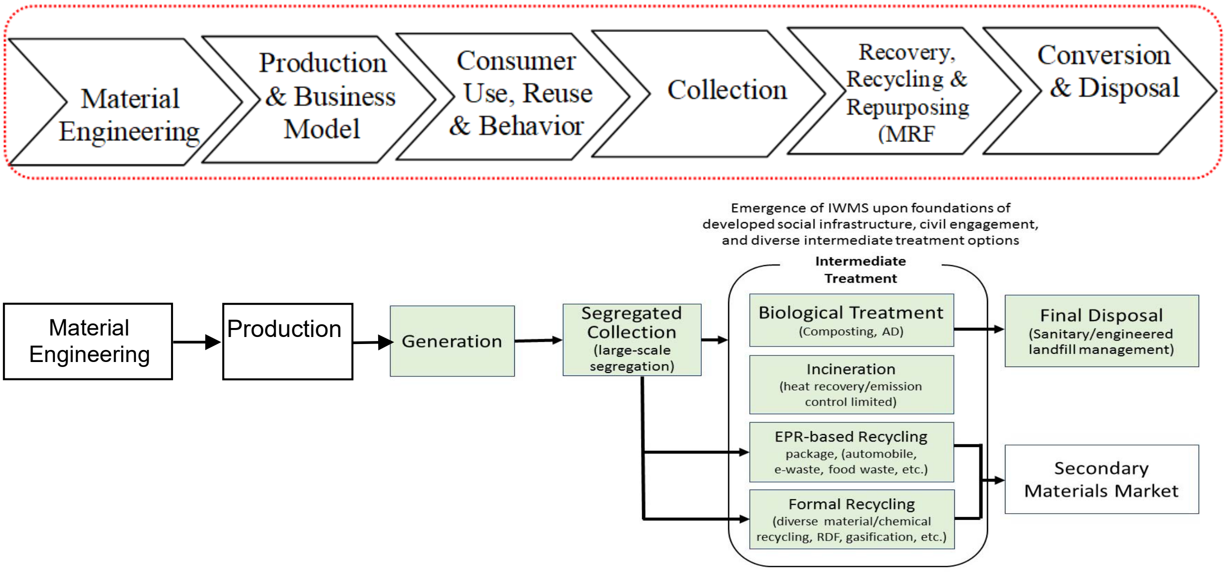

Figure 4.3-3: Model 3 –Integrated Resource Efficiency, 3R Waste Management and Circular Economy System

There are some salient features of Model 3 as shown in figure 4.3-3

- Segregation practices are widely practiced and customized available treatment options
- Complete waste collection coverage
- Recyclable waste collection conducted by formal sector leading to conversion and assimilation of informal sector into the formal chain.
- Recycling industry gets expanded.
- Resource Efficiency and material engineering are introduced and practiced.
- Incineration with heat recovery representing the major treatment option while diverse options also exist including sanitary landfill.
- Insignificant illegal disposal and treatment
- Environmentally benign alternate products are introduced in the market which are easy to segregate and recycle.
- Material engineering undergoes transformation with internalization of design for environment.

Model 3 represents integrated waste management systems where entire waste value chain gets integrated to the product and material flow chain. The major characteristics of the waste ecosystem is the circularity, reduced environmental and health risks sustainability and resource efficiency. The transition to circular economy can keep the value of resources and products at a high level and minimize waste production (Khajuria et al., 2022).

4.4 Internalization and Evolution of 3RGs

An analysis of internalization and evolution of 3RGs has been carried out considering two most trending words such as "Circularity" and "Sustainability" in Asia and the Pacific region. Section 4.3 clearly indicates the 3RGs have made a significant impact in triggering transformation from linear economy to circular economy. Most of the countries are adopting

3R and circular economy policies, regulation, programmes, plans and projects related to Circularity thereby pulling their economies towards material recycling, resource productivity pushing for resource efficiency and sustainability.

Figure 4.4-1 shows the concept of circular economy, it is an emerging economic model with the involvement of the private sector and the domain of environmental protection (Khajuria, 2021). The circular economy is designed to be a self-regenerating model where the reused material enters the production cycle and in ludes industrial symbiosis. The circular economy has a significant potential to achieve sustainable development through stopping the exhaustion of natural resources, lowering environmental damage from the withdrawal and undertaking of virgin materials, and reducing pollution from the procedure of process, use, and end-of-life of materials. The shift of circular economy refers to 'make-use-reuse-remake-recycle' from the linear economy 'take-make-dispose-pollute'.

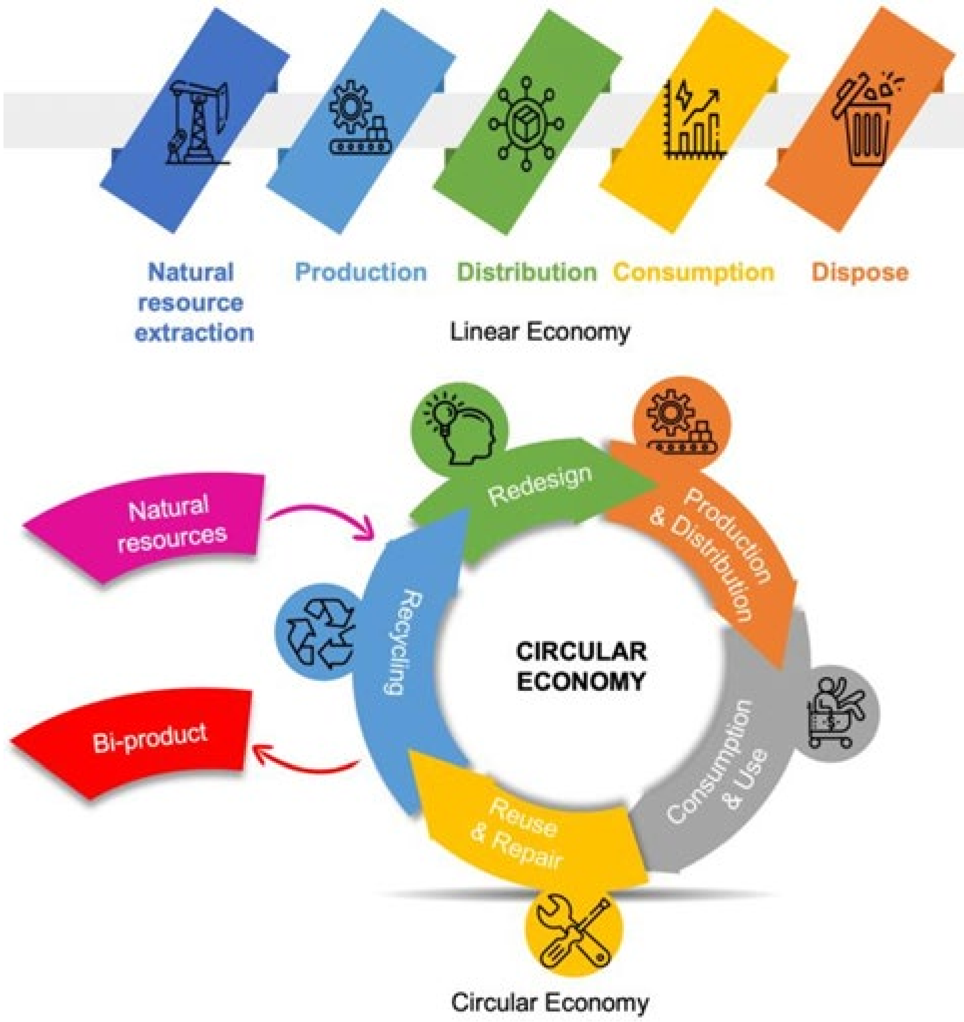

Figure 4.4-1: Linear Economy versus Circular Economy

Following below represents few countries' analysis: -

Japan

Fundamental Law for Establishing a Sound Material-Cycle Society (basic framework law) came into force in 2001. It is the law to ensure material recycling in society and to reduce consumption of natural resources to reduce environmental burden. It is aimed to promote waste management and 3Rs. There are waste management laws and laws for promotion of effective utilization of resources. These laws are conceptually based on EPR.

The Law for Promotion of Sorted Collection and Recycling of Containers and Packaging, known as the Containers and Packaging Recycling Law aims to promote recycling and reduce the amount of container and packaging waste produced by households, which accounts for 60 percent of its volume and 20-30 percent of its weight. Under this law, consumers, municipalities and businesses are each required to play their part in reducing emissions and recycling waste. Changes from the amendment in 2006 include promotion of emission reductions, high quality sorted collections (contributing funds to municipalities) and altering the PET bottle category (to include containers such as noodle broth bottles).

Consumers must reduce their waste emissions through making reasonable choices of containers and packaging and sort their container and packaging waste for collection. Businesses that manufacture or use products covered by the law are required to recycle those products. Businesses may also contract out recycling work for a recycling fee to the Japan Containers and Packaging Recycling Association. Municipalities must establish sorted collection plans and take the necessary measures to collect container and packaging waste separately in their areas. In order to assist sorted collection, containers and packaging are also required by law to be labeled with identification marks. Because of the wide variety of materials from which plastic products are made, it is recommended that such products also bear a "material mark" as well as an identification mark. As well as the identification and material marks specified by the Containers and Packaging Recycling Law, the symbols below are sometimes seen. They are the material identification SPI codes used on containers in the USA.

Republic of Korea

The "Waste Control Act" (1986) is the umbrella act that guides South Korea's waste management. Act on Promotion of saving and recycling resources 1992 is the "Act on Resource Recirculation of Electrical and Electronic Waste and End of Life Vehicles", as well as tyres, lubricant, batteries, and fluorescent lamps, Styrofoam float, and packaging materials (metal can, glass bottle, carton pack, PET bottle, synthetic resin packaging material) that are used to pack food and beverages, agricultural products, marine products, livestock products, cleansers, medicines and cosmetics, etc.) A mandatory recycling ratio for each EPR product category is announced every year by the Ministry of Environment. According to the article 11 and article 12 of Resource Circulation Act 2016 the Ministry of Environment should establish the Master Plan for Resource Circulation every 10 years, for enforcement. Article 14 of this Act, of the Ministry of Environment should set mid to long-term target values per stage for final disposal rate, circulated use (actual recycling) rate, and energy recovery rate, and promote measures for their accomplishment.

One of the Republic's major priorities has been to minimise its use of resources while meeting the country's high demand for energy. It is adopted as an efficient system for recovering resources from landfill and encouraging reuse and recycling. The Republic of Korea introduced its EPR system for packaging in 2003. The "Act on the Promotion of saving and Recycling of Resources" states the duties of producers and importers of EPR items other than the products that fall under the Eco-Assurance Act, including to collect and recycle the end-of-life products. The Recycling Act facilitates a take-back system by enabling the producers and importers to add bond money to the consumer prices to increase the collection of empty containers. The producers and importers shall refund the bond money when a consumer returns the empty containers. Producers of beverages are utilizing the system, and the level of bond money is about 40 percent of the cost for manufacturing a new bottle. The producers may establish a waste collection facilitating centre (Producer Responsibility Organization, PRO), which should compensate for the cost of waste collection borne by the local governments. Producers and importers of EPR items shall collect and recycle the end-of-life products or packaging materials or pay the allotted share of charges to the PROs. Also, producers or importers shall endeavour to facilitate recycling by; developing recycling technology, resource efficient designing, restricting use of hazardous substances, and producing or importing easier-to-recycle products. Producers or importers may establish a PRO for recycling to carry out the obligatory recycling responsibility.

The government of the Republic of Korea introduced a number of recycling initiatives, such as a *Volume-Based Waste Fee System, Extended Producer Responsibility, a deposit refund system* and *a waste charging system*. Waste generated in detached homes and small business premises is collected by local authorities and transferred to material recovery facilities (MRF) (public and private) for further treatment. Packaging from large apartment blocks and other buildings is collected by private recyclers and sent to privately-operated MRFs, from which it is then delivered to recyclers and manufacturers to produce recycled products.

The central government is responsible for drawing up and implementing regulations on EPR, while local governments are tasked with ensuring effective, responsible waste collection and improving rates of recycling and reuse. The *Korea Environment Corporation* monitors the EPR system and ensures that producers and importers comply with requirements to report their sales and import data, as well as data on waste collection and recycling. Monitoring is enhanced by a number of labelling systems for products covered by the EPR system, including information on the recyclability of packaging and how it should be disposed off. These labels are produced by importers and manufacturers.

The EPR system primarily covers Batteries (mercury, silver oxide, lithium, nickel-cadmium, manganese, nickel hydrogen), tyres, lubricants, fluorescent lamps, styrofoam. The packaging include metal cans, glass bottles, cartons and card, PET bottles and synthetic resin packaging. These packaging are used to pack food and beverages, agricultural products, marine products, livestock products, cleansers, medicines, cosmetics, etc. It is currently being expanded to cover a total of 32 products including fluorescent lamps, packing films, mobile phones, audios, air conditioning units, PCs and batteries.

The key stakeholders include both government and private sector. The Ministry of Environment (MOE) is responsible for the policy and legal framework for waste management at the central level. It implements and revises waste-related legislation; develops, co-ordinates, enforces and monitors the national waste management plans; and conducts waste-related statistical surveys that inform the development and implementation of national waste policies. The MOE works closely with other ministries, including the Ministry of Health and Welfare on medical waste; the Ministry of Trade, Industry and Energy (MOTIE) on control of transboundary movements of hazardous waste; the Ministry of Land, Infrastructure and Transport on construction waste; and the Ministries of Agriculture, Food, and Rural Affairs and of Health and Welfare on food waste. The MOE also oversees management of rivers and estuaries and in charge of preventing waste from entering the sea by collecting and managing waste in collaboration with other stakeholders.

Singapore

With limited land resources available for waste disposal, the National Environment Agency (NEA) has adopted the following strategies to manage the growth in solid waste generation: (i) Minimize and segregate waste at source; (ii) Develop cost-effective collection, recycling and disposal systems, - Build a resource-efficient society, and; (iii) Maximize energy and resource recovery as well as landfill lifespan.

Currently, Singapore has in place an integrated solid waste management system. Waste that is not reused or segregated at source for recycling, is collected and sent to disposal facilities. All incinerable waste is disposed of safely at WtE plants, while non-incinerable waste and ash residues from the incineration process are disposed of at the offshore Landfill. Under the "Sustainable Singapore Blueprint," Singapore aims to become a zero waste nation and there is an overall waste recycling rate target of 70 percent by 2030. Singapore's overall recycling rate has increased from 40 percent in 2000 to 60 percent in 2014. Singapore has achieved this through a combination of initiatives, including voluntary partnerships, continued education and outreach on the 3Rs, funding schemes and industry development. Singapore has also started introducing legislation on waste reduction and recycling, such as mandatory provision of recycling receptacles in condominiums and private apartments in 2008 and the mandatory reporting of waste data and reduction plans by large commercial premises (i.e. large hotels and shopping malls) in 2014. Singapore is conducting trials on food waste recycling. It has introduced regulated E-waste management system through "Resources Sustainability Act (RSA) administered by National Environment Agency (NEA). The aim is to better manage and reduce the amount of these targeted waste streams, so as to achieve the overall waste recycling rate target of 70 percent by 2030. The country has a focus on more waste minimization and recycling, so that less resources are needed to build disposal facilities, including extending the lifespan of existing Landfill.

PR China

PR China has embarked on institutionalization of 3R approach in their waste management system since 2000. It has also introduced the principles of extended producer responsibility, resource efficiency and circularity since 2004. Solid waste management involves many government departments, and different ministries are responsible for different kinds of wastes in PR China. In practice, managing a particular kind of waste tend to involve other departments. For example, MSW management and 3R system covers the MSW collection, transportation and treatment system is the responsibility of the Ministry of Housing and Urban-rural Development (MOHURD), whereas and recyclable waste recycling system is under the Ministry of Agriculture (MOA) and the National Development and Reform Commission (NDRC). Meanwhile, Local Authorities are in charge of the collection of MSW, building and operating of MSW facilities, treatment and disposal of MSW, and recycling and reuse of recyclable waste. How to efficiently link the waste management and resource management to realize the integrated waste and resource management by strengthening cooperation of the relative government sectors, as well as the participation of relative stakeholders are key challenges.

National policy frameworks on (Municipal Solid Waste Management and Other Waste Streams) include the following:

1. Circular Economy Promotion Law 2008 (Article 2) circular economy as activities that reduce, recycle, and recover products.

2. (Article 9) Enterprises must develop strategic management systems to cut resource consumption and waste generation to be able to raise the level of waste recycling and resource recovery. (Article 15) Enterprises are responsible for recovering, reusing, and disposing of waste based on regulations. (Article 10) The State is obliged to encourage citizens to use recycled products. (Article 41) Establish buildings to facilitate waste collection and recycling.
3. Solid Waste Pollution Preventing and Control Law (2015) this law clearly defined the government and enterprises' responsibilities in solid waste disposal. It also added information that the government should encourage the development of a circular economy. The revised law regulated and limited the discharge and import of industrial solid waste.
4. 13^{th} Five Year Plan (2016–2020) The circular economy and low-carbon economy as key focus areas for policy. It introduces binding targets relevant for the circular economy, emphasizes the importance of an Extended Producer Responsibility (EPR) framework, and proposes to further strengthen municipal waste management and the remanufacturing industry. The plan aims to achieve a 73 percent reuse rate for industrial solid waste and a 90 percent treatment rate for domestic waste in rural areas by 2020.
5. National Sword Policy (2018) 'Prohibiting the Import of Foreign Waste from the Country and Promoting the Implementation of the Reform of the Management System for Solid Waste Import', banned the import of most plastics and other materials headed for that nation's recycling processors, which had handled nearly half of the world's recyclable waste for the past quarter century.
6. National Development and Reform Commission (2019) is the new policy, announcing plastic bags banned across all cities and towns in 2022, though markets selling fresh produce will be exempt until 2025. The production and sale of plastic bags that are less than 0.025 mm thick, and plastic film less than 0.01 mm thick for agricultural use will also be banned. The restaurant industry must reduce the use of single-use plastic items by 30 percent. Hotels have been told that they must not offer free single-use plastic items by 2025.
7. The Marine Environment Protection Law has undergone four amendments (1999, 2013, 2016 and 2017) since its promulgation on August 23, 1982 this Law is the basic law for the protection of marine environment, which provides an overall regulation on pollution control, ecosystem protection and resources conservation. Prevention and control of pollution is the core part of the Marine Environment Protection Law, which is stipulated in five chapters separately as: Prevention and Control of Pollution Damage to the Marine Environment Caused by Land-based Pollutants; Prevention and Control of Pollution Damage to the Marine Environment Caused by Coastal Construction Projects; Prevention and Control of Pollution Damage to the Marine Environment Caused by Marine Construction Projects; Prevention and Control of Pollution Damage to the Marine Environment Caused by Dumping of Wastes; and, Prevention and Control of Pollution Damage to the Marine Environment Caused by Vessels and Their Related Operations.
8. National Law (1980) besides the national Law, there are about 15 national regulations since the 1980s issued by the State Council to regulate the marine and coastal environment: Administrative Regulation on the Prevention and Control of Pollution Damages to the Marine Environment by Vessels; Administrative Regulation on the Prevention and Control of Pollution Damages to the Marine Environment by Coastal Engineering Construction Projects; Administrative Regulation on the Prevention and

Treatment of the Pollution and Damage to the Marine Environment by Marine Engineering Construction Projects; Regulations of PR China on the Control over Dumping Wastes into the Sea Waters; Regulations of PR China Concerning Environmental Protection in Offshore Oil Exploration and Exploitation; and Regulations on Prevention of Environmental Pollution by Ship Breaking.

There are some other initiatives and interventions such as -

1. 13th Five Year Plan includes the construction and expanding of eco-industrial parks, implementation of EPR, waste separation at source, 3Rs of food waste and construction and demolition waste. The scope of services from urban to rural areas are planned to be strengthened in the following five years.
2. PR China imposes levy or retail distribution of plastic bags
3. Ban on plastic shopping bags less than 0.025 mm in thickness (ultrathin plastic bags).
4. Fees on the sale of plastic bags: No exact fee requirement is provided by the law, this is determined by the retailer, but the fee for plastic shopping bags cannot be lower than the manufacturing cost or have any discount or be free.
5. Material and product ban: Ban on the import of used plastics for use as raw materials, including plastic bags, films, and nets, and polyvinyl, styrene polymer PET (Notice on adjusting the managing category of imported wastes (02and26and2014) Exhibit Prohibited Wastes, No. 80; 2.
6. 'Circular on Adjustments of VAT Treatment to Products and Services Output through Comprehensive Utilization of Resources (caishui[2011] No.115)' offers to reduce or eliminate value-added tax (VAT) burdens on enterprises that recycle wasted resources during production.
7. For consumers, PR China bag laws also require retailers to charge consumers a minimum amount for bags to discourage plastic waste generation.
8. In Shanghai, citizens are given incentives and penalties to influence their waste generation and management behavior.
9. Green Accounts, an automated credit bound with a smartphone, the Green Account records every correct classification of waste and will then give credits, which could be used to exchange for some goods.
10. In a bid to boost compliance, Shanghai has listed fines of up to US$14,500 for business and government organizations who violate certain recycling rules.

The key stakeholders include both government and private sector. Ministry of Housing and Urban-Rural Development; Ministry of Agriculture (MoA); The Ministry of Ecology and Environment (MEE); The Ministry of Commerce; the Department of Marine Ecology and Environment (under the Ministry of Ecology and Environment); The Ministry of Natural Resources; The Ministry of Transport; The national Development and Reform Commission; Division of International Ecological and Environmental Conventions, Department of International Cooperation and Ministry of Ecology and Environment. Local authorities manage collection, building and operating MSW facilities including treatment, recycling and disposal.

PR China has contracted private companies that manage collection, incineration, landfill disposal, and composting. Relevant associations for packaging and sustainability are PR China Plastic Recycling Association (CPRA), PR China Synthetic Resin Association Plastic Recycling Branch, PR China Association of Circular Economy (CACE), Civil societies, environmental NGOs, students, foundations and citizens; informal sector.

India

India is implementing policy and regulations, plan, programs and projects based on 3Rs. Currently its policy interventions envision going beyond 3Rs to 5Rs with focus on remanufacture and recovery. This approach adopts the principles of resource efficiency, principle of circularity, and sustainability.

India has an umbrella act on environment, Environment (Protection) Act 19 which was enacted in 1986. Under this act, number of rules covering different waste streams were enacted subsequently. Government of India has notified Solid Waste Management Rules, 2016 including Construction and Demolition waste, Plastic Waste Management Rules, 2016, E-Waste (Management) Rules, 2016. SWM Rules 2016 indicates that every concerned shall ensure door to door collection of segregated waste and its transportation in covered vehicles to processing or disposal facilities and also to ensure separate storage, collection and transportation of construction and demolition wastes within 2 years of its notification. Government of India has notified Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 for hazardous waste.

- As per the Rules, for the management of hazardous and other wastes, an occupier shall follow¬ the steps, namely (a) prevention; (b) minimization; (c) reuse, (d) recycling; (e) recovery, utilization including co-processing; (f) safe disposal.
- The occupier shall be responsible for safe and environmentally sound management of¬ hazardous and other wastes.
- The hazardous and other wastes generated in the establishment of an occupier shall be sent¬ or sold to an authorized actual user or shall be disposed of in an authorized disposal facility. The hazardous and other wastes generated in the establishment of an occupier shall be sent¬ or sold to an authorized actual user or shall be disposed of in an authorized disposal facility.
- The hazardous and other wastes shall be transported from an occupier's establishment to an¬ authorized actual user or to an authorized disposal facility in accordance with the provisions of these rules.
- The occupier who intends to get its hazardous and other wastes treated and disposed of by¬ the operator of a treatment, storage and disposal facility shall give to the operator of that facility, such specific information as may be needed for safe storage and disposal.
- The occupier shall take all the steps while managing hazardous and other wastes.

E-waste, plastic waste and construction and demolition waste and battery waste streams are covered under individual rules based on principles of extended producer responsibility. Tyre waste also covered under hazardous waste based on principle of extended producer responsibility (EPR). Biomedical waste rules and all other waste related regulations were enacted in 2016 with amendments till date. Bureau of Indian Standard (BIS), Government. of India has published IS 383:2016 to permit the use of manufactured aggregates namely recycled aggregate (RA) and recycled concrete aggregate (RCA) in lean concrete, PCC and RCC by any concerned from Construction and Demolition waste in urban areas. The Solid Waste Management Rules, 2016 which is applied to every urban local body, outgrowths in urban agglomerations, census towns as declared by the Registrar General and Census Commissioner of India, notified areas, notified industrial townships, areas under the control of Indian Railways, Airports, Airbases, Ports and harbours, Defence establishments, special economic zones, State and Central Government organisations, places of pilgrims, religious and historical importance as may be notified by respective State government from time to time and to every domestic, institutional, commercial and any other non-residential solid waste generator situated in the areas except industrial waste, hazardous waste, hazardous chemicals, bio medical wastes, e-waste, lead acid batteries and radio-active waste are covered under separate rules under the Environment (Protection) Act, 1986.

- Central Electricity Regulatory Commission (CERC), Govt. of India has recently notified Generic tariff for Waste-to-Energy of Rs. 7.04 per unit of power for plant with municipal solid waste and Rs 7.90 per unit of power for plant based on Refused Derived Fuel (RDF) which has increased the potential for setting up the waste to energy plants in the country. State Governments have also initiated process for determining the power tariff for waste to energy plants.
- Ministry of Power, Govt. of India has recently revised the Tariff Policy 2006, under the¬ Indian Electricity Act, 2003, making it mandatory for State DISCOMS to purchase 100 percent power generated from Waste-to-Energy plants in the country.
- Guidelines on Usage of Refuse Derived Fuel in Various Industries, 2018 has been released¬ to the States and UTs which will serve as reference for all stakeholders to implement and promote use of RDF across different industries.

With the change in policy adopted by the government, private sector, including small-and medium-sized enterprises (SMEs) are encouraged to implement measures to increase resource efficiency and productivity, creation of decent work and to improve environmentally-friendly practices through applying environmental standards, clean technologies, and cleaner production. As per the SWM Rules, 2016, the Local Authorities have been given responsibility for setting-up material recovery facilities or secondary storage facilities with sufficient space for sorting of recyclable materials to enable informal or authorized waste pickers and waste collectors to separate recyclables from the waste and provide easy access to waste pickers and recyclers for collection of segregated recyclable waste such as paper, plastic, metal, glass, textile from the source of generation or from material recovery facilities; Bins for storage of bio-degradable wastes shall be painted green, those for storage of recyclable wastes shall be printed white and those for storage of other wastes shall be printed black. Swachh Bharat Mission (Urban), with one of the objectives of municipal solid waste management in all towns and cities are under implementation since 2014 in all the States and UTs The program has been framed to build sustainable cities and green cities by encouraging zero waste with primary goal of waste minimization. This mission now covers rural areas of India.

Ministry of Housing and Urban Affairs (MoHUA), Government. of India is implementing Swachh Bharat Mission (SBM) in Urban areas of the country. MoHUA is implementing the SBM by providing the viable gap funding and grants to the States and UTs in urban area of the country. Under the Mission, one of the admissible components is Municipal Solid Waste management with an objective to reduce, reuse and recycle at the point of generation and proper collection, segregation, transportation, and processing at the decentralized and centralized level. The wet waste shall be used for waste to compost production and waste to energy from non-organic waste under the Mission in the country and dry waste shall follow the path of recycling. The States and Union Territories (UTs) are implementing the municipal solid waste management in the cities and, towns with their own policy, institutional, technological and financial as the subject matter is dealt with by the States and UTs. At the Central level, all policy, institutional, technological and financial support is provided to the

States and UTs. Most of initiatives undertaken by government of India support Ha Noi 3R goals.

Thailand

Several policies have been implemented in the last decade that support the implementation of 3R and the management of other wastes. E-waste policy as a part of National Integrated WEEE Management Strategy was approved by the cabinet on 24 July 2007. Draft act on the management of WEEE and other end of life products was approved by the cabinet on 19 May 2015. These include:

1. "Environment and Conservation of National Environmental Quality Act B.E. 2535 AD 1992" as basic Act on Environment. Hazardous Waste and Substances B.E. 2546 (2003), B.E. 2549 (2006), and B.E. 2548 (2005) on Hazardous waste and substances. The PPP Act (introduced in 1992, and revised in 2013 guides PPP in the waste sector. Further, National Strategy on Waste Management is a 20 year strategy on waste management. National Economic and Social Development Plan (2017–2021) is for utilization of more than 75 percent of MSW by the end of 2021. The Alternative Energy Development Plan (2012-2021) promotes energy generation from waste. The National Master Plan on Waste Management (2016-2021) promotes the concept of 3R. Plastic Debris Management Plan (2017-2021) targets to increase plastic waste recycling to at least 60 percent. National Roadmap for the development of Bio-plastic industry was developed in 2008. National 3R Strategic Plan is a 3R strategy plan for waste minimization.
2. Hazardous Waste and Substances B.E. 2546 (2003), B.E. 2549 (2006), and B.E. 2548 (2005) on Hazardous waste and substances
3. Act on the Maintenance of the Cleanliness and Orderliness of the Country Public Sanitary and Order, Act B.E. 2535 (1992) and B.E. 2560 (updated in 2017) Ch. IIIand1 on provisions for MSW management.
4. Public Health Act 1992, chapter III on Waste management.
5. Law for Promotion of Source Segregation of household waste into general waste, recyclable waste and household hazardous waste (2020) on source segregation of waste
6. Ministerial Regulation on Service Fees for Solid Waste Management on service Fees for solid waste management
7. Marine and Coastal Resources Management Act on Protect Marine and Coastal resources
8. Act on the Maintenance of the Cleanliness and orderliness of the Country (2017) proposes US$ 4.5/month/households as waste collection service fee

There are some other initiatives and interventions include such as-

1. The National Waste Management Master plan 2016- 2021 encourages private investors in waste to energy (WtE) Sector. Some of the major WtE projects include Phuket (700 tpd, 12 MW), Bangkok (500 tpd, 7-9 MW), Hatyai (250 tpd, 4-5 MW), TPI – Saraburi (3,000 tpd, 70 MW), Eastern Energy – Samet Prakarn (500 tpd, 10 MW) and Khon Kain (600 tpd, 5-6 MW).
2. Ministry of Natural Resources and Environment made a Memorandum of Understanding with 16 business organizations to not distribute plastic bags to their customers on the 15th and 30th of each month.

3. Cooperation of PCD with Plastic Institute, FTI, Thai Plastic Industry Association and Chulalongkorn University, to improve the data base on the flow of plastic material in Thailand
4. Campaigns to axe plastic cap seals of drinking water bottles (effective from 1 April 2018)
5. Prohibition of plastic bags and Styrofoam containers in national parks (announced by the Department of National Parks, Wildlife and Plant Conservation, Thailand on 8 June 2018).
6. DMCR, (MONRE) has the regular coastal clean-up all year round with public participation, in 24 coastal provinces.
7. The Sustainable University Network (SUN) with 27 universities nationwide has organized a campaign to reduce single-use plastic on all campuses by 80-90 percent over the year 2018.
8. "Public-Private Partnership for Sustainable Plastic and Waste Management" initiative, launched in June 2018 and led by the Plastic Industry Club, aims to halve the amount of ocean waste Thailand produces by 2027.

The key stakeholders include both government and private sector. Ministry of Natural Resources and Environment (MONRE) with its Office of Environmental Policy and Planning (ONEP), Pollution Control Department (PCD), and the Department of Environmental Quality Promotion (DEQP); Department of Marine and Coastal Resources (DMCR); (Director General and Foreign Affairs Sub division and Marine and Ecosystem Coastal Resources); Environmental Quality Promotion Department; Department of National Park, Wildlife and Plant Conservation; Department of Medical Services of the Ministry of Public Health; The Department of Local Administration (DLA) of the Ministry of Interior; Ministry of Industry, Municipalities, Sub-district Administration Organizations (SAO), Provincial Administrative Organization (PAO), and Special Administrative Areas (Bangkok and Pattaya City). Usage of plastic bags in its 30 hospitals from 1 October 2018, aiming to reduce the usage of 9 million bags per year. Private sector (Formal) is involved in recycling and disposal of plastic MSW, industrial and hazardous waste. Private sector is not only involved in waste to energy projects but also plastic recycling projects. Informal sector is also involved in MSW collection, sorting, transportation and disposal. About 35 plastic recycling companies are operating in Thailand.

Vietnam

In Viet Nam, the new EPR approach has come into effect in January 2022, which will impact business operations on plastic packaging including PET bottle, EPS, PSP, PVC, plastic container tray, and film. According to the EPR principles, producers will be in charge not only to produce such commodities but will be held responsible until the waste stage of their life cycle (WBCSD, 2022).

National Policy Framework (Municipal Solid Waste and Other Waste Streams) include the following regulations:

1. Decision 2149and2009andQD-TTg dated 17th December 2009 is a National Strategy for integrated management of solid waste to 2015, with a vision to 2050.
2. Law on Environmental Protection 2014 includes Regulations on MSW, water and hazardous waste management.
3. Decision 1216and2012andQD-TTg dated 05and9and2012 ratifies the National Strategy on Environmental Protection to 2020, with a vision to 2030.

4. Decision No. 166andQD-TTg dated 21and01and2014 gives plan for implementation of the National Strategy on Environmental Protection up to 2020 with a vision to 2030.
5. Decision No. 491andQD-TTg dated 07and5and2018 gives adjustment of the national strategy on integrated solid waste management to 2025, vision to 2050.
6. Decree No. 25and2009andND-CP is on Integrated Marine Resources Management and Environmental Protection.
7. Decision No. 2295andQĐ-TTg is a strategy for integrated coastal zone management (ICZM) up to 2020 and vision toward 2030.
8. Resolution No. 36-NQ andTW 2018 is a strategy for sustainable development of Viet Nam's marine economy to 2030, with a vision to 2045.
9. Law on Marine Resources and Environment and Islands (2015) is for Management of Marine Resources and Environment.
10. Decision No. 06and2018andQDTTg of 2018 is on reducing Marine Pollution.
11. Action Plan for Management of Marine Plastic Litter by 2030 states that by 2025, reduce marine plastic litter by 50 percent; collect 50 percent of abandoned, lost, or discarded fishing gear; prevent the use of single-use plastics and non-biodegradable plastic bags in 80 percent of coastal tourism sector, ensure nationwide beach cleanup campaigns are launched at least twice a year; and strive for 80 percent of marine protected areas to be free of plastic litter. By 2030, reduce marine plastic litter by 75 percent; collect 100 percent respectively.

There are some other initiatives and interventions are included such as-

1. Cities also levy's a 'sanitary' fee for waste management service covering only 60 percent of the total waste management costs. It is equivalent to 0.5 percent of the average household expenditure.
2. Circular No. 39and2008andTT-BTC (Incentives and subsidies and tax exemption and fees and charges and fines) The Viet Nam Environment Protection Fund (VEPF) provides soft loans, interest rate support, funding and cofunding, price subsidies for environment protection products, entrusted loans for waste treatment wastewater treatment facilities.
3. Decision No. 71and2010andQD-TTg for pilot investment in the public private partnership.
4. Circular No. 32and2015andTT-BCT for project development and Standardized Power Purchase Agreement for waste to energy projects.
5. Decree No. 174and2007andND-CP on Environmental Protection Fee for Solid Waste
6. Decree No. 59and2007andND-CP supports private investment in the solid waste sector.
7. Decree No. 67and2011andND-CP imposes tax on nylon bags (plastic bags) (50,000 VND and kg; 1.3 – 2.1 US/kg).
8. Circular No. 07and2012andBTNMT details the regulation on eco-friendly plastic bags.
9. Decision No. 582andQD-TTg and 2013 to approve the project on enhancing the control of environmental pollution due to the use of non-biodegradable plastic bags by 2020.
10. Memorandum of Understanding (MoU, 2009) between MONROE with Dow Chemical Vietnam LLC, SCG Group and Unilever Vietnam International Co. Ltd. on building public private (PPP) collaboration towards the circular economy in plastic waste management.
11. Viet Nam has imposed temporary restrictions on the import of plastic scraps and stopped issuing new licenses for scrap imports.

Viet Nam Environment Administration (VEA) and Viet Nam Administration of Seas and Islands (VASI) management for coasts, seas and islands in Viet Nam. Ministry of Natural Resources and Environment (MONRE); The Ministry of Construction (MOC); The Ministry of Agriculture and Rural Development (MARD; The Ministry of Health (MOH); and Ministry of Industry and Trade (MOIT). Provincial and Municipal People Committees (PPC) are responsible for overseeing environmental management within its jurisdiction; The Department of International Cooperation is responsible for collaboration on international programs on science and technology; and URENCO or CITENCO is the main state-owned company in charge of waste collection.

4.5 Strategic Evaluation

The strategic evaluation was shown by one of the universal framework called Driving force-Pressure-State-Impact-Response (DPSIR) framework. **Figure 4.5-1** depicts the complete DPSIR framework for municipal solid waste management.

Driving force: Population growth, fast economic development and rapid urbanization are the key drivers of waste generation in Asia Pacific.

Pressure: Increasing consumption, especially among the emerging middle-income class, inefficiency in resource use and inadequate urban infrastructure are the main pressures on waste management in Asia and the Pacific.

State: Waste generation in Asia and the Pacific is rising and new and complex waste streams are emerging.

Impact: Poor waste management leads to serious impacts on human health, especially in the informal recycling sector and at open dumps.

In this framework, trend of urbanization, accelerated economic development and operating cost on municipal solid waste management are used as the driving forces, which put pressure on the generation of municipal solid waste, changes in composition and overuse of land area. As the state factors, GHG attribute to methane emission and the environmental pollution are used, which cause impact on the human health, flora and fauna. Response indicators refer to the treatment technology and involvement of management agencies. Cause and effect relationship of the municipal solid waste issues are restructured using this framework and discuss on the links and indicators of each component of DPSIR (Khajuria 2010). However, the policy response is not an endpoint in itself; rather the effectiveness of policies must be continually evaluated, and adjusted if they do not have the intended effect on the pressures that impact the state of the environment.

The strategic DPSIR framework in Asia and the Pacific region has been shown in **Figure 4.5-1.**

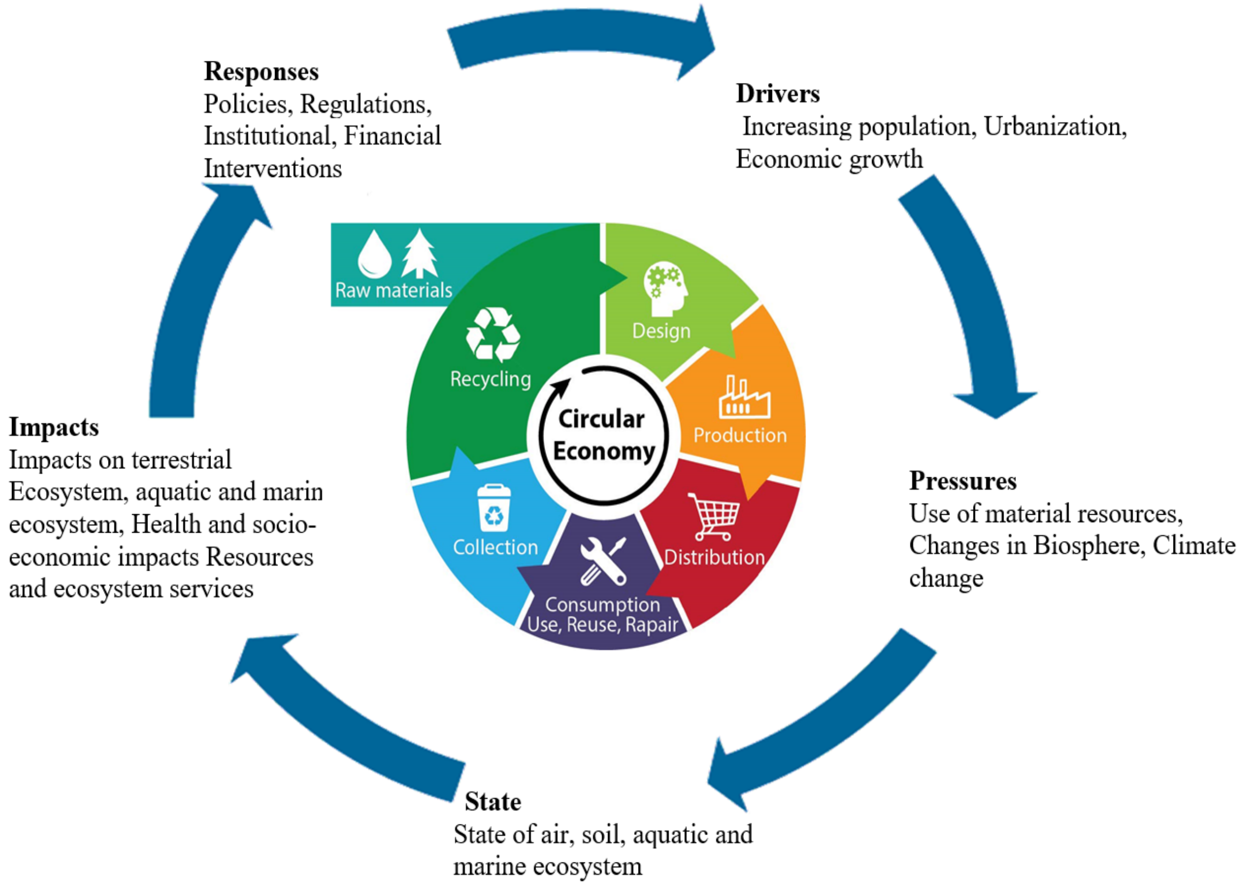

Figure 4.5-1: Conceptual image of DPSIR with Circular Economy Approach

The analysis of the response is fraught with constraints and barriers. However, the 3R policy, institutional and technology are evolving as the region embarks to adopt circular economy. Effective waste management is an efficient method which include both to increase resource efficiency and to replace fossil fuels with renewable energy sources. Addressing the problems and solutions of waste management system from 'waste' to 'resource', 'waste and resource management' and 'circular economy' all reflect the significant impact of decoupling between economy and waste management (Khajuria, 2016). The importance of circular economy has been a part of many goals and targets in the United Nations 2030 agenda for SDGs.

4.6 Key Messages: Chapter 4

A comprehensive overview of the progress achieved by countries on the 3RGs has been carried out at the national level and regional level which finds expression in existing and emerging waste management systems. 3RG 1, 3RG 2, and 3RG 3 are related to municipal solid waste and its sub streams such as paper, metal, organic waste. The majority of countries have specific 3R policies, programs and projects in managing their municipal and industrial waste.

Many countries have adopted the policies to make compost from agricultural biomass waste. Indeed, the effective management of e-waste has been prioritized and several countries have started to apply EPR-based policies for 3RG 13 and 3RG 15.

The country-wide status of the three different types of models has been described. Model 1:

Linear and Simple Waste Management System, Model 2: Resource Efficiency and 3R Waste Management System and Model 3: Integrated Resource Efficiency, 3R Waste Management and Circular Economy. An analysis of the internalization and evolution of Ha Noi 3R goals has been carried out considering "Circularity" and "Sustainability" in Asia and the Pacific region. The Ha Noi 3R declaration has made a significant impact in triggering a transformation from a "Linear' to "Circular" economy. The DPSIR framework shows the major driver, pressure, state, impact and analysis of the responses to overcome lack of efficient 3R and circular economy policies, strategies, programme and projects. A circular economy is a regenerative system in which resource input and waste, emission, and energy leakage are minimized by slowing, closing, and narrowing energy and material loops which is also important for achieving the 2030 Agenda for Sustainable Development.

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Chapter 5: Major Recommendations and the Way Forward

This chapter introduces a summary of challenges and a few recommendations based on an assessment of priority needs for 3Rs and the progress in 3R policy implementation in the region. This report highlighted various thematic sections on different new and emerging waste streams and observed data and information presented by the Regional 3R and Circular Economy Forum and submitted country reports considering the SDGs and aimed to provide few recommendations.

5.1 Summarized the challenges

The report briefed on the region's challenges based on recognition and prioritization of the issue, policy promulgation and regulation enforcement, development and evolution of the institutional framework, and technological interventions in the region. Since the launch of the 3R initiative in the region through the Regional 3R and Circular Economy Forum in Asia and the Pacific in 2009, there has been increasing prioritization of 3R policy and programmes in the region. In addition, a circular business model would be an opportunity to manage new and emerging waste in the region effectively. However, a few things could be improved in the region, such as the changes happening very slowly because of the multiple challenges throughout the entire value chain to meet the 3RGs. These challenges are categorized in various sections, as summarized in **Table 5.1-1**

Table 5.1-1: Summary of Challenges under Each Head. Source: (UNCRD et al., 2018e)

No.	Challenges
Policy and Regulatory	
1.	Uncontrolled dumping and burning of municipal wastes.
2.	Compliance to the regulations
3.	Illegal trafficking in waste.
4.	Transboundary movement
Technology	
1.	Problematic including additives in the product.
2.	Limited collection schemes and treatment technologies for different countries.
3.	Non applicability of available technology.
4.	Lack of available infrastructure
5.	Lack of technology adoption and assimilation
Institutional	
1.	Poor data on the recycling industry and waste management chain.
2.	Regulatory burdens of materials classified as waste.
3.	Concerns over environmental standards for recycling in emerging markets.
4.	Waste collection systems for wastes not available for a substantial proportion of the value chain.
5.	Lack of segregation of waste.
6.	Global markets concentrated in a small number of countries
Financial	
1.	Costs of collecting, sorting and processing waste.
2.	Limited resilience of the sector to market shocks.
3.	Lack of differentiated demand for recycled products.
4.	Competition between recycling and energy from waste.
5.	Regulatory burdens of materials classified as waste.
6.	

6.2 Key Recommendations and Way Forward

The key recommendations are proposed across the upstream, downstream, and the entire value chain in the region as described in **Table 5.2-1**

Table 5.2-1: Summary of Recommendations. Source: (UNCRD et al., 2018e)

No.	Challenges
Policy and Regulatory	
1.	Mandate requirement for recycled content to create demand.
2.	Ban or reduce contaminants including hazardous contaminants and additives.
3.	Mandate labelling for biodegradable items and improve associated standards.
4.	Use taxes or trading mechanisms to internalise the externalities associated with primary plastics. This will support the price of recycled plastics.
5.	Ban plastics from landfill to drive supply of material and increase economies of scale, reduce costs and increase resilience.
6.	Use Extended Producer Responsibility (EPR) regulation to drive supply of material and increase economies of scale, reduce costs and increase resilience.
7.	Ensure regulation is proportionate and clarify end-of-waste requirements.
8.	Develop effective voluntary standards for recycling sector to limit need for regulation.
9.	Industry-led initiatives to prevent waste crime including transboundary movement.
10.	Regulation and enforcement to ensure consistent environmental standards in global markets.
11.	Mandate sellers to establish and audit end- destinations for environmental standards.
Technology	
1.	Develop alternatives to problematic and hazardous additives and design for environment including effects of problematic additives in recycled waste.
2.	Support development of domestic reprocessing capacity to reduce reliance on global markets.
3.	Support development of better and more cost- effective technologies including digital and smart for collecting, transporting and sorting waste.
4.	Business must promote design for environment and agree to use materials that are recycled and ensure that their raw material extractions are sustainable and socially responsible.
Institutional	
1.	Use public sector procurement policies to create demand for recycled content.
2.	Provide information and training to designers and manufacturers to encourage use of recycled content.
3.	Provide information to consumers to encourage purchase of products using recycled content and drive demand.
4.	Encourage openness about standards and provide information on end-destinations.
5.	Work with supply chain to encourage use of recycled content.
6.	Standardise waste collection systems to increase economies of scale and reduce costs.
7.	Introduce mandatory data reporting mechanisms for plastics recycling.
8.	Enforcement action to reduce illegal dumping, particularly in low and middle income countries where dumping is common place.
9.	Enforcement action to reduce illegal waste trafficking.
10.	Charge waste producers for collection and disposal of non-recyclable waste.
11.	Raise public awareness in order to create demand for recycled products, and to reduce littering and dumping.
12.	Share best practice on all aspects of the collection, segregation and reprocessing supply chain.
13.	Industry-led initiative to ensure consistent environmental standards in global markets.
14.	A plan needs to be in place for consumers to use products responsibly and reduce the amount of waste created during the use phase
15.	Circularity needs to be introduced with materials.
Financial	
1.	Set statutory targets for recycling to drive supply of material, increase economies of scale, reduce costs and increase resilience of the supply chain.
2.	Mobilise investment for developing collection, sorting and processing systems, particularly in low income countries including Island Nations.

3.	Direct or indirect government support for recycled products.
4.	Incentivise recycling over energy from waste by introducing a tax to reflect the relative environmental burdenandbenefit.
5.	Support the development and demonstration of commercially viable technologies for mixed andand or low value waste.
6.	Use financial market mechanisms to increase the resilience of the market to fluctuations in prices (e.g. futures markets).
7.	Business need to invest in technologies and innovation that make it possible to avoid materials that are unrecyclable because of toxicity.

The main four categories are essential for effective waste management system:

(i) Strengthening institutional foundation – legislations, policies, strategies, and standards

One of the biggest challenges is to develop a waste management ecosystem that can promote policies, legislation, and standards on the new and emerging waste streams. Resource efficiency, resource productivity, and waste reduction measures must be accelerated in the region. This directly influences effective service delivery, clarifying roles and responsibilities among different stakeholders, and setting clear objectives, priorities, and built-in-mechanisms for implementation, monitoring, feedback, and improvement. The efficient and effective waste management system should be flexible enough to accommodate new waste streams such as waste from solar panels and electric vehicle batteries. A strict combination of policy instruments such as banning and prohibition, should be applied prudently for effective management and to make environment cleaner and safer. The involvement of stakeholder engagement and consensus building-based policy must be addressed.

(ii) Securing finance and promotion of private sector investment

There is a need to reform the existing public sector funding in waste management systems. In addition to public sector funding, there is a need to intensify the involvement of the private sector to support the waste management system. This could be through public-private partnerships and “Polluter Pay Principles.” The brands should be more accountable for the cost of pollution from their products. The public sector financing should cover a volume-based fee system, solid waste collection and treatment charges to cover investment costs as well and financial incentives such as subsidies, and soft loans, for tax benefits for sound recycling technologies can be introduced. Other mechanisms to mitigate pollution from a product should internalize costs, incurred diving its Life Cycle. Furthermore, the gaps between institutional and financial requirements should be bridged.

(iii) Filling implementation gaps between rural and urban areas

There is a huge urban and rural areas in the sound waste management systems in the region. The rural waste management system should be synergistic with urban waste management system. For example, a hub and spoke model has the potential for extending the boundaries of 3R and waste management system but also diffusing the principles of circularity and sustainability across the population. The example from India, Swachh Bharat – Rural launched with Swachh Bharat – Urba mission provide a synergistic program of garbage free India at national, regional and local level.

(iv) Promoting capacity development for emerging ecosystem, operation and maintenance

As the system is evolving with internalization of circularity, sustainability and environmental and social governance there is an urgent need for Reskilling and capacity development in the region. The quick intervention of technologies in every new and emerging waste value chain has further accelerated and needs to be done as top priority in the region. The capacity for data management and evidence-based policy making needs to be enhanced for the continued progress of the 3R and circular economy in the region.

6.3 Convergence with Sustainability and Rebooting the Economy with Circular Solutions

The extraction and processing of resources causes half of global greenhouse gas emissions and much of biodiversity loss and water stress (UNEP, 2020a). It is proved that the "take-make-use-discard" model is enormously inefficient. It not only depletes the planet's limited resources and creates a multitude of waste, pollution and health issues, it also substantially contributes to greenhouse gas (GHG) emissions (UNIDO, 2019). The major studies indicate that the world is only 8.6 percent circular (UNEP, 2020a). Measures to reduce emissions and stay within the 1.5 degree target have surged considerably, and as the world approaches 2030, taking steps to achieve the Sustainable Development Goals is becoming increasingly urgent (UN HABITAT, 2021). The circular economy presents many opportunities for businesses in the waste management sector. The model of circular economy is founded on the idea of bringing the waste back, at least partially, into the streamline of production so that it goes back into the production loop and can either become the resource for the next cycle of production or is channeled for an independent new product (Khajuria et a., 2022). It offers to design the materials for longevity, leasing and sharing assets and upgrading or repairing products, provide organisations with a steady stream of supplies (Circular, 2022). It also offers potential of the substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries (UNDRR, 2015). The Ellen MacArthur Foundation stated that, "we must use the opportunity to show that transitioning to a circular economy is "vital" to tackle climate change, as well as waste and biodiversity loss". It is crucial to promote sustainable municipal solid waste management and the transition to a low-carbon economy (Circular, 2022). So, there is huge space for circularity and sustainability to bring rapid and extensive gains. It is foreseen that future climate ambitions not only should achieve 1.5ºC but will be enhanced, not dampened.

To achieve this scenario, the above sections clearly identify that the right policies and incentives should be in place in the region. The policies incentivize intelligent design for circularity, extend product life, and establish infrastructure for waste management and recycling will be institutionalized in future in the region. In addition, it will also lead to business and finance step up in near future in the region. Furthermore, the new technologies will enhance the effective and efficient waste management system in the region. The future digitalization for networking and collaboration, innovation and education will increase the adoption and impact of sustainable lifestyles and leads to clean and safe recycling. Initiative will be taken for decontamination, neutralizing the dangerous substances, toxic free manufacturing along with safer production for people and the planet in future (UNIDO, 2019). A circular economy includes two major enabling factors: material is recycled in a secure way, ensuring that it does not lose its value; and a comprehensive and dedicated approach is taken to managing chemicals and wastes in which cost-related problems are avoided from the start. Indeed, the waste hierarchy in circular economy establishes a range of measures for waste prevention, minimization, reuse, recycling, resource conservation, safety, and energy recovery in terms of sustainability criteria (Kumar and Shukla, 2021).

The municipal solid waste could be effectively managed through a waste hierarchy approach that puts efforts to reduce consumption and increase reuse ahead of efforts focused on waste collection, recovery, and disposal This approach focused on the concrete actions, efforts and initiatives to protect development gains from the risk of climate, disaster and material depletion (UNDRR, 2015).Furthermore, this approach works hand in hand with the various global agendas, the 2030 Agenda for Sustainable Development, Sendai Framework, Basel, Rotterdam and Stockholm conventions, Paris Agreement on Climate Change, The Addis Ababa Action Agenda on Financing for Development, the New Urban Agenda.. The momentum generated by the region for facilitation of 3R policy dialogues and consolidation of 3R policies, strategies, programs and projects need to be sustained in the future. The reporting of 3RGs provide a regional framework of comprehensive understanding and this continued process may help to achieve the circularity and sustainability in the region. and would help to converge towards sustainability and other UN conventions and global agendas**.**

5.4 Key Messages: Chapter 5

The challenges have been framed based on various aspects such as recognition and prioritization of the issue, policy promulgation and regulation enforcement, development and evolution of institutional framework and, technological interventions. These challenges are categorized in policy and regulatory challenges, institutional challenges, technology challenges and financial challenges.

A way forward has been proposed in the form of summarized interventions described across the upstream, downstream and the entire chain of the product. These interventions can be classified i*n four categorized such as* (i) Strengthening institutional foundation – legislations, policies, strategies, and standards; (ii) Securing finance and promotion of private sector investment; (iii) Filling implementation gaps between rural and urban areas and; (iv) Promoting capacity development for emerging ecosystem, operation and maintenance. Finally, it is recommended that the momentum generated by the region for facilitation 3R policy dialogues and consolidation of 3R policies, strategies, programs and projects need to be sustained in the future. The reporting of 3RGs provide a regional framework of comprehensive understanding of the progress of the region and it should continue and helps to achieve and converge towards sustainability and other UN conventions.

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Appendix 1 – Ha Noi 3R Declaration[1] - Sustainable 3R Goals for Asia and the Pacific for 2013 - 2023

Preamble

We, the representatives of Asia and the Pacific countries (Australia, Bangladesh, Bhutan, Brunei Darussalam, Cambodia, PR China (hereinafter, PR China)[2], Fiji, India, Indonesia, Japan, Kiribati, Republic of Korea, Lao PDR, Malaysia, Maldives, Marshall Islands, Federated States of Micronesia, Mongolia, Myanmar, Palau, Papua New Guinea, the Philippines, Samoa, Singapore, Solomon Islands, Thailand, Timor-Leste, Tonga, Tuvalu, and Viet Nam), international organizations, bilateral and multilateral agencies, research organizations, and professionals in the field of waste management, who have met at the 4th Regional 3R Forum in Asia, held in Ha Noi, Viet Nam, from 18 to 20 March 2013, to demonstrate our renewed commitment to realizing a promising decade (2013-2023) of sustainable actions and measures for achieving resource efficient society and a green economy in the Asia and the Pacific region through the implementation of the 3Rs (reduce, reuse, and recycle),

Reaffirming, as noted in the *Johannesburg Plan of Implementation*, the need for consolidated efforts to prevent and minimize waste and to maximize reuse, recycling, and use of environmentally-friendly alternative materials, with the participation of government authorities and all stakeholders, in order to minimize adverse effects on the environment and improve resource efficiency,

Noting the key global issues in the waste sector highlighted at the 18th and 19th sessions of the Commission on Sustainable Development held in 2010 and 2011, such as: the need to move towards a zero waste society; the requirement for special attention on particular types of waste, in particular the emerging new waste streams such as electronic waste, plastics in the marine environment, and oil and lubricants; the critical role of partnerships and international cooperation; and the significance of education and public awareness that lead to behavioural change,

Reaffirming and building upon the *Tokyo 3R Statement* announced by the participants at the Inaugural Meeting of the Regional 3R Forum in Asia, held in Tokyo, Japan, on 11 and 12 November 2009, which endorsed the establishment of the Forum and set the regional priorities in the area of the 3Rs, and subsequently on the outcome of the IInd Regional 3R Forum held in Kuala Lumpur, Malaysia from 4 to 6 October 2010, which addressed the 3Rs for Green Economy and Sound Material-Cycle Society,

Building on the Recommendations of the Singapore Forum on the 3Rs in Achieving a Resource Efficient Society in Asia, annexed to the Chair's Summary of the 3rd Regional 3R Forum held in Singapore from 5 to 7 October 2011 and submitted by the Government of Singapore to the Rio+20 process as an official input, which listed a comprehensive set of recommendations covering a wide range of sectors based on the fundamental understanding that the 3Rs are intrinsically linked with resource efficiency in a wide range of sectors such as agriculture, industry, and energy, among others, towards transitioning to a resource-efficient and green economy,

Underscoring the critical importance of improving water use, central to all the other dimensions of sustainable development, and the fact that a third of the world's population is affected by water scarcity, which is further compounded by widespread discharge of wastes and untreated industrial effluents into rivers, water bodies, and valuable wetlands in many parts of the world, and thereby ***noting*** the important nexus between protection of freshwater resources and integrated waste management,

Noting the growing urbanization along with the diversification of waste streams worldwide as well as the growing presence of chemicals and hazardous and toxic elements in the general waste stream, which require a more extensive collaboration and partnerships among the different stakeholders – governments, civil society, private sector, local communities, international organizations, and the UN system, to deal with such complex and daunting nature of waste management challenges faced by local authorities and municipalities, and thereby further ***noting*** the objectives of IPLA3,

Reaffirming the importance of technical cooperation among developing countries (TCDC) as recognized in the *Buenos Aires Plan of Action* and as endorsed by the United Nations General Assembly (UNGA) in 19784, that

[1] The Ha Noi 3R Declaration is a legally non-binding voluntary document.
[2] China will confirm the government clearance and report back to the Secretariat in due course.

calls for strengthening overall cooperation among developing countries as well as increasing their collective and individual capacity for absorption and adaptation of technology and skills to meet their specific developmental needs,

Welcoming the United Nations Envirnment Programme (UNEP)andGoverning Council decision 27and12 to continue facilitating ongoing international cooperation and coordination focusing on waste prevention, minimization, and management, including the progress in establishing the Global Partnership on Waste Management hosted by the UNEPandInternational Environmental Technology Centre,

Acknowledging the unique and effective roles the 3Rs can play by offering a complementary and integrated package of measures and tools to harness recyclable resources, energy, and economic benefits from waste,

Recognizing that the 3R approach, which is fundamentally an approach that requires efficient use of resources from the point of extraction up to their final disposal, could make a significant contribution in reducing greenhouse gas (GHG) emissions from the entire life-cycle of resources and products,

Noting the rapid growth of resource use in the Asia and the Pacific region in the last three decades and the huge potential for future growth, and also ***noting*** the rapid growth of energy use in the region, now accounting for over 35 per cent of the world's energy consumption and expected to grow further under the "business as usual" scenario5, thereby ***recognizing*** the need to increase resource and energy efficiency for sustainable development in Asia and the Pacific,

Affirming the recommendation made by the United Nations Secretary-General's High-Level Panel on Global Sustainability, in its report titled "Resilient people, resilient planet: A future worth choosing," that Governments should adopt whole-of-government approaches to sustainable development issues, under the leadership of the Head of State or Government and involving all relevant ministries for addressing such issues across sectors (Recommendation 42),

Recognizing the issues and challenges faced by Small Island Developing States (SIDS) in achieving sustainable development in view of their unique and particular vulnerabilities, including their small size, remoteness, narrow resource and import base, and exposure to global environmental challenges and external economic shocks, including a large range of impacts from climate change and potentially more frequent and intense natural disasters,

Noting the importance of adopting a life-cycle approach and of further development and implementation of policies for resource efficiency and environmentally-sound waste management as contained in the Outcomes Document of the *Rio+20–the UNCSD-"The Future We Want*", and wherein, the Heads of States and Governments adopted the 10-year framework of programmes on sustainable consumption and production and committed to further reduce, reuse, and recycle waste (3Rs) and to increase energy recovery from waste, with a view to managing the majority of global waste, including e-waste and plastics that pose particular challenges, in an environmentally-sound manner and, where possible, as a resource,

Noting further the call of the Heads of States and Governments at Rio+20 for the development and enforcement of comprehensive national and local waste management policies, strategies, laws and regulations, and new and innovative public-private partnerships among industry, governments, academia, and other non-governmental stakeholders aiming to enhance capacity and technology for environmentally-sound chemicals and waste management, including waste prevention,

Express our resolve to voluntarily develop, introduce, and implement policy options, programmes, and projects towards realizing the following sustainable 3R goals in the region, with an ultimate goal of achieving a resource-efficient and resilient society and transitioning to green economy:

Sustainable 3R Goals (3RGs) for Asia and the Pacific for 2013-2023

I. 3R Goals in Urban and Industrial Areas	
a) 3Rs in municipal solid waste	
Goal 1	Significant **reduction** in the quantity of **municipal solid waste** generated, by instituting policies, programmes, and projects at national and local levels, encouraging both producers and consumers to reduce the waste through greening production, greening lifestyle, and sustainable consumption.

Goal 2	Full-scale utilization of the **organic component of municipal waste, including food waste,** as a valuable resource, thereby achieving multiple benefits such as the reduction of waste flows to final disposal sites, reduction of GHG emission, improvement in resource efficiency, energy recovery, and employment creation.
Goal 3	Achieve significant **increase in recycling rate** of recyclables (e.g., plastic, paper, metal, etc.), by introducing policies and measures, and by setting up financial mechanisms and institutional frameworks involving relevant stakeholders (e.g., producers, consumers, recycling industry, users of recycled materials, etc.) and development of modern recycling industry.
Goal 4	Build **sustainable cities and green cities** by encouraging "**zero waste**" through sound policies, strategies, institutional mechanisms, and multi-stakeholder partnerships (giving specific importance to private sector involvement) with a primary goal of **waste minimization**
b) 3Rs in industrial waste	
Goal 5	Encourage the **private sector**, including small- and medium-sized enterprises (**SMEs**) to implement measures to increase **resource efficiency and productivity**, creation of decent work and to improve environmentally-friendly practices through applying environmental standards, clean technologies, and cleaner production.
Goal 6	Promote the **greening of the value chain** by encouraging industries and associated suppliers and vendors in socially responsible and inclusive ways.
Goal 7	Promote **industrial symbiosis** (i.e., recycling of waste from one industry as a resource for another), by providing relevant incentives and support.
Goal 8	Build **local capacity** of both current and future practitioners, to enable the private sector (including SMEs) to obtain the necessary knowledge and technical skills to foster green industry and create decent, productive work.
Goal 9	Develop proper **classification and inventory of hazardous waste** as a prerequisite towards sound management of such waste.
II. 3R Goals in Rural Areas	
Goal 10	**Reduce losses in the overall food supply chain** (production, post harvesting and storage, processing and packaging, distribution), leading to reduction of waste while increasing the quantity and improving the quality of products reaching consumers.
Goal 11	Promote full scale **use of agricultural biomass waste and livestock waste** through reuse and recycle measures as appropriate, to achieve a number of co-benefits including GHG emission reduction, energy security, sustainable livelihoods in rural areas and poverty reduction, among others.
III. 3R Goals for New and Emerging Wastes	
Goal 12	Strengthen regional, national, and local efforts to address the issue of **waste, in particular plastics** in the marine and coastal environment.
Goal 13	Ensure **environmentally-sound management of e-waste** at all stages, including collection, storage, transportation, recovery, recycling, treatment, and disposal with appropriate consideration for working conditions, including **health and safety aspects** of those involved.
Goal 14	Effective enforcement of established mechanisms for preventing illegal and inappropriate export and import of waste, including transit trade, especially of hazardous waste and e-waste.
Goal 15	Progressive implementation of **"extended producer responsibility (EPR)"** by encouraging producers, importers, and retailers and other relevant stakeholders to fulfill their responsibilities for collecting, recycling, and disposal of new and emerging waste streams, in particular e-waste.
Goal 16	**Promote the 3R concept** in health-care waste management.
IV. 3R Goals for Cross-cutting Issues	
Goal 17	Improve **resource efficiency and resource productivity** by greening jobs nation-wide in all economic and development sectors.
Goal 18	Maximize co-benefits from waste management technologies for local air, water, oceans, and soil pollution and global climate change.
Goal 19	Enhance **national and local knowledge base and research network on the 3Rs and resource efficiency**, through facilitating effective and dynamic linkages among all stakeholders, including governments, municipalities, the private sector, and scientific communities.
Goal 20	Strengthen multi-stakeholder partnerships among governments, civil society, and the private sector in raising public awareness and advancing the 3Rs, sustainable consumption and production, and resource efficiency, leading to the behavioural change of the citizens and change in production patterns.
Goal 21	**Integrate the 3Rs** in formal education at primary, secondary, and tertiary levels as well as non-

	formal education such as community learning and development, in accordance with Education for Sustainable Development.
Goal 22	**Integrate the 3R concept** in relevant policies and programmes, of key ministries and agencies such as Ministry of Environment, Ministry of Agriculture, Forestry and Fisheries, Ministry of Industry, Ministry of Trade and Commerce, Ministry of Energy, Ministry of Water Resources, Ministry of Transport, Ministry of Health, Ministry of Construction, Ministry of Finance, Ministry of Labour, Ministry of Land and Urban Development, Ministry of Education, and other relevant ministries towards transitioning to a resource-efficient and zero waste society.
Goal 23	Promote **green and socially responsible procurement** at all levels, thereby creating and expanding 3R industries and markets for environmentally-friendly goods and products.
Goal 24	**Phase out harmful subsidies that favour unsustainable use of resources (raw materials and water) and energy**, and channel the freed funds in support of implementing the 3Rs and efforts to improve resource and energy efficiency.
Goal 25	**Protect public health and ecosystems, including freshwater and marine resources** by **eliminating illegal** activities of open dumping, including dumping in the oceans, and controlling open burning in both urban and rural areas.
Goal 26	Facilitate the international circulation of re-usable and recyclable resources as well as remanufactured products as mutually agreed by countries and in accordance with international and national laws, especially the *Basel Convention*, which contributes to the reduction of negative environmental impacts and the effective management of resources.
Goal 27	Promote data collection, compilation and sharing, public announcement and application of statistics on wastes and the 3Rs, to understand the state of waste management and resource efficiency.
Goal 28	Promote heat recovery (waste-to-energy), in case wastes are not re-usable or recyclable and proper and sustainable management is secured.
Goal 29	Promote overall regional cooperation and multi-stakeholder partnerships based on different levels of linkages such as government-to-government, municipality-to-municipality, industry-to-industry, (research) institute-to-institute, and NGO-to-NGO. Encourage technology transfer and technical and financial supports for 3Rs from developed countries to less developed countries.
Goal 30	Pay special attention to issues and challenges faced by developing countries including SIDS in achieving sustainable development.
Goal 31	Promote 3R + "Return" concept which stands for Reduce, Reuse, Recycle and "Return" where recycling is difficult due to the absence of available recycling industries and limited scale of markets in SIDS, especially in the Pacific Region.
Goal 32	Complete elimination of illegal engagement of children in the **informal waste sector** and gradually **improve** the working conditions and livelihood security, including **mandatory provision of health insurance,** for all workers.
Goal 33	Promote 3Rs taking into account gender considerations.

Below is the list of monitoring indicators that the countries may use for monitoring specific progress made on 3Rs and resource efficiency. The *Ha Noi 3R Declaration* is a legally non-binding and voluntary document, and thus countries may opt for developing a number of additional and alternative indicators and measures to monitor progress in their respective countries.

The objective of such a comprehensive list of indicators is to provide guidelines for objective measurement and monitoring of the implementation of 3Rs to achieve the desired goals.

The countries may wish to develop their own sets of indicators in order to determine **specific, quantifiable targets within a timeframe** using the recommended set of indicators below, against which progress can be monitored and recorded in a systematic manner.

GOALS	MONITORING INDICATORS
I. 3R Goals in Urban and Industrial Areas	
a) 3Rs in municipal solid waste (MSW)	
1) Significant **reduction** in the quantity of **municipal solid waste** generated, by instituting policies, programmes and projects at national and local levels, encouraging both producers and consumers to reduce waste through greening	• Total generation of MSW per capita. • Total amount of MSW going to landfill. • Number of Integrated Solid Waste Managementand3Rs or other relevant policies and

GOALS	MONITORING INDICATORS
production, greening lifestyle, and sustainable consumption.	programmes introduced at local levels. • Specific policies and mechanisms that lead to reduction of disposable plastic bags, packaging, and other single-use consumer products. • Annual government expenditure per capita on consumer awareness-raising. • Total waste disposed per capita.
2) Full-scale utilization of the **organic component of municipal waste, including food waste,** as a valuable resource, thereby achieving multiple benefits such as the reduction of waste flows to final disposal site, reduction of GHG emission, improvement in resource efficiency, energy recovery, and employment creation.	• Organic waste landfilled per capita, or per amount landfilled. • Amount of organic component of MSW composted. • Amount of organic waste component of MSW treated by anaerobic digestion. • Number of cities that have introduced successful source separation programmes. • Number of jobs in organic waste management (formal and informal). • Amount of organic waste component of MSW treated by waste-to-energy.
3) Achieve significant **increase in recycling rate** of recyclables (e.g., plastic, paper, metal, etc.), by introducing policies and measures, and by setting up financial mechanisms and institutional frameworks involving relevant stakeholders (e.g., producers, consumers, recycling industry, users of recycled materials, etc.) and development of modern recycling industry.	• Overall Recycling Rate (percent). • Recycling rate (percent) of paper. • Recycling rate (percent) of plastic. • Market size of recyclables. • Number of state-of-art recycling facilities for key recyclables. • Employment in recycling industries. • Number of cities that have introduced successful source separation programmes.
4) Build **sustainable cities and green cities** by encouraging "**zero waste**" through sound policies, strategies, institutional mechanism, and multi-stakeholder partnerships (giving specific importance to private sector involvement) with primary goal of **waste minimization**.	• Number of cities adopting zero waste strategies. • National policies and programmes introduced and strengthened to support local authorities in implementing zero-waste programmes. • Number of public-private-partnerships in waste management. • Amount of private sector investment in waste management sector. • Number of registered private sector firms with track record of providing waste management services. • Number of cities that implement inclusive and integrated waste management systems that address the environmental, social, and labour (meaningful work) issues of waste, and include informal workers and organizations in their systems.
b) 3Rs in Industrial sector (including SMEs)	
5) Encourage **private sector**, including small- and medium-sized enterprises (**SMEs)** to implement measures to increase **resource efficiency and productivity**, creation of decent work and to improve environmentally-friendly practices through applying environmental standards, clean technologies, and cleaner production.	• Policy instrument(s) that support resource efficiency and productivity are introduced or strengthened at national and local levels. • Policy instruments are introduced aiming at improving labour conditions and eliminating substandard employment contracts. • Number of SMEs receiving expert advice, training, and other support from the Centre of Excellence for resource efficiency (e.g., Cleaner Production Centre). • Annual government expenditure on cleaner

GOALS	MONITORING INDICATORS
	production programmes as a per cent of Gross domestic product
6) Promote the **greening of the value chain** by encouraging industries and associated suppliers and vendors in socially responsible and inclusive ways.	• Number of companies that have introduced green supply chain management. • Number of companies that have introduced green accounting and voluntary environmental performance evaluation (The International Organization for Standardization, 14000). • Number of companies that have introduced social accounting (SA 8000) in consultation with workers (and through Social Dialogue in the workplace). • Vocational training activities and programmes on skills for green jobs in the waste management value chain incorporated in local and national Technical and Vocational Education and Training policies and programmes.
7) Promote **industrial symbiosis** (i.e., recycling of waste from one industry as a resource for another), by providing relevant incentives and support.	• Number of eco-industrial parks and the like. • Policy instrument(s) introduced or strengthened to incentivize industrial symbiosis. • Recycling rate (percent) of industrial waste from selected sectors.
8) Build **local capacity** of both current and future practitioners, to enable private sector (including SMEs) to obtain the necessary knowledge and technical skills to foster green industry and create decent, productive work.	• Number of qualified technical advisors on resource and energy efficiency. • Specific curricula developed and introduced for universities, business schools, employers organizations, worker's organizations, and vocational schools aiming at increased productivity including through improved working conditions and decent labour contracts. • Annual government expenditure on building capacity of SMEs in promoting environmentally-friendly technologies and practices.
9) Develop proper **classification and inventory of hazardous waste** as a prerequisite towards sound management of hazardous waste.	• Proper classification and inventory of hazardous waste developed.
II. 3R Goals in Rural Areas	
10) **Reduce losses in the overall food supply chain** (production, post harvesting and storage, processing and packaging, distribution), leading to reduction of waste while increasing the quantity and improving the quality of products reaching the consumers.	• Percentage of food loss at each stage of food supply chain.
11) Promote full-scale **use of agricultural biomass waste and livestock waste** through reuse and recycling measures as appropriate, to achieve a number of co-benefits including GHG emission reduction, energy security, sustainable livelihoods in rural areas, and poverty reduction, among others.	• Amount of agricultural biomass waste and livestock waste recycled. • Number of new projects initiated that use agricultural biomass waste and livestock waste as material inputs.
III. 3R Goals for New and Emerging Wastes	
12) Strengthen regional, national and local efforts to address the issue of **waste, in particular plastics** in the marine and coastal environment.	• Number of coastal cities with complete ban on use of plastics packaging materials. • Issues of plastic waste considered as part of integrated coastal zone management (ICZM) plans. • National policies concerning plastic waste developed or strengthened, taking into consideration the impacts of plastic waste in

GOALS	MONITORING INDICATORS
	marine and coastal environment. • Regional initiatives initiated and strengthened to address the issue of plastic waste in the marine and coastal environment.
13) Ensure **environmentally-sound management of e-waste** at all stages, including collection, storage, transportation, recovery, recycling, treatment, and disposal, with appropriate considerations on working conditions, including **health and safety aspects** of those involved.	• Formal standards, certification system, and licensing procedures established and enforced. • Technical support services made available to informal sector and SMEs involved in e-waste management, that have raised awareness of workers and employers on the hazards of e-waste management and recycling at all stages. • Presence of, and access to, appropriate health-care services for informal sector workers. • Number of state-of-the-art recycling facilities for e-waste (such as mobile phones at their end-of-life). • Guidelines on environmentally-sound management of e-waste at all stages, including occupational safety and health standards, appropriate work spaces, and infrastructure, and protective working equipment developed and incorporated into local regulatory frameworks.
14) Effective enforcement of established mechanisms for preventing illegal and inappropriate export and import of waste, including transit trade, especially hazardous waste and e-waste.	• Reduction in the number of incidents of illegal export and import of e-waste against a measured baseline in a specific year. • Number of well-trained customs officials tracking illegal export and import.
15) Progressive implementation of **"extended producer responsibility (EPR)"** by encouraging producers, importers, and retailers and other relevant stakeholders to fulfill their responsibilities for collecting, recycling, and disposal of new and emerging waste streams, in particular e-waste.	• New EPR policies enacted, or existing policies strengthened. • List of (or number of) products and product groups targeted by EPR nationally.
16) **Promote 3R concept** in health-care waste management.	
IV. 3R Goals for Cross-cutting Issues	
17) Improve **resource efficiency and resource productivity** by greening jobs nation-wide in all economic and development sectors.	• Economy-wide Material Flow Accounting indicators, such as Total Material Requirement, Direct Material Input, and Domestic Material Consumption. • Energy efficiency schemes. • Product standards. • Guidelines on greening, including waste management businesses and jobs. • Number of green jobs, taking into consideration nationally-defined indicators. • Number of decent jobs, particularly in the areas of waste reduction and recycling, green product design and other green sectors.
18) Maximize co-benefits from waste management technologies for local air, water, oceans, and soil pollution and global climate change.	
19) Enhance **national and local knowledge base and research network on the 3Rs and resource efficiency**, through facilitating an effective and	• Policies introduced and strengthened, encouraging interaction between universities and private sector. • Number of collaborative projects, joint

GOALS	MONITORING INDICATORS
dynamic linkage among all stakeholders, including governments, municipalities, the private sector and scientific communities.	conferences and seminars by universities, government, and private sector. • Annual government expenditure in support of research and development on the 3Rs.
20) Strengthen multi-stakeholder partnerships among governments, civil society, and the private sector in raising public awareness and advancing the 3Rs, sustainable consumption and production, and resource efficiency, leading to the behavioural change of citizens and change in production patterns.	• Number of NGOs actively engaged in 3R promotion (e.g., waste reduction, recycling, composting, and green purchasing). • Annual government expenditure on public extension programmes. • Existence of national association of waste management and recycling professionals. • Charge for garbage collection. • Existence of ad-hoc multi-stakeholder committee to promote the 3Rs.
21) **Integrate the 3Rs** in formal education at primary, secondary, and tertiary levels as well as non-formal education such as community learning and development, in accordance with Education for Sustainable Development.	• Number of universities offering courses on the 3Rs and waste management at undergraduate or post graduate levels that include technical procedures, and environmental and social and labor impacts and opportunities. • Waste management, as a social and environmental challenge and the 3Rs and waste issues integrated into school curriculum. • Existence of community-based 3R activities.
22) **Integrate the 3R concept** in relevant policies and programmes, of key ministries and agencies such as Ministry of Environment, Ministry of Agriculture, Forestry and Fisheries, Ministry of Industry, Ministry of Trade and Commerce, Ministry of Energy, Ministry of Water Resources, Ministry of Transport, Ministry of Health, Ministry of Construction, Ministry of Finance, Ministry of Labour, Ministry of Land and Urban Development, Ministry of Education, and other relevant ministries towards transitioning to a resource efficient and zero waste society.	• Existence of a national 3R task force. • Number of sectoral policies and programmes that have integrated 3R concepts. • Number of cities introducing state-of-the-art 3R technologies in various sectors.
23) Promote **green and socially-responsible procurement** at all levels, thereby creating and expanding 3R industries and markets for environmentally-friendly goods and products.	• Number of government ministries that have adopted green procurement policy. • Eco-labels and eco-labeling schemes. • Labour standards, in particular safety of workers, embedded in waste management contracts. • Incentives in place for large-scale contractors to employ and train informal waste workers as needed. • Number of cities that have adopted green procurement policy.
24) **Phase out harmful subsidies that favour unsustainable use of resources (raw materials and water) and energy**, and channel the freed funds in support of implementing the 3Rs and efforts to improve resources and energy efficiency.	• Subsidies that favour unsustainable use of resources and energy are phased out. • Policy instruments(s) and programmes are in place in support of 3Rs and resourceand energy efficiency.
25) **Protect public health and ecosystem, including freshwater and marine resources** by **eliminating illegal** activities of open dumping, including dumping into the oceans, and controlling open burning in both urban and rural areas.	• Number of cities with open dumping and open burning. • Number of major rivers with open dumping and direct discharge of untreated domestic waste and industrial effluents. • Biological Oxygen Demand of major rivers, lakes,

GOALS	MONITORING INDICATORS
	etc.
26) Facilitate the international circulation of re-usable and recyclable resources as well as remanufactured products as mutually agreed by countries and in accordance with international and national laws, especially the *Basel Convention*, which contributes to the reduction of negative environmental impacts and the effective management of resources.	• Existence of framework for bilateral and multilateral cooperative activities toward efficient, legal, and appropriate trade of circulative resources. • Number of facilities certified by authorized bodies for environmental standard certification. • Market size of waste management and recycling industry. • Number of eco-industrial parks.
27) Promote data collection, compilation, and sharing, public announcements and application of statistics on waste and the 3Rs, to understand the state of waste management and resource efficiency.	• Existence of basic data on wastes and the 3Rs (such as material flow, resource productivity, cyclical use rate, amount of final disposal, and amount of exports and imports of wastes and recycled materials) required for 3R policy-making, planning, implementation, and monitoring. • Number of access to websites providing information on wastes and the 3Rs.
28) Promote heat recovery (waste-to-energy), in case wastes are not re-usable or recyclable and proper and sustainable management is secured.	• Existence of incentives to promote heat recovery. • Number of facilities equipped with heat recovery system.
29) Promote overall regional cooperation and multi-stakeholder partnerships based on different levels of linkages such as government-to-government, municipality-to-municipality, industry-to-industry, (research) institute-to-institute, and NGO-to-NGO. Encourage technology transfer and technical and financial supports for 3Rs from developed countries to less developed countries.	
30) Pay special attention to issues and challenges faced by developing countries including SIDS for achieving sustainable development.	• Number of 3R related projects implemented. • Number of 3R related projects linked to Climate Change, Biodiversity, Disaster Management, Tourism, and Industry.
31) Promote 3R + "Return" concept which stands for Reduce, Reuse, Recycle and "Return" where recycling is difficult due to the absence of available recycling industries and limited scale of market in SIDS, especially in the Pacific Region.	• Number of countries that have developed the 3R (+ "Return") strategy. • Number of countries that have developed and implemented economic instruments such as the container deposit programme, etc. • Number of recycling companies and organizations that have been trained on basic technique for recycling (preliminary processing). • Implementation of periodical review on "Return" collaboration between the Asia and the Pacific countries through 3R and Circular Economy Forum in Asia.
32) Complete elimination of illegal engagement of children in the **informal waste sector** and gradually **improve** working conditions and livelihood security, including **mandatory provision of health insurance** for all workers.	• Number of children in hazardous child labour (ILO definition) in waste sector (target set for 0). • Clear policy framework for informal waste sector integration in place. • Effective policy framework for integrating informal waste activities into integrated waste management schemes. • Waste pickers provided with contributory social security. • Landfill sites accessible only to registered waste pickers.

GOALS	MONITORING INDICATORS
	• Number of workers in informal and formal sector with access to social security and health care services. • Number of labour inspections in waste sector.

Appendix – 2: Country Reporting Guidelines

I. 3R Goals in Urban/Industrial Areas (3Rs in municipal solid waste)	
Goal 1	Significant **reduction** in the quantity of **municipal solid waste** generated, by instituting policies, programmes, and projects at national and local levels, encouraging both producers and consumers to reduce the waste through greening production, greening lifestyle, and sustainable consumption.

Q-1 What specific 3R policies, programmes and projects, are implemented to reduce the quantity of municipal solid waste?

Q-2 What is the level of participation of households in "source" segregation of municipal waste streams? (Please check the appropriate box)

☐ Very High (> 90%)
☐ High (>70%)
☐ Average (50-~70%)
☐ Low or not satisfactory (< 50%)
☐ Does not exist

***Q-3 Total annual governmen*t expenditure per capita (US$ per capita) in municipal solid waste management**

Challenges (policy/ institutional/ technological/ financial) faced in implementation:

Examples of pilot projects, master plans and/or policies developed or under development – include websites where relevant

Important policies/programmes/projects/master plans the government plans to undertake within next five years

Is this Goal relevant for your country*?* ☐ Highly ☐ Partially ☐ Not at all

I. 3R Goals in Urban/Industrial Areas (3Rs in municipal solid waste)	
Goal 2	Full-scale utilization of the organic component of municipal waste, including food waste, as a valuable resource, thereby achieving multiple benefits such as the reduction of waste flows to final disposal sites, reduction of GHG emission, improvement in resource efficiency, energy recovery, and employment creation.

Q-1 Does the central government have policies or support to utilize or reduce the organic waste such as composting, energy recovery and improving efficiency in food processing?

Q-2 What is happening to country's organic waste? (Please check the appropriate box)

☐ mostly landfilled
☐ mostly incinerated
☐ both landfilled and incinerated
☐ mostly open dumped or open burned

Challenges (policy/ institutional/ technological/ financial) faced in implementation:

Examples of pilot projects, master plans and/or policies developed or under development – include websites where relevant

Important policies/programmes/projects/master plans the government plans to undertake within next five years

I. 3R Goals in Urban/Industrial Areas (3Rs in municipal solid waste)	
Goal 2	Full-scale utilization of the organic component of municipal waste, including food waste, as a valuable resource, thereby achieving multiple benefits such as the reduction of waste flows to final disposal sites, reduction of GHG emission, improvement in resource efficiency, energy recovery, and employment creation.
Is this Goal relevant for your country*?* ☐ Highly ☐ Partially ☐ Not at all	

I. 3R Goals in Urban/Industrial Areas (3Rs in municipal solid waste)	
Goal 3	Achieve significant **increase in recycling rate** of recyclables (e.g., plastic, paper, metal, etc.), by introducing policies and measures, and by setting up financial mechanisms and institutional frameworks involving relevant stakeholders (e.g., producers, consumers, recycling industry, users of recycled materials, etc.) and development of modern recycling industry.

Q-1 What is the recycling rate of various recyclables? (Please check the appropriate cell & add more waste streams as relevant for the country)

Rate / Type	Very High (>90%)	High (>70%)	Average (50-~60%)	Poor (<50%)	Recycling does not exist	Definition of recycling rate*
Paper						
Plastic						
Metal						
Construction waste						
e-waste						
others						

**Note: Please specify in the cell which of the following definitions(ie., 1 or 2 or 3) is followed for recycling rate*
Definition 1: (collected recyclable waste)/(estimated generation of waste)
Definition 2: (volume of utilized recyclable waste)/(volume of raw material)
Definition 3: (volume of utilized recyclable waste)/(volume of collected waste for recycling)

Q-2 What specific policies are introduced at local and national level for prevention or reduction of waste streams – paper, plastic, metal, construction waste, e-waste?

Q-3 What is the rate of resource recovery from various waste streams?

Rate / Type	Very High (>90%)	High (>70%)	Average (50-~60%)	Poor (<50%)	Recycling does not exist
Paper					
Plastic					
Metal					
Construction waste					
e-waste					

(Please check the appropriate cell & add more waste streams as relevant for the country)

Q-4 What is the level of existence of resource recovery facilities/ infrastructures in cities?

Level / Type	Every Major City	Few Major Cities only	Does not exist	Supportive policy or programmes exists	No supportive policy or programmes
Paper					
Plastic					
Metal					
Construction waste					
e-waste					

I. 3R Goals in Urban/Industrial Areas (3Rs in municipal solid waste)	
Goal 3	Achieve significant **increase in recycling rate** of recyclables (e.g., plastic, paper, metal, etc.), by introducing policies and measures, and by setting up financial mechanisms and institutional frameworks involving relevant stakeholders (e.g., producers, consumers, recycling industry, users of recycled materials, etc.) and development of modern recycling industry.
Challenges (policy/ institutional/ technological/ financial) faced in implementation:	
Examples of pilot projects, master plans and/or policies developed or under development – include websites where relevant	
Important policies/programmes/projects/master plans the government plans to undertake within next five years	
Is this Goal relevant for your country? ☐ Highly ☐ Partially ☐ Not at all	

I. 3R Goals in Urban/Industrial Areas (3Rs in municipal solid waste)	
Goal 4	Build **sustainable cities /green cities** by encouraging "**zero waste**" through sound policies, strategies, institutional mechanisms, and multi-stakeholder partnerships (giving specific importance to private sector involvement) with a primary goal of **waste minimization**
Q-1 What specific waste management policies and programmes are introduced to encourage private sector participation in municipal waste management? ***Q-2 What are the major waste management areas that have strong involvement of private and business sector?*** (Please check appropriate boxes and add other areas if not listed below) ☐ waste collection ☐ resource recovery ☐ waste recycling ☐ waste to energy, composting, etc. ☐ PPP projects in waste sector	
Challenges (policy/ institutional/ technological/ financial) faced in implementation:	
Examples of pilot projects, master plans and/or policies developed or under development – include websites where relevant	
Important policies/programmes/projects/master plans the government plans to undertake within next five years	
Is this Goal relevant for your country? ☐ Highly ☐ Partially ☐ Not at all	

I. 3R Goals in Urban/Industrial Areas (3Rs in Industrial waste)	
Goal 5	Encourage the **private sector**, including small-and medium-sized enterprises (SMEs) to implement measures to increase **resource efficiency and productivity**, creation of decent work and to improve environmentally-friendly practices through applying environmental standards, clean technologies, and cleaner production.
Q-1 What are the major clean technology related policies aiming to increase energy and resource efficiency of SMEs? ***Q-2 What are the capacity building programmes currently in place to build the technical capacity of SMEs in 3R areas?***	
Challenges (policy/ institutional/ technological/ financial) faced in implementation:	
Examples of pilot projects, master plans and/or policies developed or under development – include websites	

I. 3R Goals in Urban/Industrial Areas (3Rs in Industrial waste)	
Goal 5	Encourage the **private sector**, including small-and medium-sized enterprises (SMEs) to implement measures to increase **resource efficiency and productivity**, creation of decent work and to improve environmentally-friendly practices through applying environmental standards, clean technologies, and cleaner production.
where relevant	
Important policies/programmes/projects/master plans the government plans to undertake within next five years	
Is this Goal relevant for your country? ☐ Highly ☐ Partially ☐ Not at all	

I. 3R Goals in Urban/Industrial Areas (3Rs in Industrial waste)	
Goal 6	Promote the **greening of the value chain** by encouraging industries and associated suppliers and vendors in socially responsible and inclusive ways.
Q-1 What percent of companies and industries have introduced green accounting and voluntary environmental performance evaluation (Ref: ISO 14000)? ☐ Very High (> 90%) ☐ High (>70%) ☐ Average (50-~70%) ☐ Low or not satisfactory (< 50%) ☐ None ***Q-2 What percent of companies and industries have introduced social accounting (Ref: SA 8000) in consultation with their workers?*** ☐ Very High (> 90%) ☐ High (>70%) ☐ Average (50-~70%) ☐ Low or not satisfactory (< 50%) ☐ None ***Q 3 Does government have a programme for promoting greening of the value chain? What specific policies, programmes and incentives are introduced to promote greening of value chain?***	
Challenges (policy/ institutional/ technological/ financial) faced in implementation:	
Examples of pilot projects, master plans and/or policies developed or under development – include websites where relevant	
Important policies/programmes/projects/master plans the government plans to undertake within next five years	
Is this Goal relevant for your country? ☐ Highly ☐ Partially ☐ Not at all	

I. 3R Goals in Urban/Industrial Areas (3Rs in Industrial waste)	
Goal 7	Promote **industrial symbiosis** (i.e., recycling of waste from one industry as a resource for another), by providing relevant incentives and support.
Q-1 Does your government have policies and programmes promoting industrial symbiosis in industrial parks or zones? What specific policies, programmes and incentives are introduced to promote industrial symbiosis? ***Q-2 How many eco-industrial parks or zones or the like, which is supported by the government, are there in the country?***	
Challenges (policy/ institutional/ technological/ financial) faced in implementation:	
Examples of pilot projects, master plans and/or policies developed or under development – include websites where relevant	
Important policies/programmes/projects/master plans the government plans to undertake within next five years	
Is this Goal relevant for your country? ☐ Highly ☐ Partially ☐ Not at all	

I. 3R Goals in Urban/Industrial Areas (3Rs in Industrial waste)	
Goal 8	Build **local capacity** of both current and future practitioners, to enable the private sector (including SMEs) to obtain the necessary knowledge and technical skills to foster green industry and create decent, productive work.
Q-1 How many dedicated training facilities or centers are there to cater the needs of SMEs and practitioners in the areas of cleaner production, resource efficiency and environment-friendly technologies, etc.? ***Q-2 Please provide an indicative figure on annual government (US $) expenditure on building technical capacity of SMEs and practitioners in the areas of cleaner production, resource efficiency and environment-friendly technologies, etc.?***	
Challenges (policy/ institutional/ technological/ financial) faced in implementation:	
Examples of pilot projects, master plans and/or policies developed or under development – include websites where relevant	
Important policies/programmes/projects/master plans the government plans to undertake within next five years	
Is this Goal relevant for your country? ☐ Highly ☐ Partially ☐ Not at all	

I. 3R Goals in Urban/Industrial Areas (3Rs in Industrial waste)	
Goal 9	Develop proper **classification and inventory of hazardous waste** as a prerequisite towards sound management of such waste.
Q-1 Is there a systematic classification of hazardous waste? If so, please attach. ☐ Yes ☐ No ***Q-2 What specific rules and regulations are introduced to separate, store, treat, transportation and disposal of hazardous waste?***	
Challenges (policy/ institutional/ technological/ financial) faced in implementation:	
Examples of pilot projects, master plans and/or policies developed or under development – include websites where relevant	

I. 3R Goals in Urban/Industrial Areas (3Rs in Industrial waste)	
Goal 9	Develop proper **classification and inventory of hazardous waste** as a prerequisite towards sound management of such waste.
Important policies/programmes/projects/master plans the government plans to undertake within next five years	
Is this Goal relevant for your country? ☐ Highly ☐ Partially ☐ Not at all	

II. 3R Goals in Rural Areas	
Goal 10	**Reduce losses in the overall food supply chain** (production, post harvesting and storage, processing and packaging, distribution), leading to reduction of waste while increasing the quantity and improving the quality of products reaching consumers.
Q-1 What specific policies, rules and regulations, including awareness programmes, are introduced to minimize food or crop waste? ***Q-2 Is there any continuing education services or awareness programmes for the farmers or agricultural marketing associations on reduction of crop wastes for increased food security?*** ***Q-3 What is the average wastage of crops or agricultural produce between farms to consumers, if there is a study in your country?*** ☐ Very High (> 20~ 30%) ☐ High (10~20%) ☐ Medium (5~10%) ☐ Low (< 5%) ☐ Negligible (<1%)	
Challenges (policy/ institutional/ technological/ financial) faced in implementation:	
Examples of pilot projects, master plans and/or policies developed or under development – include websites where relevant	
Important policies/programmes/projects/master plans the government plans to undertake within next five years	
Is this Goal relevant for your country? ☐ Highly ☐ Partially ☐ Not at all	

II. 3R Goals in Rural Areas	
Goal 11	Promote full scale **use of agricultural biomass waste and livestock waste** through reuse and/or recycle measures as appropriate, to achieve a number of co-benefits including GHG emission reduction, energy security, sustainable livelihoods in rural areas and poverty reduction, among others.
Q-1 How much amount of – (a) agricultural biomass waste and (b) livestock waste are grossly generated per annum? ***Q-2 How are most of the agricultural biomass wastes utilized or treated?*** (Please check all appropriate boxes) ☐ as secondary raw material input (for paper, bioplastic, furniture, etc.) ☐ biogas/electricity generation ☐ composts/fertilizers ☐ mostly left unutilized or open dumped ☐ mostly open burned ***Q-3 What specific policies, guidelines, and technologies are introduced for efficient utilization of***	

II. 3R Goals in Rural Areas	
Goal 11	Promote full scale **use of agricultural biomass waste and livestock waste** through reuse and/or recycle measures as appropriate, to achieve a number of co-benefits including GHG emission reduction, energy security, sustainable livelihoods in rural areas and poverty reduction, among others.
agricultural biomass waste and livestock waste as a secondary material inputs towards full scale economic benefits? Relevant websites could be shared for additional information.	
Challenges (policy/ institutional/ technological/ financial) faced in implementation:	
Examples of pilot projects, master plans and/or policies developed or under development – include websites where relevant	
Important policies/programmes/projects/master plans the government plans to undertake within next five years	
Is this Goal relevant for your country*?* ☐ Highly ☐ Partially ☐ Not at all	

III. 3R Goals for New and Emerging Wastes	
Goal 12	Strengthen regional, national, and local efforts to address the issue of **waste, in particular plastics** in the marine and coastal environment.
Q-1 What specific policies and regulations are in place to address the issue of plastic wastes in coastal and marine environment? ***Q-2 What extent issue of plastic waste is considered in integrated coastal zone management (ICZM)?*** *(Please check the appropriate box)* ☐ Very much ☐ Somehow ☐ Not at all ***Q-3 Please provide a list of centre of excellences or dedicated scientific and research programmes established to address the impacts of micro-plastic participles (<5 mm) on coastal and marine species? If yes, please provide relevant websites.***	
Challenges (policy/ institutional/ technological/ financial) faced in implementation:	
Examples of pilot projects, master plans and/or policies developed or under development – include websites where relevant	
Important policies/programmes/projects/master plans the government plans to undertake within next five years	
Is this Goal relevant for your country*?* ☐ Highly ☐ Partially ☐ Not at all	

III. 3R Goals for New and Emerging Wastes	
Goal 13	Ensure **environmentally-sound management of e-waste** at all stages, including collection, storage, transportation, recovery, recycling, treatment, and disposal with appropriate consideration for working conditions, including **health and safety aspects** of those involved.

Q-1 How do people usually recycle their e-waste (waste electrical and electronic equipment)? (Please check the appropriate box in order of priority by filling in numbers like 1, 2, 3, 4,….etc., for example 1 => Highest priority)

Check if applicable	Number in priority order	
		Take to recycling center / resource recovery facilities
		Take to landfill
		Take to the retailer
		Take to local charity for re-use
		Take to second-hand shop for re-use
		Ship back to the manufacturer
		Ship back to the manufacturer
		Recycle in another country
		Do not know how people dispose

Q-2 What specific policies and regulations are in place to ensure health and safety aspects of those involved in e-waste management (handling/sorting/resource recovery/recycling)?

Q-3 How much amount of e-waste is generated and recycled per year?

Type of e-waste	Estimated total volume generated (ton/year)	% of collected by permitted recycler	% of volume recycled in collected
Television			
Computer			
Mobile phone			
Refrigerators			
Washing machines			
Air conditioners			
Others…			

Challenges (policy/ institutional/ technological/ financial) faced in implementation:

Examples of pilot projects, master plans and/or policies developed or under development – include websites where relevant

Important policies/programmes/projects/master plans the government plans to undertake within next five years

Is this Goal relevant for your country? ☐ Highly ☐ Partially ☐ Not at all

III. 3R Goals for New and Emerging Wastes	
Goal 14	Effective enforcement of established mechanisms for preventing illegal and inappropriate export and import of waste, including transit trade, especially of hazardous waste and e-waste.

Q-1 What specific policies and regulations are introduced to prevent illegal import and export of e-waste?

Q-2 Do you have required number of well-trained custom or other officials (for airport. sea-port, land border control, etc.) to track illegal export and import of e-waste?
☐ Yes ☐ No

Challenges (policy/ institutional/ technological/ financial) faced in implementation:

Examples of pilot projects, master plans and/or policies developed or under development – include websites

III. 3R Goals for New and Emerging Wastes	
Goal 14	Effective enforcement of established mechanisms for preventing illegal and inappropriate export and import of waste, including transit trade, especially of hazardous waste and e-waste.
where relevant	
Important policies/programmes/projects/master plans the government plans to undertake within next five years	
Is this Goal relevant for your country*?* ☐ Highly ☐ Partially ☐ Not at all	

III. 3R Goals for New and Emerging Wastes	
Goal 15	Progressive implementation of "**extended producer responsibility (EPR)**" by encouraging producers, importers, and retailers and other relevant stakeholders to fulfill their responsibilities for collecting, recycling, and disposal of new and emerging waste streams, in particular e-waste.
Q-1 What specific Extended Product Responsibility (EPR) policies are enacted or introduced? (If there is none, then skip Q-2 below) ***Q2 Please provide a list of products and product groups targeted by EPR nationally?***	
Challenges (policy/ institutional/ technological/ financial) faced in implementation:	
Examples of pilot projects, master plans and/or policies developed or under development – include websites where relevant	
Important policies/programmes/projects/master plans the government plans to undertake within next five years	
Is this Goal relevant for your country*?* ☐ Highly ☐ Partially ☐ Not at all	

III. 3R Goals for New and Emerging Wastes	
Goal 16	**Promote the 3R concept** in health-care waste management.
Q-1 What specific policies and regulations are in place for healthcare waste management? ***Q-2 What is the total annual government expenditure towards healthcare waste management (US$ per year)?*** ***Q-3 List the agencies or authorities responsible for healthcare waste management.*** ***Q-4 What is the common practice for disposal of healthcare wastes?*** (Please check the appropriate box and add if any other practice followed) ☐ open dumping (untreated) ☐ open burning (untreated) ☐ ordinary landfilling (untreated) ☐ sanitary landfilling (treated) ☐ Low cost small scale incineration (do not meet air emission standards) ☐ Highly controlled air incineration (dedicated/modern medical waste incinerators) ☐ Other methods (please specify names:	
Challenges (policy/ institutional/ technological/ financial) faced in implementation:	
Examples of pilot projects, master plans and/or policies developed or under development – include websites where relevant	

III. 3R Goals for New and Emerging Wastes	
Goal 16	**Promote the 3R concept** in health-care waste management.
Important policies/programmes/projects/master plans the government plans to undertake within next five years	
Is this Goal relevant for your country? ☐ Highly ☐ Partially ☐ Not at all	

IV. 3R Goals for Cross-cutting Issues	
Goal 17	Improve **resource efficiency and resource productivity** by greening jobs nation-wide in all economic and development sectors.
Q-1 What specific policies and guidelines are introduced for product standard (towards quality/durability, environment/eco-friendliness, labour standard)? ***Q-2 What specific energy efficiency schemes are introduced for production, manufacturing and service sector?*** ***Q-3 What specific policies are introduced to create green jobs in product and waste sector?***	
Challenges (policy/ institutional/ technological/ financial) faced in implementation:	
Examples of pilot projects, master plans and/or policies developed or under development – include websites where relevant	
Important policies/programmes/projects/master plans the government plans to undertake within next five years	
Is this Goal relevant for your country? ☐ Highly ☐ Partially ☐ Not at all	

IV. 3R Goals for Cross-cutting Issues	
Goal 18	Maximize co-benefits from waste management technologies for local air, water, oceans, and soil pollution and global climate change.
Q-1 Please share how climate mitigation is addressed in waste management policies and programmes for co-benefits?	
Challenges (policy/ institutional/ technological/ financial) faced in implementation:	
Examples of pilot projects, master plans and/or policies developed or under development – include websites where relevant	
Important policies/programmes/projects/master plans the government plans to undertake within next five years	
Is this Goal relevant for your country? ☐ Highly ☐ Partially ☐ Not at all	

IV. 3R Goals for Cross–cutting Issues	
Goal 19	Enhance **national and local knowledge base and research network on the 3Rs and resource efficiency**, through facilitating effective and dynamic linkages among all stakeholders, including governments, municipalities, the private sector, and scientific communities.
Q-1 What specific policies are introduced to encourage triangular cooperation between government, scientific & research institutions and private/business sector in 3R areas? ***Q-2 Please share the number and list of dedicated scientific institution, or coordinating centers in the areas of 3Rs (e.g., waste minimization technologies, eco-products, cleaner production, recycling technologies, industrial symbiosis, resource efficiency, etc.)?***	
Challenges (policy/ institutional/ technological/ financial) faced in implementation:	
Examples of pilot projects, master plans and/or policies developed or under development – include websites where relevant	
Important policies/programmes/projects/master plans the government plans to undertake within next five years	
Is this Goal relevant for your country? ☐ Highly ☐ Partially ☐ Not at all	

IV. 3R Goals for Cross–cutting Issues	
Goal 20	Strengthen multi-stakeholder partnerships among governments, civil society, and the private sector in raising public awareness and advancing the 3Rs, sustainable consumption and production, and resource efficiency, leading to the behavioural change of the citizens and change in production patterns.
Q-1 Does central government have official dialogue with multi-stakeholders in the process to formulate 3R-related policies and regulations? Which stakeholders are involved in the dialogue?(Please check all applicable) ☐ NGOs ☐ Industrial Association ☐ Local Government ☐ Academic Institution ☐ Others, please add/specify ( ) ***Q-2 What is the level of NGOs' involvement in 3R, sustainable production and consumption, resource efficiency related promotional activities?*** (Please check the appropriate box) ☐ Very high ☐ Moderate ☐ Low ☐ Almost Negligible ***Q-3 What is the level of citizens' awareness on beneficial aspects of 3R, sustainable production and consumption and resource efficiency.*** (Please check the appropriate box) ☐ Very high ☐ Moderate ☐ Low ☐ Almost Negligible	
Challenges (policy/ institutional/ technological/ financial) faced in implementation:	
Examples of pilot projects, master plans and/or policies developed or under development – include websites where relevant	
Important policies/programmes/projects/master plans the government plans to undertake within next five years	
Is this Goal relevant for your country? ☐ Highly ☐ Partially ☐ Not at all	

IV. 3R Goals for Cross–cutting Issues	
Goal 21	**Integrate the 3Rs** in formal education at primary, secondary, and tertiary levels as well as non-formal education such as community learning and development, in accordance with Education for Sustainable Development.
Q-1 Provide a list of formal programmes that addresses areas of 3R and resource efficiency as part of the academic curriculum? ***Q-2 Please provide an overview of the Government policies and programmes to promote community learning and development (non-formal education) on 3R and sustainable waste management.*** ***Q-3 Please provide a list of academic and research institutions offering PhD programmes in the areas of 3Rs and resource efficiency?*** ***Q-4 Please provide a list of management institutions (offering BBA / MBA courses) which have integrated resource efficiency and life cycle assessment (LCA) as part of their curriculum or course development?***	
Challenges (policy/ institutional/ technological/ financial) faced in implementation:	
Examples of pilot projects, master plans and/or policies developed or under development – include websites where relevant	
Important policies/programmes/projects/master plans the government plans to undertake within next five years	
Is this Goal relevant for your country*?* ☐ Highly ☐ Partially ☐ Not at all	

IV. 3R Goals for Cross-cutting Issues	
Goal 22	**Integrate the 3R concept** in relevant policies and programmes, of key ministries and agencies such as Ministry of Environment, Ministry of Agriculture, Forestry and Fisheries, Ministry of Industry, Ministry of Trade and Commerce, Ministry of Energy, Ministry of Water Resources, Ministry of Transport, Ministry of Health, Ministry of Construction, Ministry of Finance, Ministry of Labour, Ministry of Land and Urban Development, Ministry of Education, and other relevant ministries towards transitioning to a resource-efficient and zero waste society.
Q-1 Please list the name of the Ministries and major Government Agencies which are promoting 3R and resource efficiency as part of their policy, planning and developmental activities at local and national level. ***Q-2 What type of coordination mechanism are there among ministries and agencies for a resource efficient economic development?*** □ Official regular coordination meeting among ministries and agencies □ Official ad-hoc coordination meeting among ministries and agencies □ Informal meeting among ministries and agencies □ Other coordination mechanisms (please add/specify)	
Challenges (policy/ institutional/ technological/ financial) faced in implementation:	
Examples of pilot projects, master plans and/or policies developed or under development – include websites where relevant	
Important policies/programmes/projects/master plans the government plans to undertake within next five years	
Is this Goal relevant for your country*?* ☐ Highly ☐ Partially ☐ Not at all	

IV. 3R Goals for Cross-cutting Issues	
Goal 23	Promote **green and socially responsible procurement** at all levels, thereby creating and expanding 3R industries and markets for environmentally-friendly goods and products.
Q-1 What specific policies are introduced to promote green and social responsible procurement? ***Q-2 Please provide details of eco-labelling schemes of your country.*** ***Q-3 Please provide a list of criteria for eco-labeled products and services in your country.*** ***Q-4 Please provide the list of Ministries and major Government Agencies which have adopted green procurement policy.*** ***Q-5 What % of municipalities have adopted the green procurement policy?***	
Challenges (policy/ institutional/ technological/ financial) faced in implementation:	
Examples of pilot projects, master plans and/or policies developed or under development – include websites where relevant	
Important policies/programmes/projects/master plans the government plans to undertake within next five years	
Is this Goal relevant for your country? ☐ Highly ☐ Partially ☐ Not at all	

IV. 3R Goals for Cross-cutting Issues	
Goal 24	**Phase out harmful subsidies that favour unsustainable use of resources (raw materials and water) and energy**, and channel the freed funds in support of implementing the 3Rs and efforts to improve resource/energy efficiency.
Q-1 Are there any government subsidy programmes that directly or indirectly favour unsustainable use of resources (raw materials, water, and energy)? If so, please provide a list of such programmes along with the responsible Ministry or Agency administering and implementing it.	
Challenges (policy/ institutional/ technological/ financial) faced in implementation:	
Examples of pilot projects, master plans and/or policies developed or under development – include websites where relevant	
Important policies/programmes/projects/master plans the government plans to undertake within next five years	
Is this Goal relevant for your country? ☐ Highly ☐ Partially ☐ Not at all	

IV. 3R Goals for Cross-cutting Issues	
Goal 25	**Protect public health and ecosystems, including freshwater and marine resources by eliminating illegal** activities of open dumping, including dumping in the oceans, and controlling open burning in both urban and rural areas.
Q-1 Is waste management a public health priority in your country? ***Q-2 What are the rules and regulations to prevent open dumping and open burning of waste?*** ***Q-3 Rank the five most important rivers in terms of water quality (BOD values) passing through major cities and urban areas?*** ***Q-4 What are the specific laws, rules and regulations in place to prevent littering in river and water bodies?*** ***Q-5 What are the specific laws, rules and regulations in place to prevent marine littering?***	
Challenges (policy/ institutional/ technological/ financial) faced in implementation:	
Examples of pilot projects, master plans and/or policies developed or under development – include websites where relevant	
Important policies/programmes/projects/master plans the government plans to undertake within next five years	
Is this Goal relevant for your country? ☐ Highly ☐ Partially ☐ Not at all	

IV. 3R Goals for Cross–cutting Issues	
Goal 26	Facilitate the international circulation of re-usable and recyclable resources as well as remanufactured products as mutually agreed by countries and in accordance with international and national laws, especially the Basel Convention, which contributes to the reduction of negative environmental impacts and the effective management of resources.
Q-1 What are major recycling industries in your country? ***Q-2 Please specify the regulation on transboundary movement of hazardous waste.*** ***Q-3 If your government has restriction on import of non-hazardous waste or quality control of non-hazardous waste, please list it up.*** ***Q-4 Does your government restrict import of remanufactured goods?*** ***Q-5 Does your government regard remanufactured goods as secondhand goods, and regulate it as secondhand goods?***	
Challenges (policy/ institutional/ technological/ financial) faced in implementation:	
Examples of pilot projects, master plans and/or policies developed or under development – include websites where relevant	
Important policies/programmes/projects/master plans the government plans to undertake within next five years	
Is this Goal relevant for your country? ☐ Highly ☐ Partially ☐ Not at all	

IV. 3R Goals for Cross–cutting Issues	
Goal 27	Promote data collection, compilation and sharing, public announcement and application of statistics on wastes and the 3Rs, to understand the state of waste management and resource efficiency.

Q-1 Please give an overview on availability of various data and information on material flow and waste management by checking (X or✓) the appropriate boxes. (Please respond on both "Data Availability" and Monitoring Base")

Data Type	Data Availability			Monitoring Base	
	Good	Very limited	No data exist	Good	Not good
Waste generation					
Material flow					
Cyclical use					
Amount of final disposal					
Disposal to land					
Direct disposal to water					
Import of waste					
Export of waste					
Total landfilled waste					
Import of recyclables					
Export of recyclables					
Hazardous waste generation (solid, liquid, sludge, etc.)					
e-waste generation					

(Please add any other date type relevant to your country)

IV. 3R Goals for Cross−cutting Issues	
Goal 27	Promote data collection, compilation and sharing, public announcement and application of statistics on wastes and the 3Rs, to understand the state of waste management and resource efficiency.
Q-2 What are the current and planned government policies and programmes to strengthen data and information availability in waste sector?	
Challenges (policy/ institutional/ technological/ financial) faced in implementation:	
Examples of pilot projects, master plans and/or policies developed or under development – include websites where relevant	
Important policies/programmes/projects/master plans the government plans to undertake within next five years	
Is this Goal relevant for your country? ☐ Highly ☐ Partially ☐ Not at all	

IV. 3R Goals for Cross−cutting Issues	
Goal 28	Promote heat recovery (waste-to-energy), in case wastes are not re-usable or recyclable and proper and sustainable management is secured.
Q-1 What are the government policies and programmes, including incentives, for waste-to-energy programmes?	
Challenges (policy/ institutional/ technological/ financial) faced in implementation:	
Examples of pilot projects, master plans and/or policies developed or under development – include websites where relevant	
Important policies/programmes/projects/master plans the government plans to undertake within next five years	
Is this Goal relevant for your country? ☐ Highly ☐ Partially ☐ Not at all	

IV. 3R Goals for Cross−cutting Issues	
Goal 29	Promote overall regional cooperation and multi-stakeholder partnerships based on different levels of linkages such as government-to-government, municipality-to-municipality, industry-to-industry, (research) institute-to-institute, and NGO-to-NGO. Encourage technology transfer and technical and financial supports for 3Rs from developed countries to less developed countries.
Q-1 Please provide a list of on-going bilateral/multi-lateral technical cooperation in 3R areas? ***Q-2 What actions are being taken to promote inter-municipal or regional cooperation in areas of waste exchanges, resource recovery, recycling, waste-to-energy and trade of recyclables?***	
Challenges (policy/ institutional/ technological/ financial) faced in implementation:	
Examples of pilot projects, master plans and/or policies developed or under development – include websites where relevant	
Important policies/programmes/projects/master plans the government plans to undertake within next five years	
Is this Goal relevant for your country? ☐ Highly ☐ Partially ☐ Not at all	

IV. 3R Goals for Cross–cutting Issues	
Goal 30	Pay special attention to issues and challenges faced by developing countries including SIDS in achieving sustainable development.
Q-1 Please describe any past and on-going cooperation with SIDS (Small Island Developing States) countries in 3R areas. ***Q-2 Please list 3R related projects linked to climate change, biodiversity, disaster management and sustainable tourism. (This is to be reported by SIDS countries only)***	
Challenges (policy/ institutional/ technological/ financial) faced in implementation:	
Examples of pilot projects, master plans and/or policies developed or under development – include websites where relevant	
Important policies/programmes/projects/master plans the government plans to undertake within next five years	
Is this Goal relevant for your country? ☐ Highly ☐ Partially ☐ Not at all	

IV. 3R Goals for Cross–cutting Issues	
Goal 31	Promote 3R + "Return" concept which stands for Reduce, Reuse, Recycle and "Return" where recycling is difficult due to the absence of available recycling industries and limited scale of markets in SIDS, especially in the Pacific Region.
Q-1 What specific policies, programme, including pilot projects, are implemented to promote 3R+ "Return" concept? (This is to be reported by SIDS countries only)	
Challenges (policy/ institutional/ technological/ financial) faced in implementation:	
Examples of pilot projects, master plans and/or policies developed or under development – include websites where relevant	
Important policies/programmes/projects/master plans the government plans to undertake within next five years (2016~2021)	
Is this Goal relevant for your country? ☐ Highly ☐ Partially ☐ Not at all	

IV. 3R Goals for Cross–cutting Issues	
Goal 32	Complete elimination of illegal engagement of children in the **informal waste sector** and gradually **improve** the working conditions and livelihood security, including **mandatory provision of health insurance**, for all workers.
Q-1 What is the approximate market size (in US$) of the informal waste sector? ***Q-2 Number of annual labor inspections in waste sector?*** ***Q-3 Is health insurance a mandatory to all informal workers in waste sector by law?*** ***Q-4 What specific policies and enforcement mechanisms are in place to prevent illegal engagement of children in waste sector?*** ***Q-5 Number of landfill sites accessible to register waste pickers?*** ***Q-6 Average life span of informal waste workers?*** ***Q-7 Any government vaccination programmes for informal waste workers?*** ***Q-8 Any public awareness programmes for informal waste workers on health and safety measures?***	
Challenges (policy/ institutional/ technological/ financial) faced in implementation:	
Examples of pilot projects, master plans and/or policies developed or under development – include websites where relevant	

IV. 3R Goals for Cross−cutting Issues	
Goal 32	Complete elimination of illegal engagement of children in the **informal waste sector** and gradually **improve** the working conditions and livelihood security, including **mandatory provision of health insurance**, for all workers.
Important policies/programs/projects/master plans the government plans to undertake within next five years	
Is this Goal relevant for your country? ☐ Highly ☐ Partially ☐ Not at all	

IV. 3R Goals for Cross−cutting Issues	
Goal 33	Promote 3Rs taking into account gender considerations.
Q-1 Please give a brief assessment on how the national, provincial and municipal governments incorporate gender considerations in waste reduction, reuse and recycle.	
Challenges (policy/ institutional/ technological/ financial) faced in implementation:	
Examples of pilot projects, master plans and/or policies developed or under development – include websites where relevant	
Important policies/programmes/projects/master plans the government plans to undertake within next five years	
Is this Goal relevant for your country? ☐ Highly ☐ Partially ☐ Not at all	

Q- Please provide a brief comprehensive summary of important 3R and resource efficiency policies or programmes/ projects/ master plans of your country.

Appendix – 3: Ha Noi Goal 1: Reduction in municipal solid waste (3RGs 1)

Sr. No.	Country	8th Regional 3R Forum (2018)			9th Regional 3R Forum (2019)			10th Regional 3R and Circular Economy Forum (2020)			11th Regional 3R and Circular Economy Forum (2021)		
		Q1	Q2	Q3 (Capex and Opex – in US$ - 2014-15)	Q1	Q2	Q3	Q1	Q2	Q3	Q1	Q2	Q3
1	Afghanistan	NA	Low	25 percent and Person									
2	Bangladesh	Y	Low	NA	Y	Low	NA	Y	Low	NA			
3	Bhutan	Y	Low	NA	Y	Low	NA	Y	NA	NA			
4	Cambodia	Y	NA	NA	Y	Low	2 million US$ (2015)						
5	Cook Islands										Y	High	25andcapita
6	Federated States of Micronesia	Y	NA	NA	Y	Average	20000 – 30000	Y	Average	NA			
7	India				Y	High	1230 million						
8	Indonesia				Y	Low	NA						
9	Japan				Y	Very High	143andcapita	Y	Very High	157andcapita	Y	Very High	153andcapita
10	Kiribati	Y	Low	172127	Y	Average	3andcapita						
11	Kyrgyzstan	Y	Average	NA									
12	Lao PDR	Y	High	240963	Y	Average	1-1.5andcapita						
13	Malaysia	Y	Average	C – 22407061.61 and O - 431432708.22				Y	Average	24andcapita			
14	Marshall Islands	Y	Low	NA									
15	Mauritius	Y	Low	40 and capita									
16	Mongolia	Y	NA	4.5 million	Y	NA	4.5 million						
17	Myanmar	NA	Average	NA	Y	Low	NA	Y	Average	NA			
18	Nauru										Y	Low	NA
19	Nepal	Y	Low	2.16andcapita	Y	Low	2.2andcapita						
20	Pakistan	Y	Low	NA	Y	Does not exist	NA						
21	Palau	Y	Low	100	Y	Average	NA				Y	Average	NA
23	Philippines				Y	Average	5-24 percent of annual budget						
24	Republic of Korea	Y	Very High	300 Million	Y	Very High	310 million						
25	Russian Federation	Y	Low	20 Million									
26	Singapore	Y	High	NA	Y	High	NA	Y	Average	NA	Y	Average	NA
27	Solomon Islands	Y	Low	130000									
28	Sri Lanka	Y	Average	2 billion	Y	Average	1.52 and capita						
29	Thailand	Y	Low	1-2 and capita	Y	Low	1-2 and capita	Y	Average	1-2 and capita			
30	Timor Leste				Y	Low	900000						
31	Tonga	NA	Average	100000 (2013-14)									
32	Tuvalu	Y	Average	22.18andcapita	Y	High	26.85andcapita						
33	Vietnam	Y	Low	302 Million									

Note: Q-1 What specific 3R policies, programmes and projects, are implemented to reduce the quantity of municipal solid waste?
Q-2 What is the level of participation of households in "source" segregation of municipal waste streams?
Q-3 Total annual government expenditure per capita (US$ per capita) in municipal solid waste management in 2014-2015
Y- Yes; H- High; Avg.- Average; VH- Very High; NE- Not Exists; NA- Not available; PO- Policy; I – Institutional; T- Technical; F- Financial; PP- Pilot project; MP – Master plan; PRO – Programme; PR- Project; P – Poor; VM- Very much; Reg. – Regulation; G- Guidelines

Sr. No.	Country	8th Regional 3R Forum (2018)			9th Regional 3R Forum (2019)			10th Regional 3R and Circular Economy Forum (2020)			11th Regional 3R and Circular Economy Forum (2021)		
		Challenges	**Examples**	**(2016 – 21)**	**Challenges**	**Examples**	**(2016 – 21)**	**Challenges**	**Examples**	**(2016 – 21)**	**Challenges**	**Examples**	**(2016 – 21)**
1	Afghanistan	NA	NA	NA									
2	Bangladesh	T, I, F	PP, PRO	PO, MP	PO, I, T, F	PRO, PR	MP, PRO, PO	PO, I, T, F	PP, PRO	MP, PO			
3	Bhutan	I, T, F	PP	PP	I, T, F	MP, PRO, PP	PRO, PR, MP	I, F, T	PO, PP, PRO	MP, PP, PO			
4	Cambodia	F, T	MP	MP	F, T, I	PRO, MP	PP, MP						
5	Cook Islands										PO, F, I	Y	PO, MP
6	Federated States of Micronesia	I, T	MP, PR	MP	F	PO, MP, PR	PRO, MP	I, F	PO, PP	PRO			
7	India				PO, I, F, T	PO, MP, PP	PRO						
8	Indonesia				F	PO, PR	PO, MP						
9	Japan				I	PRO, MP	MP	I	MP	PO, PRO	I	PP, MP, PO	MP
10	Kiribati	F, T	MP	MP	F, T	MP, PR	MP						
11	Kyrgyzstan	T, I	PP	PRO									
12	Lao PDR	PO, F	PP	PO, PRO	F, T	MP	PO, MP						
13	Malaysia	PO, I, F	PO, MP	PO, PRO				PO, PRO, F	PO, MP	PRO			
14	Marshall Islands	T	PRO, PR	PO									
15	Mauritius	PO, F	MP	PR									
16	Mongolia	I, F, PO	MP	PO, PRO	I, F	MP	PRO, PO						
17	Myanmar	PO, I, T, F	MP	MP	PO, F	NA	MP	I, F	PP	MP			
18	Nauru										PO, F, I	PP, PO	PO, MP
19	Nepal	I, T, F	MP	PRO	I, T, F	MP, PP	PRO, PO						
20	Pakistan	I, T, F	PP	PO, MP	F, T	PRO, MP	PO, PR, PRO						
21	Palau	PO, I	MP	PR, MP	PO, I	MP	PP				PO, I	PP, MP	NA
23	Philippines				PO, I, T, F	PP	PP						
24	Republic of Korea	NA	NA	PO	NA	MP	PO						
25	Russian Federation	PO, F, T, I	PR, MP	PO									
26	Singapore	I	MP	PO, MP	T, I	MP, PRO	PO	I, T	PP, MP	PO, PRO	T, I	MP	PO, MP
27	Solomon Islands	I, T, F	PP, PRO	MP									
28	Sri Lanka	I, T	NA	PP	I, T, F	MP	PO, PR						
29	Thailand	F, T	MP	MP, PO	F, T	MP	MP, PO	PO, I, F	MP	MP, PO			
30	Timor Leste				NA	NA	PR						
31	Tonga	I, F	PRO	MP									
32	Tuvalu	I, T, F	PP, MP, PO	PR, MP	PO, I, F	PO, MP, PP	PO, MP, PRO, PR						
33	Vietnam	T, I	NA	PO, MP									

Note: Q-1 What specific 3R policies, programmes and projects, are implemented to reduce the quantity of municipal solid waste?
Q-2 What is the level of participation of households in "source" segregation of municipal waste streams?
Q-3 Total annual government expenditure per capita (US$ per capita) in municipal solid waste management in 2014-2015
Y- Yes; H- High; Avg.- Average; VH- Very High; NE- Not Exists; NA- Not available; PO- Policy; I – Institutional; T- Technical; F- Financial; PP- Pilot project; MP – Master plan; PRO – Programme; PR- Project; P – Poor; VM- Very much; Reg. – Regulation; G- Guidelines
Prepared from Regional 3R Forum Country Reports (2018, 2019, 2020, 2021);;
https:andandwww.uncrd.or.jpand?page=viewandnr=1217andtype=13andmenu=198

Appendix – 4: Ha Noi Goal 3: Increase in recycling rate (3RGs 3)

Sr. No.	Country	8th Regional 3R Forum (2018)				9th Regional 3R Forum (2019)				10th Regional 3R and Circular Economy Forum (2020)				11th Regional 3R Forum (2021)			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	Afghanistan	A, B, E – P and C – H and D, F – NE	NA	A – Avg and B, C – P and D – NE and E – H	Y												
2	Bangladesh	A – Avg and B, E, F – H and C – VH	NA	A, B – Avg and C, E – VH and D – P	Y	A – Avg and B, E, F – H and C –VH and D – P	NA	A, B – Avg and C, E – VH and D – P	Y	A – Avg and B, E, F – H and C – VH and D – P	NA	A, B – Avg and C, E – VH and D – P	Y				
3	Bhutan	A, D, E – P and B – H and C – VH	Y	A, D – P and B – Avg and C – H and E – NA	Y	A, B – H and C – VH and D, E – P	Y	A, B – Avg and C – H and D – P and E – Not exist	Y	A, B – H and C – VH and D, E – P	Y	A, B – Avg and C – H and D – P and E – NE	Y				
4	Cambodia	B, E – H and C – VH and D – Avg	Y	A, B, C, D, E – P	Y	A, D, E – Avg and C – VH and B – H	Y	A, B, C, D – P	Y								
5	Cook Islands													A, B, C, D – NE and F – P	Y	A, B, C, D, E – NE and F – P	Y
6	Federated States of Micronesia	F – VH	Y	A, B – P and C – H and D – Avg and E – NE and F – VH	Y	F – VH	Y	A, B – P and C – H and D – Avg and E – Not exist and F – VH	Y	F – VH	Y	A, B – P and C – H and D – Avg and E – NE and F – VH	Y				
7	India					A, B – H and C, E – Avgand D - P	Y	A, B – Avg and C, D, E – P	Y								
8	Indonesia					A, B, C, E – P and D – Not exist	Y	A, B, C, E – P and D – Not exist	Y								
9	Japan					F, D, C – VH and A, B, E – H	Y	A, B, E – H and C, D, F - VH	NA	A, B, E – H and C, D, F – VH	Y	A – Avg and B – H and C, D, E – VH	Y	A, B, E – H and C, D, F – VH	Y	A – A and B – H and C, D, E – VH	Y
10	Kiribati	A, B, C, D, E – NE and F – VH	NA	A, B, C, D, E – NE and F – VH	Y	A, B, C, D, E – Not exist	NA	A, B, C, D, E – Not exist	Y								
11	Kyrgyzstan	A, D, E – P and B – Avg and C – H	Y	A, D, E – P and B – Avg and C –H	Y												
12	Lao PDR	NA	NA	NA	NA	A, C – H and B, F – Avg and D, E – P	Y	A, B – Avg and C – H and D, E – P	Y								
13	Malaysia	A, B, C – H and D – P	Y	B – H and D – P	Y					A, B, C – H and D – P	Y	B – H and D - P	Y				
14	Marshall Islands	A, C, F – P and D, B, E – NE	Y	A, B, D, E – P and C – Avg	Y												
15	Mauritius	A, B, D, E, F – P and C – H	Y	A, B, D, E – P and C – H	Y												
16	Mongolia	A, D – P and B – Avg and C – H and	Y	A, B, D – P and C – Avg and E – NE	Y	NA	NA	NA	NA								

Sr. No.	Country	8th Regional 3R Forum (2018)				9th Regional 3R Forum (2019)				10th Regional 3R and Circular Economy Forum (2020)				11th Regional 3R Forum (2021)			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
		E – NE															
17	Myanmar	NA	NA	NA	NA	NA	NA	NA	NA	A, B, C – H and D – Avg and E – P and F – NE	NA	A, B, C – H and D – P and E – NE	Y				
18	Nauru													A, B, C, D, E – P and F – NE	Y	A, B, C, D, E – P	Y
19	Nepal	A, B – Avg and C – H and D, E – NE and F - P	NA	A, B, C – P and D, E - NE	Y	A, B – Avg and C – H and D, E – Not Exist and F - P	NA	A, B, C – P and D, E – Not exist	Y								
20	Pakistan	A, B, C, D, F – P	Y	A, B, C, D – P	Y	A, C – VH and B – Avg and D, E – P	NA	A, C – H and B – Avg and D, E – Not exist	Y								
21	Palau	A, D – P and B, C, F – Avg and E – NE	Y	A, D – P and B, C – Avg and E – NE	Y	A, B, D, E, F – P and C – H	Y	A, B – Avg and C – H and D, E – P	Y					A, B, C, F – Avg and D, E – P	NA	A, B, C, E – Avg and D – P	Y
23	Philippines					A, B, C – VH and D, E, F – H	Y	A, B – VH and C, D, E – H	Y								
24	Republic of Korea	A, B, C, D, E – VH	Y	A – H and B, E – Avg and C, D – P	Y	A, B, C, D, E – VH	Y	A – H, B, E – Avg and C, D – P	Y								
25	Russian Federation	A, C – H and B, D, E, F – P	Y	A, C – H and B, D, E – P	Y												
26	Singapore	A – Avg and C, D – VH and B, F – P	Y	NA	Y	A – Avg and B, E, F – P and C, D – H	Y	NA	Y	A, B, F – P and C, D - VH	Y	A, B, F – P and C, D - VH	Y	A, B, F – P and C, D - VH	Y	A, B – P and C, D - VH	Y
27	Solomon Islands	A, B, E – NE and C, D, F – P	Y	A, B, E – P and C – Avg and D – NE	Y												
28	Sri Lanka	A, B, C, D, E – P	NA	A, B, C, D, E – P	Y	A, B, C, E – Avg and D – P	NA	A, B, C, E – Avg and D – P	Y								
29	Thailand	A, B – H and C – Avg and D, E, F – P	Y	A, B – H and C – Avg and D, E – P	Y	A, B – H and C – Avg and D, E, F – P	Y	A, B – H and C – Avg and D, E – P	Y	A – H and C – Avg and B, E, D – P and F – NE	Y	A – H and C – Avg and B, D – P and E – NE	Y				
30	Timor Leste					NA	Y	NA	NA								
31	Tonga	A, B – NE and C – VH and D – H and E – P	Y	A, B – NE and C – H and D – Avg and E - P	Y												
32	Tuvalu	A, B, E, F – NE and C – P	NA	A, B, D – NE and C, E – Avg	Y	A, B – NE and C, D, E – P and F – H	Y	A, B – Not exist and C, D, E – P and F – VH	Y								
33	Vietnam	A – Avg and B, E – H and C – VH	Y	NA	NA												

Note: Q-1 What is the recycling rate of various recyclables?
Q-2 What specific policies are introduced at local and national level for prevention or reduction of waste streams – paper, plastic, metal, construction waste, e-waste?
Q-3 What is the rate of resource recovery from various waste streams?

Q-4 What is the level of existence of resource recovery facilitiesand infrastructures in cities?
Prepared from Regional 3R Forum Country Reports (2018, 2019, 2020, 2021);;
https:andandwww.uncrd.or.jpand?page=viewandnr=1217andtype=13andmenu=198

Sr. No.	Country	8th Regional 3R Forum (2018)			9th Regional 3R Forum (2019)			10th Regional 3R and Circular Economy Forum (2020)			11th Regional 3R and Circular Economy Forum (2021)		
		Challenges	Examples	(2016 – 21)	Challenges	Examples	(2016 – 21)	Challenges	Examples	(2016 – 21)	Challenges	Examples	(2016 – 21)
1	Afghanistan	PO, I, F	PP	MP									
2	Bangladesh	PO, I, F	PRO, PP	MP	PO, I, T, F	PP, PR	PO, PR	Po, I, T, F	PRO, PP	MP, PO			
3	Bhutan	I, F	PP	PRO	I, T	I, PP	PR	T, F	PP	PRO, PR			
4	Cambodia	F, T	NA	NA	T, F	NA	MP						
5	Cook Islands										I, F, T	PP, MP, PO	PO, PR, MP
6	Federated States of Micronesia	F	PP	MP	F	PP	I, T	F	PP, PRO	PO			
7	India				PO	I, PP	PR, I						
8	Indonesia				I	NA	MP, PO						
9	Japan				NA	NA	NA	I	MP, PP	MP	I	PP, MP, PO	PO, PRO, PR, MP
10	Kiribati	F, T, I	PP	MP	F, T	PP	PO						
11	Kyrgyzstan	NA	NA	PRO									
12	Lao PDR	PO, I, F, T	PP	PO, PP, MP	PO, F	PP	MP						
13	Malaysia	F	PP	PRO				F	PP	MP			
14	Marshall Islands	I	PP	PP									
15	Mauritius	PO, F	NA	PRO									
16	Mongolia	PO, F, T	PP	PO	F, T, PO	PP, MP	MP						
17	Myanmar	PO, I, T, F	NA	MP	PO, F	NA	NA	T, F	Y (Website)	MP			
18	Nauru										I, F, PO	NA	PO, MP
19	Nepal	PO, F, T	MP	MP	PO, T, F	PP	MP						
20	Pakistan	PO, I	PP	PO, MP	PO, I	PP	PO, PR, PRO						
21	Palau	NA	NA	NA	I, PO	NA	NA				PO	NA	NA
23	Philippines				PO, I, T	I, PP	PO, I						
24	Republic of Korea	NA	NA	NA	NA	NA	MP						
25	Russian Federation	PO, I, F	PO	PO, PRO, PR									
26	Singapore	I, T	NA	MP	PO, T, F	NA	PO, MP	I, F	PP		F, I, T	PP	PO, PR
27	Solomon Islands	PO, T, I	PP	MP									
28	Sri Lanka	I	MP	MP	T, PO	PP	PO						
29	Thailand	PO, F	PRO, PP, MP	MP	PO, F	PP, PO	MP	Po, I	MP, PRO, PP	MP			
30	Timor Leste				NA	NA	NA						
31	Tonga	F, I	PP	PR									
32	Tuvalu	PO, I, T, F	PRO, PR	MP	PO	PP	PO, MP						
33	Vietnam	T, F	PR, PO	NA									

Note: Y- Yes; H- High; Avg.- Average; VH- Very High; NE- Not Exists; NA- Not available; PO- Policy; I – Institutional; T- Technical; F- Financial; PP- Pilot project; MP – Master plan; PRO – Programme; PR- Project; P – Poor; VM- Very much; Reg. – Regulation; G- Guidelines; A – Paper; B – Plastic; C – Metal; D - Construction Waste; E - E-waste; F – Others
Prepared from Regional 3R Forum Country Reports (2018, 2019, 2020, 2021);
https:andandwww.uncrd.or.jpand?page=viewandnr=1217andtype=13andmenu=198

Appendix – 5: Ha Noi Goal 9 : Classification and Inventory of Hazardous Waste (3RGs 9)

Sr. No.	Country	8th Regional 3R Forum (2018)		9th Regional 3R Forum (2019)		10th Regional 3R and Circular Economy Forum (2020)		11th Regional 3R and Circular Economy Forum (2021)	
		Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2
1	Afghanistan	Y	Y						
2	Bangladesh	Y	Y	Y	Y	Y	Y		
3	Bhutan	NA	Y	NA	Y	Y	Y		
4	Cambodia	NA	NA	Y	Y				
5	Cook Islands							Y	Y
6	Federated States of Micronesia	NA	Y	Y	Y	Y	Y		
7	India			NA	Y				
8	Indonesia			Y	Y				
9	Japan			Y	Y	Y	Y	Y	Y
10	Kiribati	NA	NA	NA	Y				
11	Kyrgyzstan	Y	Y						
12	Lao PDR	NA	NA	Y	Y				
13	Malaysia	Y	Y			Y	Y		
14	Marshall Islands	NA	Y						
15	Mauritius	NA	Y						
16	Mongolia	NA	Y	NA	Y				
17	Myanmar	NA	NA	Y	Y	Y	Y		
18	Nauru							N	N (Being Developed)
19	Nepal	NA	Y	NA	Y				
20	Pakistan	NA	Y	NA	Y				
21	Palau	NA	NA	NA	NA			N	NA
23	Philippines			NA	Y				
24	Republic of Korea	Y	Y	Y	Y				
25	Russian Federation	Y	Y						
26	Singapore	Y	Y	Y	Y	Y	Y	Y	Y
27	Solomon Islands	NA	Y						
28	Sri Lanka	Y	Y	Y	Y				
29	Thailand	Y	Y	Y	Y	Y	Y		
30	Timor Leste			NA	NA				
31	Tonga	Y	Y						
32	Tuvalu	NA	Y	NA	Y				
33	Vietnam	Y	Y						

Note: Q-1 Is there a systematic classification of hazardous waste?

Q-2 What specific rules and regulations are introduced to separate, store, treat, transportation and disposal of hazardous waste?

Prepared from Regional 3R Forum Country Reports (2018, 2019, 2020, 2021);

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Sr. No.	Country	8th Regional 3R Forum (2018)			9th Regional 3R Forum (2019)			10th Regional 3R and Circular Economy Forum (2020)			11th Regional 3R and Circular Economy Forum (2021)		
		Challenges	**Examples**	**(2016 – 21)**	**Challenges**	**Examples**	**(2016 – 21)**	**Challenges**	**Examples**	**(2016 – 21)**	**Challenges**	**Examples**	**(2016 – 21)**
1	Afghanistan	T, F	NA	NA									
2	Bangladesh	I	PO, PP	MP	I, PO	MP, PO	MP	I	PP	MP			
3	Bhutan	I, T, F	PO, MP	PO, MP	I, F, T	PO	MP	I, T, F	MP	MP			
4	Cambodia	F, T	NA	NA	T, F	NA	NA						
5	Cook Islands										PO, I, F	Y, GEF POP	PO, MP
6	Federated States of Micronesia	F	PR, MP	MP	F	PP, MP	MP	F	PP, MP	MP			
7	India				NA	NA	I						
8	Indonesia				I, F	PP	PO						
9	Japan				PO, I	Y (Website)	PO	T, PO	PP, MP, PO	PO	T, PO, I	Y	PO
10	Kiribati	PO, I, P, F	MP	PO, MP	PO, I, T, F	PP, MP	PO, MP						
11	Kyrgyzstan	NA	PO	MP									
12	Lao PDR	NA	NA	NA	I, F, T	Y (Website)	MP						
13	Malaysia	PO	Y (Website)	NA				PO, I	PO	N			
14	Marshall Islands	I	NA	NA									
15	Mauritius	T	NA	PR									
16	Mongolia	I, F	PR	PO, PRO	T, F	PP, PO	PRO						
17	Myanmar	PO, I, T, F	PR	MP	PO, I, T	PP	PRO	T, F	MP	MP			
18	Nauru										PO, I, F	Y	PO
19	Nepal	NA	NA	NA	PO	NA	PO						
20	Pakistan	NA	PO, PR	PO, MP	NA	NA	PO, MP						
21	Palau	PR	NA	NA	I	NA	NA				T	NA	NA
23	Philippines				I, T	Y (Website)	Y (Website)						
24	Republic of Korea	NA	NA	NA	NA	NA	NA						
25	Russian Federation	PO, I	NA	PR									
26	Singapore	NA	NA	PO	NA	NA	PO	NA	PO, MP	NA	NA	PR	NA
27	Solomon Islands	PO, I	PR, MP	MP									
28	Sri Lanka	PO	NA	NA	I, F, T	Y (Website)	MP						
29	Thailand	I, T	PP, MP	MP	I, T	PP, MP	MP	T, I	PP, MP	MP			
30	Timor Leste				NA	NA	NA						
31	Tonga	I	PP	PR, MP									
32	Tuvalu	I, F	NA	PO, MP	PO, I, F	MP	PO, MP						
33	Vietnam	I, T	PO	NA									

Note: Y- Yes; H- High; Avg.- Average; VH- Very High; NE- Not Exists; NA- Not available; PO- Policy; I – Institutional; T- Technical; F- Financial; PP- Pilot project; MP – Master plan; PRO – Programme; PR- Project; P – Poor; VM- Very much; Reg. – Regulation; G- Guidelines

Prepared from Regional 3R Forum Country Reports (2018, 2019, 2020, 2021);

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Appendix – 6: Ha Noi Goal 11: Use of agricultural biomass waste and livestock waste (3RGs 11)

Sr. No.	Country	8th Regional 3R Forum (2018)			9th Regional 3R Forum (2019)			10th Regional 3R and Circular Economy Forum (2020)			11th Regional 3R and Circular Economy Forum (2021)		
		Q1	Q2	Q3	Q1	Q2	Q3	Q1	Q2	Q3	Q1	Q2	Q3
1	Afghanistan	NA	C, D	NA									
2	Bangladesh	Y	B, C	Y	Y	B, C	PO, MP	Y	B, C	MP, PO			
3	Bhutan	NA	NA	NA	NA	NA	NA	NA	NA	NA			
4	Cambodia	NA	NA	Y	NA	B, C, E	PRO						
5	Cook Islands										NA	C, E	NA
6	Federated States of Micronesia	Y	NA	Y	Y	NA	PO	N	NA	PO			
7	India				Y	NA	NA						
8	Indonesia				Y	A, B, C	NA						
9	Japan				Y	A, C, D	MP, PO	Y (Range 24 percent - 95 percent) of different types	A, B, C, D	PO	Y (Range 13 – 100 percent of different types	A, B, C, D	PO
10	Kiribati	NA	NA	NA	NA	C, D, E	NA						
11	Kyrgyzstan	Y	B, C	Y									
12	Lao PDR	NA	NA	NA	Y	E	PRO, MP						
13	Malaysia	NA	NA	NA				NA	B	NA			
14	Marshall Islands	NA	NA	NA									
15	Mauritius	NA	D	NA									
16	Mongolia	Y	NA	NA	Y	D, E	NA						
17	Myanmar	NA	NA	NA	NA	NA	NA	Y	A, B, C	MP, PO			
18	Nauru										Y	NA	NA
19	Nepal	NA	D, E	NA	NA	B, C, D	MP, PO						
20	Pakistan	Y	A	Y	Y	A	PO, MP						
21	Palau	NA	C	NA	NA	C	NA				NA	C	NA
23	Philippines				NA	A, C, D, E	T						
24	Republic of Korea	NA	NA	NA	NA	NA	NA						
25	Russian Federation	NA	D	Y									
26	Singapore	NA	B	NA	NA	B	NA	NA	B, C	NA	NA	B, C	NA
27	Solomon Islands	NA	D, E	NA									
28	Sri Lanka	NA	C, D	Y	NA	NA	PO						
29	Thailand	Y	B, C, E	Y	Y	B, C	MP	Y	B, C, E	MP			
30	Timor Leste				NA	NA	NA						
31	Tonga	NA	A, B, C, D, E	Y									
32	Tuvalu	NA	NA	Y	NA	B, C	MP, PO						
33	Vietnam	Y	C, D	Y									

Note: Q-1 How much amount of – (a) agricultural biomass waste and (b) livestock waste are grossly generated per annum?
Q-2 How is most of the agricultural biomass wastes utilized or treated?
Q-3 What specific policies, guidelines, and technologies are introduced for efficient utilization of agricultural biomass waste and livestock waste as a secondary material inputs towards full scale economic benefits?
Y- Yes; H- High; Avg.- Average; VH- Very High; NE- Not Exists; NA- Not available; PO- Policy; I – Institutional; T- Technical; F- Financial; PP- Pilot project; MP – Master plan; PRO – Programme; PR- Project; P – Poor; VM- Very much; Reg. – Regulation; G- Guidelines; A - As secondary raw material input (for paper, bioplastic, furniture, etc.); B - Biogasandelectricity generation; C - Compostsandfertilizers; D - Mostly left unutilized or open dumped; E - Mostly open burned
Prepared from Regional 3R Forum Country Reports (2018, 2019, 2020, 2021);
https:andandwww.uncrd.or.jpand?page=viewandnr=1217andtype=13andmenu=198

Sr. No.	Country	8th Regional 3R Forum (2018)			9th Regional 3R Forum (2019)			10th Regional 3R and Circular Economy Forum (2020)			11th Regional 3R and Circular Economy Forum (2021)		
		Challenges	Examples	(2016 – 21)	Challenges	Examples	(2016 – 21)	Challenges	Examples	(2016 – 21)	Challenges	Examples	(2016 – 21)
1	Afghanistan	NA	NA	NA									
2	Bangladesh	PO, I, T, F	MP	PO, MP	PO, F, T	PO, MP	MP, po	PO, I, F, T	MP	PO			
3	Bhutan	I, F	PR	PR	F	PP	MP	F	PP	PRO			
4	Cambodia	F, T	NA	NA	T, F	NA	NA						
5	Cook Islands										NA	NA	MP
6	Federated States of Micronesia	I, F	PO, PP	PO	F	PO, PP, MP	PO	I, F	PRO	PO			
7	India				NA	NA	NA						
8	Indonesia				PO	NA	PRO						
9	Japan				I	Y (Website)	MP	I	PP, MP, PO	PO	I	Y	PO
10	Kiribati	NA	NA	NA	NA	NA	NA						
11	Kyrgyzstan	T	MP	MP									
12	Lao PDR	NA	NA	NA	I	PP	I, PRO						
13	Malaysia	NA	NA	NA				NA	MP, PO	NA			
14	Marshall Islands	F	PP	NA									
15	Mauritius	PO, I	NA	PR									
16	Mongolia	PO, I	NA	NA	PO	NA	NA						
17	Myanmar	PO, I, F, T	NA	NA	NA	NA	NA	T, F	PP	MP			
18	Nauru										PO, I, F	Y	PO
19	Nepal	NA	NA	NA	F, T, I	NA	PRO						
20	Pakistan	PO, I	PP	PO, MP	I, PO	PP	MP						
21	Palau	NA	NA	NA	NA	NA	NA				NA	NA	NA
23	Philippines				I	PP	PO						
24	Republic of Korea	NA	NA	NA	NA	NA	NA						
25	Russian Federation	I	NA	MP									
26	Singapore	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
27	Solomon Islands	NA	NA	NA									
28	Sri Lanka	I, F	NA	NA	I, T, F	PP	MP						
29	Thailand	T, F	PP	MP	F, T	PP	MP	T	PP	PO			
30	Timor Leste				NA	NA	NA						
31	Tonga	I	PR	PR									
32	Tuvalu	I, F, T	PP	PR, MP	F, T, PO	PP, PO	MP, PO						
33	Vietnam	PO	PO	PRO									

Note: Y- Yes; H- High; Avg.- Average; VH- Very High; NE- Not Exists; NA- Not available; PO- Policy; I – Institutional; T- Technical; F- Financial; PP- Pilot project; MP – Master plan; PRO – Programme; PR- Project; P – Poor; VM- Very much; Reg. – Regulation; G- Guidelines; A - As secondary raw material input (for paper, bioplastic, furniture, etc.); B - Biogasandelectricity generation; C - Compostsandfertilizers; D - Mostly left unutilized or open dumped; E - Mostly open burned
Prepared from Regional 3R Forum Country Reports (2018, 2019, 2020, 2021);
https:andandwww.uncrd.or.jpand?page=viewandnr=1217andtype=13andmenu=198

Appendix – 7: Ha Noi Goal 12: Eliminating Marine Plastics (3RGs 12)

Sr. No.	Country	8th Regional 3R Forum (2018)			9th Regional 3R Forum (2019)			10th Regional 3R and Circular Economy Forum (2020)			11th Regional 3R and Circular Economy Forum (2021)		
		Q1	Q2	Q3	Q1	Q2	Q3	Q1	Q2	Q3	Q1	Q2	Q3
1	Afghanistan	NA	NA	NA									
2	Bangladesh	PO	Somehow	Y	PO	Somehow	Y	Y	Somehow	Y			
3	Bhutan	PO	Very much	NA	PO	Very Much	NA	Y	NA	NA			
4	Cambodia	Y	NA	NA	PO, R	Very Much	NA						
5	Cook Islands										R	NA	NA
6	Federated States of Micronesia	PO	NA	Y	PO	Very Much	Y	Y	Very Much	Y			
7	India				PO, MP	Somehow	NA						
8	Indonesia				Reg., MP	NA	Y						
9	Japan				PO	Very Much	Y	Y	Very Much	Y	R	NA	Y
10	Kiribati	PO, Reg	Somehow	NA	PO, Reg.	NA	NA						
11	Kyrgyzstan	PO	Somehow	Y									
12	Lao PDR	NA	NA	NA	PO	Somehow	Y						
13	Malaysia	PO	Very much	NA				Y	NA	Y			
14	Marshall Islands	PO	NA	NA									
15	Mauritius	NA	NA	NA									
16	Mongolia	NA	NA	NA	NA	NA	NA						
17	Myanmar	NA	NA	NA	NA	NA	NA	Y	Somehow	NA			
18	Nauru										R	Very Much	NA
19	Nepal	Reg	Somehow	Y	PO	Somehow	NA						
20	Pakistan	NA	NA	NA	NA	NA	NA						
21	Palau	PO	Somehow	NA	PO	Somehow	NA				R	Somehow	NA
23	Philippines				PO	Very Much	NA						
24	Republic of Korea	NA	NA	NA	NA	NA	NA						
25	Russian Federation	Reg	NA	NA									
26	Singapore	PO	Somehow	NA	PO	Somehow	NA	Y	Somehow	NA	R	Somehow	NA
27	Solomon Islands	Reg	Somehow	Y									
28	Sri Lanka	Reg	Somehow	Y	PRO	Somehow	Y						
29	Thailand	PO, Reg	Very much	Y	PO, Reg	Very Much	Y	Y	Y	Y			
30	Timor Leste				NA	NA	NA						
31	Tonga	PO	Somehow	NA									
32	Tuvalu	PO, Reg	Very much	NA	MP, PO	Very Much	Y						
33	Vietnam	NA	NA	NA									

Note: Q-1 What specific policies and regulations are in place to address the issue of plastic wastes in coastal and marine environment?
Q-2 What extent issue of plastic waste is considered in integrated coastal zone management (ICZM)?
Q-3 Please provide a list of centre of excellences or dedicated scientific and research programmes established to address the impacts of micro-plastic participles (<5 mm) on coastal and marine species?

Y- Yes; H- High; Avg.- Average; VH- Very High; NE- Not Exists; NA- Not available; PO- Policy; I – Institutional; T- Technical; F- Financial; PP- Pilot project; MP – Master plan; PRO – Programme; PR- Project; P – Poor; VM- Very much; Reg. – Regulation; G- Guidelines
Prepared from Regional 3R Forum Country Reports (2018, 2019, 2020, 2021);
https:andandwww.uncrd.or.jpand?page=viewandnr=1217andtype=13andmenu=198

Sr. No.	Country	8th Regional 3R Forum (2018)			9th Regional 3R Forum (2019)			10th Regional 3R and Circular Economy Forum (2020)			11th Regional 3R and Circular Economy Forum (2021)		
		Challenges	Examples	(2016 – 21)	Challenges	Examples	(2016 – 21)	Challenges	Examples	(2016 – 21)	Challenges	Examples	(2016 – 21)
1	Afghanistan	NA	NA	NA									
2	Bangladesh	PO, T	PO, MP	MP	PO, T, I	PO, MP	MP	I, T, F	PO	MP, PRO			
3	Bhutan	NA	NA	NA	NA	NA	NA	NA	NA	NA			
4	Cambodia	T, F	NA	NA	T, F	NA	NA						
5	Cook Islands										PO, I, F	PO, PP	PO
6	Federated States of Micronesia	NA	NA	NA	NA	NA	MP	NA	PO	MP			
7	India				NA	NA	I						
8	Indonesia				F, I	NA	PO						
9	Japan				PO, I	PP	PO	PO, T	PP	PO	PO, T, F	Y	PO, MP, PR
10	Kiribati	NA	NA	NA	NA	NA	NA						
11	Kyrgyzstan	I, F	MP	NA									
12	Lao PDR	NA	NA	NA	PO, I	PP	PO						
13	Malaysia	I	NA	NA				I	NA	NA			
14	Marshall Islands	I	NA	NA									
15	Mauritius	NA	NA	NA									
16	Mongolia	NA	NA	NA	NA	NA	NA						
17	Myanmar	PO, I, T, F	NA	NA	NA	NA	NA	PO, F	NA	NA			
18	Nauru										PO, I, F	Y	PO, MP
19	Nepal	T	NA	PO	PO	PP	PRO						
20	Pakistan	NA	PP	PO	NA	PO	NA						
21	Palau	T	NA	NA	I, T	NA	NA				T, I	NA	NA
23	Philippines				PO	PO	PO						
24	Republic of Korea	NA	NA	NA	NA	NA	NA						
25	Russian Federation	I, T	MP	NA									
26	Singapore	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
27	Solomon Islands	PO, I	PP	MP									
28	Sri Lanka	PO, I	PP	NA	I, PO	PP	MP						
29	Thailand	F, T, I	PP, MP	PO, MP	I, F, T	PP, MP	PP, MP	F, T	MP	MP			
30	Timor Leste				NA	NA	NA						
31	Tonga	I, F	NA	NA									
32	Tuvalu	PO, I, F	PRO	PO, MP	PO, I, T	PRO, MP, PO	MP						
33	Vietnam	NA	NA	NA									

Note: Y- Yes; H- High; Avg.- Average; VH- Very High; NE- Not Exists; NA- Not available; PO- Policy; I – Institutional; T- Technical; F- Financial; PP- Pilot project; MP – Master plan; PRO – Programme; PR- Project; P – Poor; VM- Very much; Reg. – Regulation; G- Guidelines

Prepared from Regional 3R Forum Country Reports (2018, 2019, 2020, 2021);
https:andandwww.uncrd.or.jpand?page=viewandnr=1217andtype=13andmenu=198

Appendix – 8: Ha Noi Goal 13: E-waste management (3RGs 13)

Sr. No.	Country	8th Regional 3R Forum (2018)			9th Regional 3R Forum (2019)			10th Regional 3R and Circular Economy Forum (2020)			11th Regional 3R and Circular Economy Forum (2021)		
		Q1	Q2	Q3	Q1	Q2	Q3	Q1	Q2	Q3	Q1	Q2	Q3
1	Afghanistan	C, E	NA	NA									
2	Bangladesh	A, C, E, H, I	PO	NA	A, C, E, H, I	PO	NA	A, G, C, E, F	Y	NA			
3	Bhutan	A, B, C, E, H, I	NA	NA	A, B, C, E, H, I	NA	NA	A, B, C, E, G, H	NA	NA			
4	Cambodia	NA	NA	NA	E, C, D	PO, Reg	NA						
5	Cook Islands										A, H, G, B, C, E, H	REG	NA
6	Federated States of Micronesia	A, B, I	NA	Y	A, B, I	PO	Y	A, B, O	NA	NA			
7	India				A, B, C, D, E, F	PO, Reg	NA						
8	Indonesia				A, B, E	PO, Reg	NA						
9	Japan				C, E, F, G, H	PO, Reg	Y	C, F, E, G (informal collector), h (take back by moving company	Y	Y	C, E, F	PO and REG	NA
10	Kiribati	A, B, C, D, E, F, G, H, I	PO	NA	A, B, C, D, E, F, G, H, I	PO	NA						
11	Kyrgyzstan	A, B, C, D, E, F, G, H	NA	NA									
12	Lao PDR	A, B, C, D, E, F, G, H, I	NA	NA	A, B, C, D, E, F, G, H, I	PO, Reg	NA						
13	Malaysia	A, B, C, D, E, F, G, H	Reg	Y				C, E, D, A, B, F, G	Y	NA			
14	Marshall Islands	NA	NA	NA									
15	Mauritius	A, B, D, E, F, G, H, I	NA	Y									
16	Mongolia	B, D, E	NA	Y	B, D, E	NA	Y						
17	Myanmar	NA	NA	NA	C, E, G	NA	NA	B, C, D, E, H	NA	NA			
18	Nauru	A, B, C, E	NA	NA							B, H	NA	NA
19	Nepal	A, B, C	NA	NA	A, B, C, D, E	NA	NA						
20	Pakistan	B, C, H	NA	NA	A, B, C	NA	NA						
21	Palau				B, H	NA	NA				B, G	NA	NA
23	Philippines				A, P, E, I	PO	NA						
24	Republic of Korea	A, C, D, E, F	PO	Y	A, C, D, E, F	PO, Reg	NA						
25	Russian Federation	A, B, C, D, E	Reg	Y									
26	Singapore	A, C, D, E	Reg	Y	A, C, D, E	PO, Reg	Y	E, D, C, A	Y	Y	A, C, D, E, F	PO and REG	NA
27	Solomon Islands	B, I	PO	NA									
28	Sri Lanka	A, E, H, I	NA	Y	A, E, I	NA	NA						
29	Thailand	A, D, E, H, I	PO	Y	A, D, E, H, I	PO	Y	A, G, D, E, G	Y	Y			
30	Timor Leste				NA	NA	NA						
31	Tonga	A, B	PO	NA									
32	Tuvalu	A, B	NA	Y	A, E, G, H	PO, Reg	Y						
33	Vietnam	E, F	Reg	Y									

Note: Q-1 How do people usually recycle their e-waste (waste electrical and electronic equipment)?

Q-2 What specific policies and regulations are in place to ensure health and safety aspects of those involved in e-waste management (handlingandsortingandresource recoveryandrecycling)?

Q-3 How much amount of e-waste is generated and recycled per year?

Y- Yes; H- High; Avg.- Average; VH- Very High; NE- Not Exists; NA- Not available; PO- Policy; I – Institutional; T- Technical; F- Financial; PP- Pilot project; MP – Master plan; PRO – Programme; PR- Project; P – Poor; VM- Very much; Reg. – Regulation; G- Guidelines; A - Take to recycling center and resource recovery facilities; B - Take to landfill; C - Take to the retailer; D - Take to local charity for re-use; E - Take to second-hand shop for re-use; F - Ship back to the manufacturer; G - Ship back to the manufacturer; H - Recycle in another country; I - Do not know how people dispose

Prepared from Regional 3R Forum Country Reports (2018, 2019, 2020, 2021); https:andandwww.uncrd.or.jpand?page=viewandnr=1217andtype=13andmenu=198

Sr. No.	Country	8th Regional 3R Forum (2018)	9th Regional 3R Forum (2019)	10th Regional 3R and Circular	11th Regional 3R and Circular Economy Forum

								Economy Forum (2020)			(2021)		
		Challenges	Examples	(2016 – 21)	Challenges	Examples	(2016 – 21)	Challenges	Examples	(2016 – 21)	Challenges	Examples	(2016 – 21)
1	Afghanistan	PO, T, F	NA	NA									
2	Bangladesh	PO, I, T, F	PP, MP	PO	PO, I, T	PP, MP	PO, PR	PO, T, I	PP	PO, PR			
3	Bhutan	PO, I, T, F	PO	PO, PRO	PO, I, T	PO, MP	PO, PRO	PO, I, T, F	PO, MP	PO, PRO			
4	Cambodia	F, T	NA	NA	T, F	NA	NA						
5	Cook Islands										NA	PP, PRO, MP	PO, PRO, PR
6	Federated States of Micronesia	I, F	PP	PO	T, F	PP	PO	T, F	PP	NA			
7	India				NA	PO	PO						
8	Indonesia				PO	NA	NA						
9	Japan				I	PO	PO	I,	PO	PO	PO, I	PO	PO
10	Kiribati	NA	NA	NA	PO, I, T, F	NA	NA						
11	Kyrgyzstan	PO	NA	NA									
12	Lao PDR	NA	NA	NA	PO, I	PO	PO, MP, PP						
13	Malaysia	NA	PO, PP	PR				NO	PO	PR			
14	Marshall Islands	NA	NA	NA									
15	Mauritius	F	PO	NA									
16	Mongolia	I, PO	NA	NA	PO, I, T	NA	NA						
17	Myanmar	PO, I, T, F	NA	NA	NA	NA	MP	PO, T, F	NA	NA			
18	Nauru										PO, F, I	Y	PO, MP
19	Nepal	PO, I, T, F	NA	NA	PO, I, T	NA	NA						
20	Pakistan	T, I	PP	PO, MP	I, T	NA	PO, MP						
21	Palau	I	NA	NA	NA	NA	NA				NA	NA	NA
23	Philippines				PO	PO	PO						
24	Republic of Korea	NA	NA	NA	NA	NA	NA						
25	Russian Federation	PO, I	PP	PO									
26	Singapore	I	PRO	PO	PO	PRO	I, MP	NA	PRO	NA	NA	PRO, PP	PO, PRO
27	Solomon Islands	NA	NA	NA									
28	Sri Lanka	I, T	PO	PRO	F, T	MP	PRO						
29	Thailand	PO	PP	PO	PO	PRO, MP	PO	PO, I	MP	PO			
30	Timor Leste				NA	NA	NA						
31	Tonga	I, F	PP	PR									
32	Tuvalu	I, T, F	MP	PO, MP	I, T, F	PO, MP	PO, MP						
33	Vietnam	PO, I	PO	NA									

Note: Y- Yes; H- High; Avg.- Average; VH- Very High; NE- Not Exists; NA- Not available; PO- Policy; I – Institutional; T- Technical; F- Financial; PP- Pilot project; MP – Master plan; PRO – Programme; PR- Project; P – Poor; VM- Very much; Reg. – Regulation; G- Guidelines; A - Take to recycling center and resource recovery facilities; B - Take to landfill; C - Take to the retailer; D - Take to local charity for re-use; E - Take to second-hand shop for re-use; F - Ship back to the manufacturer; G - Ship back to the manufacturer; H - Recycle in another country; I - Do not know how people dispose

Prepared from Regional 3R Forum Country Reports (2018, 2019, 2020, 2021); https:andandwww.uncrd.or.jpand?page=viewandnr=1217andtype=13andmenu=198

Appendix – 9: Ha Noi Goal 15: Implementation of Extended Producer Responsibility (EPR) (3RGs 15)

Sr. No.	Country	8th Regional 3R Forum (2018)		9th Regional 3R Forum (2019)		10th Regional 3R and Circular Economy Forum (2020)		11th Regional 3R and Circular Economy Forum (2021)	
		Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2
1	Afghanistan	NA	NA						
2	Bangladesh	NA	NA	NA	NA	NA	NA		
3	Bhutan	Y	Y	Y	Y	Y	Y		
4	Cambodia	NA	NA	NA	NA				
5	Cook Islands							Y	Y
6	Federated States of Micronesia	NA	Y	Y	Y	NA	Y		
7	India			Y	Y				
8	Indonesia			Y	Y				
9	Japan			Y	Y	Y	Y	Y	Y
10	Kiribati	NA	NA	NA	NA				
11	Kyrgyzstan	NA	NA						
12	Lao PDR	NA	NA	Y	Y				
13	Malaysia	Y	Y			Draft	Y		
14	Marshall Islands	NA	NA						
15	Mauritius	Y	Y						
16	Mongolia	NA	NA	Y	NA				
17	Myanmar	NA	NA	NA	NA	NA	NA		
18	Nauru							NA	NA
19	Nepal	NA	NA	NA	NA				
20	Pakistan	NA	NA	NA	NA				
21	Palau	Y	Y	NA	NA			NA	NA
23	Philippines			NA	NA				
24	Republic of Korea	Y	Y	Y	Y				
25	Russian Federation	Y	Y						
26	Singapore	NA	NA	Y	Y	Y	Y	Y	Y
27	Solomon Islands	Y	NA						
28	Sri Lanka	Y	Y	Y	Y				
29	Thailand	Y	Y	Y	Y	Y	Y		
30	Timor Leste			NA	NA				
31	Tonga	NA	NA						
32	Tuvalu	Y	Y	Y	Y				
33	Vietnam	Y	Y						

Note: Q-1 What specific Extended Product Responsibility (EPR) policies are enacted or introduced?

Q-2 Please provide a list of products and product groups targeted by EPR nationally?

Y- Yes; H- High; Avg.- Average; VH- Very High; NE- Not Exists; NA- Not available; PO- Policy; I – Institutional; T- Technical; F- Financial; PP- Pilot project; MP – Master plan; PRO – Programme; PR- Project; P – Poor; VM- Very much; Reg. – Regulation; G- Guidelines

Prepared from Regional 3R Forum Country Reports (2018, 2019, 2020, 2021);
https:andandwww.uncrd.or.jpand?page=viewandnr=1217andtype=13andmenu=198

Sr. No.	Country	8th Regional 3R Forum (2018)			9th Regional 3R Forum (2019)			10th Regional 3R and Circular Economy Forum (2020)			11th Regional 3R and Circular Economy Forum (2021)		
		Challenges	Examples	(2016 – 21)	Challenges	Examples	(2016 – 21)	Challenges	Examples	(2016 – 21)	Challenges	Examples	(2016 – 21)
1	Afghanistan	PO, T, F	NA	NA									
2	Bangladesh	PO, I	NA	PO	PO, I	NA	PO	PO, I	NA	PO			
3	Bhutan	T, F, I	PO, MP	PR	I, T, F	Reg, MP	PR	T, F, I	PO, MP	PR			
4	Cambodia	NA	NA	NA	T, F	NA	NA						
5	Cook Islands										PO, F, I	PO	PO
6	Federated States of Micronesia	I	NA	NA	PO	NA	NA	PO	NA	NA			
7	India				NA	NA	PO						
8	Indonesia				F, I	MP, PO	PO						
9	Japan				PO, I	MP	MP	I, PO, T	MP	MP	PO, T, I	PO	MP, PO
10	Kiribati	PO	NA	NA	PO	NA	NA						
11	Kyrgyzstan	NA	NA	NA									
12	Lao PDR	NA	NA	NA	I	NA	NA						
13	Malaysia	I	PO	PR				I, T	PO	PO, PRO			
14	Marshall Islands	F	NA	NA									
15	Mauritius	I	NA	PRO									
16	Mongolia	NA	NA	NA	PO	PP	MP						
17	Myanmar	PO, I, T, F	NA	NA	NA	NA	NA	PO, I	NA	NA			
18	Nauru										PO, F, I	NA	PO, MP
19	Nepal	PO, I	NA	NA	PO, I	NA	NA						
20	Pakistan	NA	NA	PO	NA	NA	NA						
21	Palau	T	NA	PR	NA	NA	NA				NA	NA	NA
23	Philippines				PO, PRO	NA	PO						
24	Republic of Korea	NA	NA	NA	NA	NA	NA						
25	Russian Federation	T, I	NA	PO, MP									
26	Singapore	NA	NA	PO	NA	NA	Reg	I, F	NA	PO	F, T	NA	PO
27	Solomon Islands	NA	NA	NA									
28	Sri Lanka	NA	NA	NA	I, T, F	PO	MP						
29	Thailand	PO	MP	PO	PO, Reg	MP	PO	PO	MP	PO			
30	Timor Leste				NA	NA	NA						
31	Tonga	NA	NA	NA									
32	Tuvalu	I, F	PP	PO, MP	I, F	Reg	MP, Reg						
33	Vietnam	I, F	NA	NA									

Note: Y- Yes; H- High; Avg.- Average; VH- Very High; NE- Not Exists; NA- Not available; PO- Policy; I – Institutional; T- Technical; F- Financial; PP- Pilot project; MP – Master plan; PRO – Programme; PR- Project; P – Poor; VM- Very much; Reg. – Regulation; G- Guidelines

Prepared from Regional 3R Forum Country Reports (2018, 2019, 2020, 2021);

https:andandwww.uncrd.or.jpand?page=viewandnr=1217andtype=13andmenu=198

Appendix – 10: Ha Noi Goal 17: Improve resource efficiency and resource productivity (3RGs 17)

Sr. No.	Country	8th Regional 3R Forum (2018)			9th Regional 3R Forum (2019)			10th Regional 3R and Circular Economy Forum (2020)			11th Regional 3R and Circular Economy Forum (2021)
		Q1	Q2	Q3	Q1	Q2	Q3	Q1	Q2	Q3	Q1
1	Afghanistan	G	NA	NA							
2	Bangladesh	PO, G	Y	Y	PO, G	Y	Y	Y	Y	PO	
3	Bhutan	NA	NA	NA	NA	NA	NA	NA	NA	NA	
4	Cambodia	Y	NA	NA	MP	Under Development	Y				
5	Cook Islands										Y
6	Federated States of Micronesia	NA	NA	NA	NA	NA	NA	NA	NA	NA	
7	India				G	NA	NA				
8	Indonesia				PO	Y	NA				
9	Japan				PO	Y	Y	Y	Y	PO, PRO	Y
10	Kiribati	G	NA	NA	NA	NA	NA				
11	Kyrgyzstan	PO	Y	NA							
12	Lao PDR	NA	NA	NA	PO, G	Y	Y				
13	Malaysia	NA	NA	NA				NA	NA	NA	
14	Marshall Islands	G	Y	NA							
15	Mauritius	PO	NA	NA							
16	Mongolia	NA	NA	NA	PO	Y	Y				
17	Myanmar	NA	NA	NA	NA	NA	NA	Y	Y	PO	
18	Nauru										NA
19	Nepal	PO	NA	NA	PO	NA	NA				
20	Pakistan	PO, G	Y	NA	PO	Y	NA				
21	Palau	NA	NA	NA	NA	NA	NA				NA
23	Philippines				PO	Y	Y				
24	Republic of Korea	NA	NA	NA	PO	NA	NA				
25	Russian Federation	PO	Y	Y							
26	Singapore	G	Y	NA	PO	Y	NA	Y	Y	PO, I	Y (GHG reduction)
27	Solomon Islands	NA	NA	NA							
28	Sri Lanka	G	Y	Y	G	Y	Y				
29	Thailand	G	Y	Y	G	Y	Y	Y	Y	PO, MP	
30	Timor Leste				NA	NA	NA				
31	Tonga	NA	NA	NA							
32	Tuvalu	NA	NA	NA	NA	NA	NA				
33	Vietnam	G	Y	NA							

Note: Q-1 What specific policies and guidelines are introduced for product standard (towards qualityanddurability, environmentandeco-friendliness, labor standard)?

Q-2 What specific energy efficiency schemes are introduced for production, manufacturing and service sector?

Q-3 What specific policies are introduced to create green jobs in product and waste sector?

Y- Yes; H- High; Avg.- Average; VH- Very High; NE- Not Exists; NA- Not available; PO- Policy; I – Institutional; T- Technical; F- Financial; PP- Pilot project; MP – Master plan; PRO – Programme; PR- Project; P – Poor; VM- Very much; Reg. – Regulation; G- Guidelines

Prepared from Regional 3R Forum Country Reports (2018, 2019, 2020, 2021);
https:andandwww.uncrd.or.jpand?page=viewandnr=1217andtype=13andmenu=198

Sr. No.	Country	8th Regional 3R Forum (2018)			9th Regional 3R Forum (2019)			10th Regional 3R and Circular Economy Forum (2020)			11th Regional 3R and Circular Economy Forum (2021)		
		Challenges	Examples	(2016 – 21)	Challenges	Examples	(2016 – 21)	Challenges	Examples	(2016 – 21)	Challenges	Examples	(2016 – 21)
1	Afghanistan	PO, T, F	NA	NA									
2	Bangladesh	PO, T, F	PP	MP	PO, T, F	PP	MP						
3	Bhutan	NA	PRO	PRO	NA	PO	PO	T, I, F	PRO, PR	MP			
4	Cambodia	F, T	NA	NA	I	NA	PRO	NA	PRO, PR	PR			
5	Cook Islands										I	PP, MP	PO
6	Federated States of Micronesia	NA	NA	NA	NA	NA	NA	NA	NA	NA			
7	India				NA	NA	NA						
8	Indonesia				NA	NA	PO						
9	Japan				NA	NA	NA	NA	NA	NA	PO, I, T	Y (Regional Circular and Ecological Spheres)	MP
10	Kiribati	NA	NA	NA	PO, I, T, F	NA	NA						
11	Kyrgyzstan	NA	NA	NA									
12	Lao PDR	NA	NA	NA	PO, I, F	PO	PRO, PO						
13	Malaysia	NA	NA	NA				NA	NA	NA			
14	Marshall Islands	NA	NA	NA									
15	Mauritius	PO, I	NA	PO									
16	Mongolia	PO, I	NA	NA	PO, I	PRO, PR	PO						
17	Myanmar	PO, I, T, F	NA	NA	NA	NA	NA	F	PP, MP	PO, MP			
18	Nauru										PO, F, I	Y	PO, MP
19	Nepal	NA	NA	NA	NA	NA	NA						
20	Pakistan	I, T, F	PP	PO	I, F, T	PP, MP	NA						
21	Palau	NA	NA	NA	NA	NA	NA				NA	NA	NA
23	Philippines				PO	PO, PRO	PO, PRO						
24	Republic of Korea	NA	NA	NA	NA	NA	NA						
25	Russian Federation	NA	PO	PO, MP									
26	Singapore	NA	NA	NA	NA	NA	NA	NA	PP	PO	NA	NA	MP
27	Solomon Islands	NA	NA	NA									
28	Sri Lanka	NA	NA	NA	I, F	PP, PO	MP						
29	Thailand	F	PP	PO	F	PO	PO	F	PP	PO			
30	Timor Leste				NA	NA	NA						
31	Tonga	NA	NA	NA									
32	Tuvalu	NA	NA	NA	NA	NA	NA						
33	Vietnam	PO, I, F	PO	PO									

Note: Y- Yes; H- High; Avg.- Average; VH- Very High; NE- Not Exists; NA- Not available; PO- Policy; I – Institutional; T- Technical; F- Financial; PP- Pilot project; MP – Master plan; PRO – Programme; PR- Project; P – Poor; VM- Very much; Reg. – Regulation; G- Guidelines

Prepared from Regional 3R Forum Country Reports (2018, 2019, 2020, 2021);
https:andandwww.uncrd.or.jpand?page=viewandnr=1217andtype=13andmenu=198

Appendix – 11: Ha Noi Goal 18: Co-benefits from waste management technologies (3RGs 18)

Sr. No.	Country	8th Regional 3R Forum (2018)				9th Regional 3R Forum (2019)				10th Regional 3R and Circular Economy Forum (2020)				11th Regional 3R and Circular Economy Forum (2021)			
		Q1	Challenges	Examples	(2016 – 21)	Q1	Challenges	Examples	(2016 – 21)	Q1	Challenges	Examples	(2016 – 21)	Q1	Challenges	Examples	(2016 – 21)
1	Afghanistan	PO	PO, T	NA	NA												
2	Bangladesh	PO	I, F	MP, PP	MP	Y	PP, F	PO, PR	MP, PO	Y	F	MP, PP	MP, PO				
3	Bhutan	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				
4	Cambodia	PO	F, T	NA	NA	Y	I	PP, MP, PO	PO								
5	Cook Islands													Y	I	PP, MP	PO
6	Federated States of Micronesia	PO	I, T	PP	MP	Y	I	PP	MP	Partial	I	PP	MP				
7	India					Y	NA	PP	NA								
8	Indonesia					Y	NA	NA	NA								
9	Japan					Y	I, T	MP	MP	Y	I, T	MP	MP	Y	PO, I, T	Y (Regional Circular and Ecological Spheres)	MP
10	Kiribati	NA	NA	NA	NA	NA	NA	NA	NA								
11	Kyrgyzstan	PO, G	NA	NA	NA												
12	Lao PDR	NA	NA	NA	NA	Y	PO, I	PO	MP								
13	Malaysia	G	I	NA	PO					Y	I	NA	MP				
14	Marshall Islands	G	F, T	NA	NA												
15	Mauritius	G	F	NA	PO												
16	Mongolia	PO, G	F	PRO	PO	Y	F	PP	PO								
17	Myanmar	NA	PO, I, T, F	NA	NA	NA	NA	NA	NA	Y	T, F	Y	PO				
18	Nauru													NA	PO, F, I	Y	PO, MP
19	Nepal	G	I, F	PP	MP	Y	I, F	PP	PRO								
20	Pakistan	PO	I, T, F	NA	PR, PO, MP	Y	I, PO, F	NA	PRO, PO, MP								
21	Palau	NA	T, F	NA	NA	NA	PRO	NA	NA					NA	NA	NA	NA
23	Philippines					Y	T, F	NA	PO								
24	Republic of Korea	NA	NA	NA	NA	NA	NA	NA	NA								
25	Russian Federation	G	NA	NA	NA												
26	Singapore	PO, G	NA	NA	MP	Y	NA	NA	MP	Y	NA	NA	MP	Y (GHG reduction)	NA	NA	MP
27	Solomon Islands	NA	NA	NA	NA												
28	Sri Lanka	G	NA	NA	PRO	Y	PO, I, T	PRO	PO, PRO								
29	Thailand	G	PO, T	PP, MP	MP	Y	I, T	PP	MP	Y	PO, T	PP, MP	MP				
30	Timor Leste					NA	NA	NA	NA								
31	Tonga	G	I	MP	MP												
32	Tuvalu	NA	NA	NA	NA	Y	I, T	PRO, MP	MP, PR								
33	Vietnam	G	F, I	NA	MP												

Note: Q-1 Please share how climate mitigation is addressed in waste management policies and programmes for co-benefits?
Y- Yes; H- High; Avg.- Average; VH- Very High; NE- Not Exists; NA- Not available; PO- Policy; I – Institutional; T- Technical; F- Financial; PP- Pilot project; MP – Master plan; PRO – Programme; PR- Project; P – Poor; VM- Very much; Reg. – Regulation; G- Guidelines
Prepared from Regional 3R Forum Country Reports (2018, 2019, 2020, 2021);
https:andandwww.uncrd.or.jpand?page=viewandnr=1217andtype=13andmenu=198

SUSTAINABLE DEVELOPMENT GOALS

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