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Water Quality and Security in Asia and the Pacific ~ What 3R and Circular Economy can Offer?

(Background Paper for Plenary Session 2 of the Programme)

Final Draft

This background paper has been prepared by Prof. C. Visvanathan, for the Eighth Regional 3R Forum in Asia and the Pacific. The views expressed herein are those of the author only and do not necessarily reflect the views of the United Nations.

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Final Draft Report

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Abbreviations and Acronyms

3R	Reduce, Reuse, Recycle
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
GWP	Global Water Partnership
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IWRM	Integrated Water Resources Management
LID	Low Impact Development
MDG	Millennium Development Goal
MUS	Multiple Use Systems
OECD	Organisation for Economic Co-operation and Development
PPP	Public-Private Partnership
PRC	People's Republic of China
SCP	Sustainable Consumption and Production
SDG	Sustainable Development Goal(s)
SIDS	Small Islands Developing States
SME	Small and Medium Enterprise(s)
SUDS	Sustainable Urban Drainage System
UN DESA	United Nations Department of Economic and Social Affairs
UN ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
WDM	Water Demand Management
WHO	World Health Organisation
WWAP	World Water Assessment Programme
WCT	Water Conservation Tax
WBF	Water Borne Fee

Foreword

Water security is an indispensable part of the economic, social and environmental well-being of any country or region. In the Asia-Pacific region, this topic is particularly relevant in the context of its growing demographic and economic development. It will not be an exaggeration to state that water security governs the path to achieving national agendas and development goals such as poverty reduction, inclusive growth, food security and gender equality among others.

It is expected that there will be 22 megacities in Asia-Pacific region by 2030, and the population will rise to 5 billion by 2050. Against this backdrop of rapid growth and urbanisation, it is important to highlight the dire state of water resources, availability and accessibility in the region. These problems are brought about collectively by poor infrastructure planning, economic constraints, lack of political will and public participation. It has been estimated that the cost of inaction would mean that more than 3 billion would live in water-stressed conditions in the region. Thus, it is imperative that the countries of the Asia-Pacific address the water security challenges urgently and vehemently by ensuring a holistic implementation of *reduce*, *reuse* and *recycle* (3R) strategies.

This report, entitled "Water quality and security in Asia Pacific: What 3R and Circular Economy can Offer?", is prepared to guide and support The Eighth Regional 3R Forum in Asia and the Pacific for the effective implementation of the Mal'e and Adelaide 3R Declaration. This report serves as a reference document to provide inputs to the "Indore 3R Declaration on Achieving Clean Water, Clean Land, and Clean Air in Cities".

To summarise, this report has described the causes of Asia and Pacific's vulnerability to water security issues and has attempted to shed light on holistic solutions of 3Rs in water management for attaining water security in the region through wastewater reuse and recycle. In addition, it has highlighted the significance of 3R principles for sustainable abstraction and consumption of water resources, as well as decentralised treatment and recovery of wastewater. It also intends to support Asian countries in their attempt to transform towards circular water economy. It has, thus, provided a meaningful insight to water and freshwater nexus in the context of its relevance for implementing post-2015 development agenda/Sustainable Development Goals (SDGs). In the end, this report has endorsed cooperation (partnership) between the public and the private sectors to regulate and finance governmental plans that support schemes to improve water security in the Asia-Pacific region.

Considering the gravity of the issue, it is vital that coordinated actions and innovative strategies are aimed at addressing the challenges of sustainable water management at hand. This report has built upon this argument, and has provided a concise overview on the way forward, that is not only appropriate in the context of this region but also essential to meet the water demands in the years to follow.

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Executive Summary

Amid Asia's rapid economic and socio-cultural growth, the modernisation and advances in industrialisation, agriculture and urbanisation have put the region's water security, availability and accessibility in the fore. Nearly two billion people in the Asia Pacific region have poor or limited accessibility to water, and the number is expected to reach five billion in the year 2050. Making matters worse, the quality of existing water resources have been deteriorated by the mixing of polluted, untreated water in the freshwater system as nearly 90% of the total wastewater generated in the region is mixed without adequate treatment. To further aggravate the situation, climate change induced disasters have proliferated the situation of water quality and quantity and its uncertain demand and supply situation. Proper management of water resources and sustainable development of water infrastructures are crucial with regards to addressing the issues raised in the sustainable development goals. It is important to realise that water management is not only a standalone goal (SDG Goal 6), but has close connections to other socio-economic, environmental and development issues. The role of sustainable management of water resources in poverty alleviation and food security needs to be stressed vehemently as well. Furthermore, water security is also a transboundary and political issue as wars and conflicts have arisen over water rights. This paints a clear picture as to the role of water resources in the mainframe of the development of the region. This mandates the need for a coordinated set of actions that are geared at handling water and wastewater management issues holistically, giving due attention to the economics and feasibility of the actions proposed.

In this direction, this report has tried to highlight the potential and the need for the reuse of treated wastewater. This is important to emphasise as water use *reduction*, and *reuse* and *recycling* of wastewater still remain underappreciated and underutilised in the region. Though the 3R strategies have been widely discussed and applied in the solid waste management sector, its applicability and suitability are relevant in water sector as well. For example, the strategies to reduce water demand and use include both holistic and atomistic approaches such as watershed conservation, improving irrigation efficiency and fostering alternative sources of water like rainwater harvesting. The successful application of Multiple Use Water Systems (MUS) in India and Nepal have provided yet another opportunity to harness efficient water systems. Developing separate systems could pave the way to divert storm water for reuse for other purposes, whereas advanced treatment systems could enable the recycling of wastewater for water and nutrients recovery.

The concept of circular water economy strongly resonates with those to attain wastewater reuse and recycle as it focuses on harnessing natural water cycles and synchronise with the whole water/waste cycle including water supply, sanitation and wastewater reclamation, and reuse. This approach is contrary to the linear systems widely adopted in the region today where the uptake of water resources is dominated by the line of abstraction, use and disposal. As such, Asia-Pacific region could lead the way in promoting circular economy of water by successfully implementing 3R strategies. The transition to circular water economy through adopting 3R principles requires a clear national and regional strategy, concrete work plan and adequate investments to make proper arrangements for adequate infrastructure and technological interventions, backed appropriately by policy and financial mechanisms. This also requires attracting public acceptance and investments. For example, it is rather problematic in the region that, despite regulations on the discharge of industrial wastewater, much of it is discharged directly into natural waterways. Similarly, rainwater, in lieu of reusing as a secondary source, is allowed to mix into the sewerage systems of the cities at present. These situations point to

the lack of governmental policies and regulations, or at least poor implementation of the same. Similarly, this scenario is also a result of lack of sense of responsibility and consumer-driven efforts, often a consequence of poor social acceptance of reused water, and awareness or mechanism to exploit the opportunities presented in circular water economy. The economic constraints such as investment funding and the long-term financial viability of different schemes (or lack thereof) as well as fragmented political and bureaucratic systems also hinder the promotion and implementation of sustainable water management plans.

The strategies incorporated in circular water economy envision and address potential future water demand, wastewater generation, as well as technological innovations in wastewater recycling. As such, existing institutional, policy, finance, technology, and behavioural barriers should be considered, and where appropriate and necessary, modified or completely changed to make room for those that endorse and encourage holistic water management. For example, industries, based on their capital investments, could be mandated to adopt an on-site central wastewater treatment plant, or adopt zero liquid discharge (ZLD) production processes. These could, in turn, lead to the closed-loop economy to save both environment and water charges, and promote sustainability. Such decentralised systems are not only economical but also suitable for different site conditions and environments. In addition, they also provide the leverage of having a better control than centralised systems.

The transformation to circular water economy requires affirmative actions from national governments to increase water use efficiency, and increase investment not only in water supply infrastructure but also wastewater management. For example, upstream watershed management can be enforced through appropriate tariffs and incentives for natural infrastructure systems. Similarly, reusing (grey)water in industries, agriculture and aquaculture can be encouraged by setting up national and regional industrial and health standards. In addition, the governments should leverage the transfer of appropriate technology and focus on capacity development to build a strong workforce that can make and exploit the transition. As for the financial arrangement, water infrastructures should be developed by partnering both private and public sectors (PPP model) which will help share risks between the public and private sectors. PPP model also brings better and more efficient construction and operation of projects through increased predictability, accountability and transparency of costs and funding.

In conclusion, the region should acknowledge the role of water in the socio-economic progresses in the years to follow. It is important to hold sustainable water management at the center of all policies and development agendas since it is closely linked to all socio-economic, human and environmental development activities. The implementation of 3R strategies could serve well in attaining this goal. The existing linear water systems are often inefficient – from catchment to consumer, back to catchment, in which the quality and quantity of water is often lost, wasted and misused. Such systems will only worsen the gap between water supply and demand in the future. On the contrary, the closed loop systems offer diversified resource options, efficient conveyance and optimal reuse. Thus, the transition to circular water economy offers the chance to promote sustainable living and promote new business opportunities to attract not just the countries, but also the residents to participate actively.

1 Introduction

1.1 Background

Water lies at the centre of the three pillars of sustainable development-economy, society and the environment. It implies that it is an indispensable part of the political, health, economic, personal, food, energy and environmental facets of development as it plays a vital role in achieving poverty reduction, inclusive growth, public health, food security, lives of dignity for all and long-lasting harmony with Earth's essential ecosystems. However, despite the abundance of water resources on the planet, several anthropogenic and natural causes have led to an increasingly difficult situation where it is becoming a scarce and competitive resource. The World Health Organization (WHO) reported in 2015 that 884 million people lacked even a basic drinking-water service, including 159 million people who were dependent on surface water (WHO & UNICEF, 2017). It further stated that at least 2 billion people used drinking water with possible faecal contamination. If immediate action is not taken, it has been estimated that about 1.8 billion people will be living in countries or regions with absolute water scarcity (<1000 m^3/capita/year), and half of the world's population could be living under water stressed (<1700 m^3/capita/year) conditions by 2025 (Mitra, 2014). To make matters worse, the most affected population will be the ones inhabiting developing countries, mainly in regions that are already experiencing water stress and in areas with limited access to safe drinking water and adequate sanitation facilities. By 2050, global water demand is projected to increase to 55%, mainly due to growing demands from industrial and domestic activities (WWAP, 2015).

The reasons for the depleting and degrading conditions of water can be attributed to a combination of natural and anthropogenic factors such as erratic distribution and availability of freshwater resources in different geographical regions, increasing water abstraction from an expanding population, urbanisation, impacts of climate change on water resources, industrial pollution and overall poor water management. The release of untreated municipal solid waste and sewage, industrial effluent and poor agricultural practices is adding a huge pollution load to the rivers. For instance, an estimated 333, 000 tonnes of plastic waste is dumped into the East China Sea via China's Yangtze River every year (Daily Asian Age, 2017). In the Ganges, 115, 000 tonnes of plastic waste is dumped annually (D'Mello, 2017). The 22-km stretch of the Yamuna River along Delhi receives 3.9 billion L/d of sewage every day from 21 drain outlets (Yadav, 2013). Not only the freshwater resources like rivers and lakes but groundwater resources that satisfy basic daily water needs of 2.5 billion people are also diminishing. An estimated 20% of the world's aquifers being overexploited, leading to serious consequences such as land subsidence and saltwater intrusion in coastal areas (WWAP, 2015). Over-extraction of groundwater, often exceeding the natural recharge rate, have caused ground subsidence and also the salinization of freshwater resources, especially in Small Islands Developing States (SIDS). Such damage to freshwater resources threatens annually up to USD 1.75 trillion in ecosystem services, such as agricultural and fisheries production, and environmental and biodiversity benefits (Niko, 2013).

All these staggering statistics point to the fact that the water is getting scarcer globally. The impact is even more profound in the Asia and Pacific region as it has witnessed remarkable socioeconomic and demographic transition in the past two decades. The Asia and Pacific region, on one hand, has the highest annual water withdrawal of all the world's regions (around 2500 km^3/yr), owing to its geographic size, large population and irrigation practices (water for agriculture continues to consume 80% of the region's resources). On the other hand, it suffers water pollution due to lack of proper treatment of wastewater. As much as 80-90% of wastewater is directly disposed of into receiving water bodies without treatment in the region (UN-ESCAP, 2013). Consequently, 80% of Asia's rivers have been deemed to be in poor health. The access to a secure and clean supply of freshwater resources has been and will continue to burden the people of this region. About 1.7 billion people lack access to basic sanitation in 2015, and with a predicted population of 5.2 billion by 2050 and hosting 22 megacities by 2030, the region's finite water resources will be placed under enormous pressure (ADB, 2016). In fact, if "business as usual" is allowed, it has been estimated that in 2050, 3.4 billion people could be living in water-stressed areas of Asia (ADB, 2016).

The degradation of fresh water sources is an impetus to the freshwater crisis due to expanding industrialisation, urbanisation, and extensive agricultural development. On top of it, cities in Asia and the Pacific, especially the island countries are at risk of climate-related disasters such as typhoons, hurricanes, cyclones, and rising sea level making their freshwater resources more vulnerable. UN-Water Statistics show that by 2050 the number of people vulnerable to flood disaster is expected to increase to 2 billion (UN-ESCAP, 2015). Similarly, climate change could force an additional 1.8 billion people to live in a water scarce environment by 2080 (UN-ESCAP, 2015).

Amidst growing concern over diminishing waters and degrading water quality, the issues and threats to water security has been recognised as a principal agenda in international forums like the Ministerial Declaration of the Second World Water Forum in the Hague, Netherlands in March 2000, and the outcome document of the 2012 UN Conference on Sustainable Development (Rio+20), 'The Future We Want.' In general, these forums and discussions have emphasised the need to foster a holistic approach to address the crisis of freshwater resource management by putting values to alternative sources of water including treatment and reuse of wastewater. More importantly, some regional forums have put forth the concept of water supply and demand management through water consumption *reduction*, *reuse* and *recycling* (3R). In particular, the Ha Noi 3R Forum (2013) and Surabaya 3R Forum (2014) reiterated the significance of 3R methodology as a means to securing water supply managing and controlling pollution from wastewater. The Eighth Regional 3R Forum in Asia and the Pacific, under the theme of "Achieving Clean Water, Clean Land and Clean Air through 3R and Resource Efficiency- A 21st Century Vision for Asia-Pacific Communities" provides a consolidated view of 3R principle for sustainable consumption of water resources and treatment and recovery of wastewater to close the water cycle loop.

This background paper details the status and availability of world's water resources and specifically discusses the status and challenges to water security in Asia and the Pacific in section 2. Section 3 deals with the way forward in the realisation of water security in attaining sustainable development goals (SDGs). Similarly, section 4 responds to the region's water security challenges through integrated water resource management using 3R principles in making wastewater reuse as a favourable solution to water scarcity. Section 5 of this report discusses water governance and policy issues to streamline 3R strategies in the context of water security while Section 6 concludes the background paper by providing financing options that are essential in managing water infrastructures.

1.2 Water security

1.2.1 Concept of water security

Water security is an evolving concept and encompasses a broad range of topics ranging from biophysical to infrastructural, institutional, political, social, and financial aspects of water resources. In the 1990s, water security was perceived as a vague topic, limited to a general vision, without concrete understanding or definitions. It was often associated with other human security issues such as food and military security (Cook & Bakker, 2012). In 2000, the water security was first comprehensively defined by World Water Commission in the Hague, Netherlands as "access to enough safe water at an affordable cost to lead a clean, healthy and productive life while ensuring that the natural environment is protected and enhanced". Over the years, many organisations have modified the definitions of water security, during which it was viewed in terms of water availability, accessibility, reliability and sustainability. The impacts of climate change were also associated with water security.

In 2013, UN-Water defined water security as “the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability (UN-Water, 2016).” This is considered one of the most comprehensive definitions of water security and has gained much endorsement and approval as it captures the dynamic dimensions of water and water-related issues and offers a holistic outlook for addressing water challenges.

1.2.2 Key elements of water security

Within the diverse definitions and understanding of water security, some common themes and trends can be identified. On the whole, it can be summarised to contain a range of elements which have been listed as follows:

- Access to safe and sufficient drinking water at an affordable cost in order to meet basic needs including sanitation and hygiene, and safeguard health and levels of well-being,
- Protection of livelihoods, human rights, and cultural and recreational values,
- Preservation and protection of ecosystems in water allocation and management systems in order to maintain their ability to deliver and sustain functioning of essential ecosystem services,
- Water supplies for socioeconomic development and activities (such as energy, transport, industry, tourism),
- Collection and treatment of used water to protect human life and the environment from pollution,
- Collaborative approaches to transboundary water resources management within and between countries to promote freshwater sustainability and cooperation,
- The ability to cope with uncertainties and risks of water-related hazards, such as floods, droughts and pollution, among others, and,
- Good governance and accountability, and the due consideration of the interests of all stakeholders through appropriate and effective legal regimes; transparent, participatory, and accountable institutions; properly planned, operated, and maintained infrastructure and capacity development.

The Asian Water Development Outlook report ADB (2016) has incorporated these common trends of water security under five key dimensions as briefly described below. These multiple dimensions of water security also include poverty reduction and governance as cross-cutting issues.

- *Key Dimension 1: Household Water Security*
  Household water security is the cornerstone of water security, which addresses access to piped water supply, and access to improved sanitation and hygiene.
- *Key Dimension 2: Economic Water Security*
  Economic water security measures the productive use of water to sustain economic growth in the food production, industry, and energy sectors of the economy.
- *Key Dimension 3: Urban Water Security*
  The urban water security indicators measure the creation of better water management and services, wastewater treatment and drainage systems.
- *Key Dimension 4: Environmental Water Security*

The environmental water security indicator assesses the health of rivers and measures progress on restoring rivers and ecosystems to health on a national and regional scale.

- *Key Dimension 5: Resilience to Water-Related Disasters*
  This dimension looks into water-related disaster risks, and the coping strategies and capacities.

Similarly, these common trends have been categorised by Cook & Bakker (2012) under four headings: water availability, human vulnerability to hazards, development- and food-related human needs, and sustainability. Based on this information, it is clear that water security cannot be explained without proper recognition of the underlying dimensions that make up the concept. As such, the definitions of key terminologies associated with water security has been summarised in **Table 1-1**.

Table 1-1: Definitions of terminologies associated with water security

Terminology	Definition
Water accessibility	Having a source of safe water with availability of at least 20 litres of drinking water per person per day within 1 kilometre of the dwelling, corresponding to a maximum water hauling round trip of 30 minutes
Water affordability	Ability to access safe and sufficient drinking water at an affordable cost in order to meet basic needs including sanitation, hygiene, health and well-being
Water availability	The amount of fresh water (groundwater and surface water) that could be used for domestic, industrial and/or agricultural purposes
Water reliability	Hydraulic and quality reliability to meet the water demands with reasonable limitations and fluctuations within the accepted levels and expectations of the customer
Water resilience	Function of the nature of the failure, and the ability for the failure to be corrected or accommodated without affecting reliability of the system
Water scarcity	Occurs when annual water supplies drop below 1,000 m^3 per person, or when more than 40 percent of available water is used
Water security	The availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water-related risks to people, environments and economies
Water stress	Occurs when annual water supplies drop below 1,700 m^3 per person

2 Water security: status, threats and challenges in Asia and Pacific

2.1 Water accessibility and availability in Asia Pacific region

Asia Pacific region is one of the global hotspots for risks against water insecurity. This is mainly because of the rapidly increasing population along with accelerated urbanisation rate, intensified industrial development and extensive agricultural development. Climate change impacts have further aggravated the water stresses in the region as it has increased its vulnerability to several climate-induced disasters. The subsequent sections shed light on the water security status, threats and challenges in the region.

The challenges of water in the Asia-Pacific region is a cumulative effect of poor access to adequate quantity and quality of drinking water supply, limited coverage of sewerage networks and (often non-existing) wastewater treatment systems. Furthermore, this region has an increasing water demand for multiple uses and the concurrent pollution loads and ecosystem degradation. Asia Pacific region also happens to be one of the most disaster-prone regions in the world and is vulnerable to events such as floods and droughts. In fact, between 2006 and 2016, it was estimated that 700 million people had died and 1.7 billion had been affected due to serious storms, floods, and heatwaves (ADB, 2016).

The depleting availability of water is a major concern in the region. In particular, Asia-Pacific sub-regions with high population densities such as East and North-East Asia and South and South-West Asia have less than 2,500 m^3/capita/ year (UN-ESCAP, 2015). Nearly one-third of Asia's population drinking water supply is from groundwater. India, China, Bangladesh, and Pakistan alone account for nearly half the world's total groundwater use. It is also the main source of supply for rural communities in Asia that are not connected to a drinking water network; for example, 60% of such a population in Cambodia and 76% in Bangladesh depend on tube wells (UNESCO, 2015). In large urban areas, the use of groundwater by industry is usually more than its domestic use. Not surprisingly, groundwater is key to several economic sectors in the region as 7 of the world's 15 biggest abstractors of groundwater are in the Asia Pacific region as listed in **Table 2-1** (Margat & Van der Gun, 2013). It has been estimated that groundwater irrigation contributes USD 15-30 billion annually to Asian economy (WWAP, 2015).

Table 2-1: Largest estimated annual groundwater extractions in the Asia Pacific

Country	Population in 2010 ('000)	Groundwater extraction			
		Estimated groundwater extraction (km^3/yr)	Breakdown by sector (%)		
			Groundwater Extraction for Irrigation	Groundwater Extraction for Domestic Use	Groundwater Extraction for Industry
India	1, 224, 614	251.00	89	9	2
PR of China	1, 341, 335	111.95	54	20	26
Pakistan	173, 593	64.82	94	6	0
Bangladesh	148, 692	30.21	86	13	1
Indonesia	239, 871	14.93	2	93	5
Japan	126, 536	10.94	23	29	48
Thailand	69, 122	10.74	14	60	26

Source: (Margat & Van der Gun, 2013)

Land subsidence as a result of groundwater abstraction has been observed in a number of coastal Asian cities like Bangkok, Kolkata and Dhaka. In eastern Bangkok, land subsidence rates of 10 cm per year or higher have been measured, and in several locations in Bandung, they have reached as high as 24 cm per year (UNESCO, 2015). Groundwater quality has also been affected in the region because of accumulation of natural and anthropogenic contaminants. In particular, arsenic, fluoride and iron contaminants have deteriorated the region's aquifer.

If only the access to clean drinking water is considered, the countries in the Asia and Pacific region have made a remarkable progress in this field. In fact, this region was able to meet the target 7C of the Millennium Development Goals (MDGs) on halving the proportion of people without access to safe drinking water, and did so before the 2015 deadline. Starting at 73% of the population having access to safe drinking water, the coverage reached 87% in 2006 and progressed further to 94% in 2015 (UN-ESCAP, 2015). However, there is no room for complacency despite this impressive improvement as 277 million people in Asia and Pacific region still lack access to safe drinking water. Between 1990 and 2015, the proportion of urban populations in Asia and the Pacific with access to safe drinking water improved from 94% to 97%. Access to safe drinking water in the rural areas also accelerated from 63% to 91% during the same period. In 2015, however, 213 million rural residents in the region still did not have access to safe drinking water; they accounted for three-quarters of those living without access to safe drinking water in the region. Lack of access to safe drinking water is particularly acute for rural residents in some countries in the region. As of 2015, only 33% of the rural population in Papua New Guinea had access to improved water sources. Similar situations were also found in Afghanistan (47%), Kiribati (51%), Mongolia (59%) and Timor-Leste (61%) as shown in **Figure 2-1**.

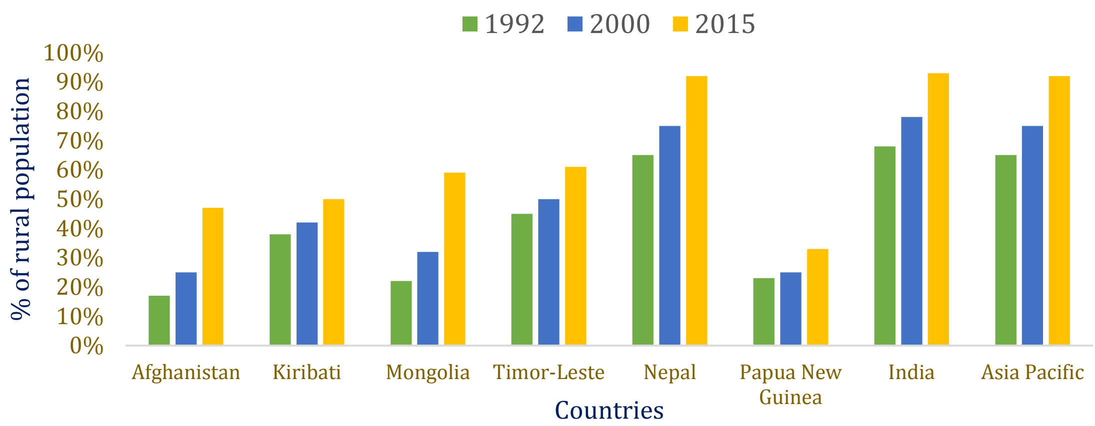


Figure 2-1: Access to improved water sources in rural areas of selected countries of Asia Pacific

Source: (UN-ESCAP, 2015)

Thus, it can be concluded that water accessibility and availability in Asia Pacific region is highly vulnerable to increasing threats and challenges of over-abstraction brought about by the rapidly growing population, urbanisation and industrialisation. If left unchecked, it is bound to hinder the economic growth of the region and serve as an impetus to socio-political and economic instability.

2.2 Wastewater, sanitation and pollution challenges

Wastewater management has long proven to be a bottleneck for the sustainable development of Asia Pacific region. Municipal sewage, industrial wastewater and agricultural runoff compound a large quantity of polluted water that is disposed of in surface water bodies without undergoing proper treatment. This has deteriorated the surrounding environment including the water quality in water bodies and the riparian environment. It has also adversely affected the health of the residents. **Figure 2-2** below indicates the percentage of wastewater treatment in Asia Pacific region. As shown in the figure, in South Asia, as little as 22% of wastewater is treated before being discharged into water bodies (UN-Water, 2017). The sub-regions other than industrialised nations such as Japan and the Republic of Korea have also not achieved proper treatment of wastewater as Pacific island countries, Central and Western Asian countries, Southeast Asian countries, and East Asian countries treat 17, 34, 38 and 57% of the wastewater generated (UN-Water, 2017). A case of such a phenomenon has been shown in **Box 2-1** which describes the case of pollution of Bangalore's lakes.

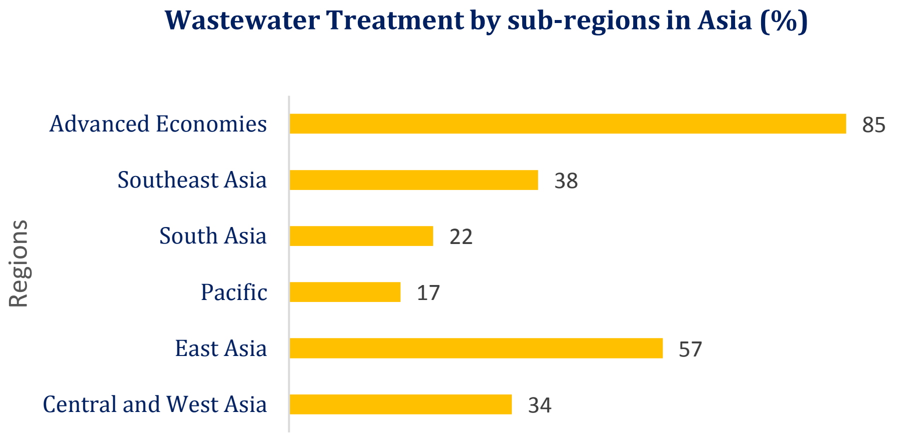


Figure 2-2: Status of wastewater treatment by sub-regions in Asia

Source: (UN-Water, 2017)

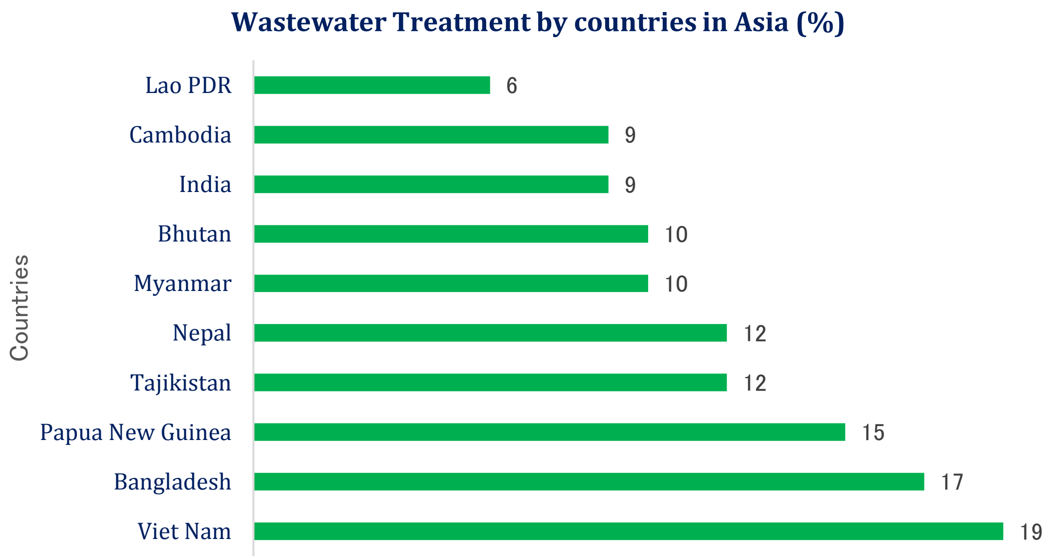


Figure 2-3: Status of wastewater treatment by countries in Asia Pacific region

Source: (UN-Water, 2017)

Box 2-1: Burning lakes of Bangalore

India's 'Silicon Valley', the city of Bangalore has a moniker of the "city of lakes". The city has 194 lakes at present. However, recent events at the lakes have dumbfounded many scientists, not to mention the residents of the city. In 2015, a thick foam layer covered the biggest lake of the city, the Bellandur Lake. Furthermore, in February 16, 2017, huge plumes of smoke was seen rising from the lake: the water body had apparently caught fire!

Bangalore has seen a rapid, unchecked urbanisation in the wake of the IT sector-fuelled economic boom of the late 1990s. However, this has come at the price of ecological balance of the city. Between 1973 and 2016, Bangalore saw a 1005% increase in paved surfaces and decline of 88% in the city's vegetation, while water bodies declined by 85% between 2000 and 2014.

Dr. TV Ramachandra from the Energy and Wetland Research Group at the Indian Institute of Science (IISc) explained that the reason behind the incidents at the lake was heavy disposal of sewage into the water bodies. As many as 400-600 million litres of untreated sewage is disposed of lakes every day which proliferates the growth of a thick layer of water hyacinth. The situation is aggravated by the open dumping of solid wastes into the lakes. The thick layer at the surface creates an anaerobic environment in the water below, where methane, a highly flammable gas, is formed. The toxic environment is also responsible for the froth formation in the lakes.

The impacts of the water pollution has already been seen in the city. The Ulsoor Lake saw dead fish floating on its waters last year owing to the pollution caused by untreated sewage and consequent depletion of dissolved oxygen. The foul odour and fumes from the lake have posed severe health hazards, and the city is on its way to chronic shortages of fresh water supply. In fact, experts fear that the pollution and the severe water crisis which will make Bangalore uninhabitable by 2025, with residents potentially having to be evacuated.

Source: (The Guardian, 2017)

2.3 Water security under climate risks

Asia Pacific region is also vulnerable to increasing threats of the impacts of climate change. It has been estimated that climate variabilities such as changes in temperature, evaporation, and precipitation will impact regional water resources. This will be brought about by the expected increases in the frequency of floods and droughts and reduced river flows, particularly during low flow periods. The countries in the East Asian region are already experiencing seasonal precipitation changes (Gosling & Arnell, 2016). Similarly, Southeast Asia is projected to suffer from growing cases of increase in temperatures, droughts, and flooding. The socioeconomically and geographically vulnerable (like low-lying, flood-prone areas) countries like Bangladesh will be further impacted by underlying water and food insecurity.

From the supply side, the water cycle is set to be drastically affected by climate change which will, in turn, affect the quantity and quality of water resources available to meet human and environmental demands. If (or rather, when) this happens, severe losses to lives, properties, infrastructures will take place. In the water sector, climate change will affect the quantity through higher intensity precipitation causing floods in some regions and droughts in others. For instance, climate change can lower minimum flows in rivers, affecting water availability and quality for flora and fauna, drinking water intake, energy production (hydropower), thermal plant cooling and navigation. One such case of Delhi water supply has been described in **Box 2-2** explaining the impact of climate change in the water supply to the residents of the city. On the other hand, from a water demand perspective, climate change is likely to increase water demand through changes in demand from industrial cooling, household use, or irrigation.

Box 2-2: Impacts of climate change on water availability in Delhi

Delhi depends largely on three river systems for its raw water supply, namely, Yamuna, Ganga, and the Beas. It gets 1.4 billion liters of water from the Western Yamuna Canal every day amounting to 48 % of Delhi's total water supply. Other sources include raw water from Upper Ganga Canal and Bhakra Beas Management Board (BBMB). At present, the contribution of raw water from the three sources is 84 % of the total. Currently about 455 million liters of water is supplied through groundwater extraction.

Under climate change, it is assumed that the water availability from the Yamuna River would vary with the change in discharges. The availability from Beas and Ganga would vary according to 0.03 °C temperature rise scenario in a study for Ganga discharge at Haridwar. Considering that Beas River carries more glacial content compared to Ganga River, it is expected that the discharges would change more rapidly in case of Beas. A study on changes in rainfall patterns and surplus deficit sensitivity analysis revealed that under the influence of climate change, there is an increase in water availability till 2041 and then a sharp decline in the latter part of the century. Owing to their location in the Himalayas, these sources would be able to add only 3 billion liters per day in 2041 against the envisaged 4 billion liters per day. This would further decline to 2.3 billion liters per day by the end of the century. Existing riverine sources will also be impacted and would decline from approximately 3.8 billion liters per day in 2011 to approximately 2.5 billion liters per day in 2101. Consequently, there would be a surplus of water for the next few decades, and Delhi would be in a position to meet its water demand as a result of additional discharges in the existing and additionally planned water from riverine sources. This would be followed by a steep decline in the post-2041 period as a result of depletion of glacier systems. By 2101 there will be a deficit of 2.9 billion lieters per day for a population stabilization of 40 million as against 590 million leters per day in the case without taking into account the climate change impacts.

Source: (Pathak, Shukla, Garg, & Dholakia, 2015)

The effects in water quality are also projected to adversely affect the lives of people and the aquatic environment. Rising sea levels will adversely affect coastal aquifers which supply water to the cities near the coast. In glacier-fed rivers, climate change can cause a temporary increase in the amount of water before a drastic decrease after some time. The natural water balance, water availability, and demand for water are highly likely to be affected by climate change-induced disasters, including rainfall variability, floods, droughts and risks to water and sanitation infrastructure because of extreme events and sea level rise, particularly in the island countries. To summarise, climate change will further compound multiple stresses from rapid urbanisation, industrialisation, and economic development as Asia and the Pacific has some of the most vulnerable countries to climate change. Combating climate change will require global actions for increased investments in adaptation and mitigation to enhance resilience.

2.4 Socio-political impacts of water scarcity

The inability to secure water security has several socio-political impacts considering that water lies at the core of all lives and their social and economic welfare. For example, Asia's struggle to address water security challenges has been most evident in farmers of poor, developing countries who rely on rainfall for irrigation and do not have the means to irrigate from surface water bodies or groundwater. This social unrest and struggle have at times led to state- and national-level conflicts. This has been illustrated in **Box 2-3.**

Box 2-3: Socio-political impacts of water scarcity in India

In India, poor crop yields, erratic rainfall patterns (heavy bursts of rainfall in some places and drought in others) as well as depletion of ground/surface water for irrigation have led to a strong financial insecurity and crises among India's farmers. This has resulted in a growing concern of suicide by farmers. It has been reported by the Aurangabad Divisional Commissioner on August 14 that Marathwada, Maharastra had recorded 580 farmers' suicide cases between January 1, 2017 and August 13, 2017. In addition, it has also been reported that 34 farmers had committed suicide between August 7 and August 13. To make matter worse, the family of the deceased have been left behind a huge debt to pay.

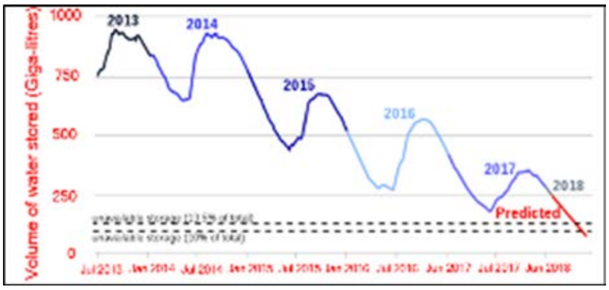
Source: (India Today, 2017)

The conflict due to water shortages are not only restricted to communities but also to state and national levels in India. One of the most controversial state-level water disputes in India is the sharing of waters of the Cauvery River between Karnataka and Tamil Nadu states. Cauvery drains an entire area of 802 km. In Tamil Nadu, it occupies a basin area of 44,000 km^2 and 32,000 km^2 in Karnataka. Considering that both the states are heavily dependent on Cauvery River for agricultural purposes and that riparian lives depend on any changes made to the flow, securing water from this River is of huge significance to the states. The problem of water shortages has been exacerbated by inadequate rainfall. As such, the two states have been engage in a long conflict since 1892. In September 2016, the Supreme Court of India ordered Karnataka to release 425 m^3/s of water for 10 days which was met with protests and resistance from the farmers of Karnataka. The controversy has not yet met a consensual end as of today.

Source: (Indian Express, 2016)

Climate change induced water related disasters has serious socio-political impacts. A case study on ongoing water crisis in Cape Town is presented in Box 2-4. This could be a warning to the cities in Asia Pacific region that are also in risk of facing the repercussions of the 'new normal'. This also strongly calls attention of other regions, particularly the Asia Pacific, to plan ahead in time so as to regulate the usage of water properly through 3R measures, and make the urban areas resilient to climate change induced disasters through proper water management.

Box 2-4: Cape Town Water Crisis



Cape Town in South Africa may become the first major city to run out of water! The ongoing unprecedented drought that began in 2015 has put Cape Town with less than 100 days worth of water left in its reservoir. The city meets its water supply from six major dams, which are recharged by rainfall. The city population has grown up by 79 % whilst dam water storage increased by mere 15 %, since 1995.

2015-2017 has been the driest 3-year period, since 1933. This is attributed to El nino weather pattern and climate change, according to University of Cape Town. The city was declared reeling under the worst drought of the century in the end of May 2017. Dam levels are predicted to decline to critically low levels, and the city has made plans for 'Day Zero' on mid-May 2018 (pushed from mid-April due to decline in agricultural usage). Hopefully, rainy season in Cape Town region commences during the month of May. Day Zero is calculated every week based on current reservoir capacity and daily consumption. The silt and debris make the last 10% of a dam's water unusable. City authorities have decided that once the dams reach 13.5% capacity, municipal water supply will be turned off for all but essential services, like hospitals. Water consumption will be rationed at 25 litres per person per day from Day Zero, the bare minimum needed to maintain health and hygiene. Residents will be forced to wait at secured distribution points to fetch water under the watch of armed guards. Some 50000 people are estimated to be pushed below poverty line due to job losses and inflation. Climate scientists have called this 'a once in a millennium event.

Day Zero is planned to be avoided through various measures including capping the household water usage at 50 liters per person, per day, augmentation of water supply from other provinces to 200 distribution points across the city of Cape Town, new water projects like Desalination plants, Reuse and Recycle of greywater and deployment of forces to prevent chaos. Companies will rely on tankers from less drought-prone parts of the country, for a price. Climate change researchers predict more frequent dry years and fewer wet years to come. More likely, they say, Capetonians are just getting a preview of the new normal.

Source: (TIME, 2018)

3 Water security with relation to Sustainable Development Goals (SDGs)

3.1 Water and the SDGs

The significance of water and its management and security in the global context was highlighted by the World Economic Forum when, in 2015, it declared water crises as the greatest risk facing humanity (WEF, 2015). To reiterate the magnitude of the problem, 193 member states of the UN General Assembly signed a newly developed agenda in September 2015 to drive sustainable actions up to 2030, including goals for sustainable use and management of water resources. The 17 Sustainable Development Goals (SDGs) set out 169 targets for the member countries to achieve within the stipulated time based on their experiences, successes, gaps and lessons from the Millennium Development Goals (MDGs).

Water has been incorporated directly and indirectly to 14 of the 17 goals as shown in **Figure 3.1**. This highlights the fact that water management is an integral and inseparable part of the development agenda, particularly to those related to food, energy and the environment. Furthermore, to emphasize the need to bear a collective responsibility, Goal 6 of the SDG has been dedicated to water security alone. This goal calls for the need to "ensure availability and sustainable management of water and sanitation for all". A standalone water goal has paved the way to raise the profile of water issues and signal the political commitment to address water security challenges. In addition, the relevancy of water management issue on goals other than goal 6 champions the need to manage water in an integrated manner. In other words, it recognises the critical importance of managing water resources for sustainable development, and the need for the water and water-using sectors to collaborate and move beyond their traditional fragmented 'silo' approach to an integrated approach to water resources management (Shah, 2016). The details of Goal 6 has been depicted in Section 3.2, followed by connection to other goals in Section 3.3, highlighting the need to address water security issues by fostering Integrated Water Resources Management (IWRM) practices to seize the opportunity presented by SDGs for making significant progress on a wide range of development issues.

#	Goal	Sub-goals																		
1	No Poverty	1.1	1.2	1.3	1.4	1.5	1.a	1.b												
2	No Hunger	2.1	2.2	2.3	2.4	2.5	2a	2.b	2.c											
3	Health	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	3.a	3.b	3.c	3.d						
4	Education	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.1	4.b	4.c									
5	Gender Equality	5.1	5.2	5.3	5.4	5.5	5.6	5.a	5.b	5.c										
6	Water and Sanitation	6.1	6.2	6.3	6.4	6.5	6.6	6.a	6.b											
7	Energy	7.1	7.2	7.3	7.a	7.b														
8	Economy	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.9	8.10	8.a	8.b	8.c						
9	Infrastructure	9.1	9.2	9.3	9.4	9.5	9.a	9.b	9.c											
10	Inequality	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.a	10.b	10.c									
11	Cities	11.1	11.2	11.3	11.4	11.5	11.6	11.7	11.a	11.b	11.c									
12	SCP	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	12.a	12.b	12.c								
13	Climate Change	13.1	13.2	13.3	13.a	13.b														
14	Marine Life	14.1	14.2	14.3	14.4	14.5	14.6	14.7	14.a	14.B	14.c									
15	Ecosystem	15.1	15.2	15.3	15.4	15.5	15.6	15.7	15.8	15.9	15.a	15.b	15.c							
16	Reduced inequalities	16.1	16.2	16.3	16.4	16.5	16.6	16.7	16.8	16.9	16.10	16.a								
17	Global	17.1	17.2	17.3	17.4	17.5	17.6	17.7	17.8	17.9	17.10	17.11	17.12	17.13	17.14	17.15	17.16	17.17	17.18	17.19
#	Goal	Sub-goals																		

Goal #6 (Exclusive); Goals # 4, 10, 16 (Not directly relevant) and Other 13 Goals (with some relevance)

Figure 3-1: Linkage of water with 17 global goals of sustainability

3.2 SDG 6: Clean water and sanitation

Achieving water security is an enormous challenge brought about by the escalating water demand, worsening pollution and the increasing incidence of extreme climatic events. Against this backdrop, embedding water as a standalone goal, SDG 6: Clean Water and Sanitation, demonstrates its central role in all aspects of development and puts responsibility for water management and increasing water security in the hands of the water and water-using sectors. The key targets and enabling targets of Goal 6 have been shown in **Box 3-1**. On the whole, this goal has set specific targets in pursuit of water security by addressing all the key dimensions: water quality, quantity and accessibility. It sets out a goal to make water and sanitation universal by 2030, which implies ensuring equitable access; the end of open defecation; upholding the unique needs of vulnerable populations; reducing pollution and open-dumping of untreated sewage; increasing efficiency and addressing water scarcity; implementing integrated management of water resources; protecting and restoring ecosystems; and expanding both international capacity building, and local participation in water and sanitation management. It also champions the need for an integrated approach to water resources management, particularly through Goal 6.5, as the means of equitably sharing limited water resources among many, often conflicting, demands from people, industry, agriculture, and the environment when demand exceeds supply (Shivakoti, Bengtsson, Miyazama, & Aleksiunaite, 2015).

Box 3-1: SDG 6 and the corresponding targets

Key targets:

6.1: By 2030, achieve universal and equitable access to safe and affordable drinking water for all

6.2: By 2030, achieve access to adequate and equitable sanitation and hygiene for all, and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations

6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimising release of hazardous chemicals and materials, halving the proportion of untreated wastewater, and substantially increasing recycling and safe reuse globally

6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity, and substantially reduce the number of people suffering from water scarcity

6.5 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate

6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes

Enabling targets:

6.a By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies

6.b Support and strengthen the participation of local communities for improving water and sanitation management

Source: (UN DESA, 2015)

3.3 Linkages of water to other SDGs

Considering that water and sanitation are indispensable for a healthy life and for development in general, improved water management can help promote various aspects of sustainable development.

For instance, a target on universal access to safe drinking water and sanitation is bound to have positive spill-over effects on goals related to education and gender (improved toilets in schools lead to lower dropouts of girls), health (reduction in waterborne diseases), and environment (less pollution and reduced risk of eutrophication, if wastewater is managed properly). Similarly, a target to improve water use efficiency can increase the availability of water for drinking, irrigation, industrial uses, for energy generation or reduction in the volume of wastewater. In addition, targets on zero hunger or universal access to energy would, respectively, lead to an expansion of irrigated agriculture or the construction of water-intensive power plants, which would increase the pressure on available water resources and accentuate the need for good water management. Likewise, improved access to energy can increase water abstraction by providing energy for water pumping. Thus, water is one of the areas where the potential synergies are particularly high, but such synergies will not materialise unless well thought-out cross-sectoral actions are formed by taking into consideration its inter-linkages with other sectors and development goals.

3.4 Transforming the SDGs from ambition to action

In order to implement the components of SDGs, it is imperative that countries draw up their roadmaps based on their own priorities and lessons learned from the MDGs. To this end, the countries need to establish nationally appropriate numerical targets and select appropriate and adequate indicators to guide the implementation process. It must also be ensured that the planning process is inclusive where multi-stakeholders are incorporated to mediate the interests of various groups and sectors and take advantage of their capabilities. In particular, the areas of agriculture, energy, industrial development, urban planning, environment and health need to be linked. Similarly, the triangular partnership between the government, private sector and development partners proved quite effective in some areas but will need to be augmented significantly especially to spur reforms that attract substantial private capital and entrepreneurship. Some countries in the Asia Pacific region have transboundary river basins or aquifers. In such cases, they should proceed by setting up a joint planning and monitoring mechanism of their shared water resources. Without such joint planning, countries might face setbacks in implementing their SDGs water targets domestically.

It must also be ensured that the progress of SDGs is tracked frequently so as to be aware of the implementation status and challenges faced in the process. This requires good indicators, robust data and appropriate monitoring mechanisms. In addition, for access to water services, monitoring needs to cover both the initial construction phase of water infrastructure as well as the post-construction operation and maintenance phase so as to ensure that installed systems remain functional and that the path to attaining the successful implementation of the SDGs remain intact.

4 3R principles towards clean water solutions

Considering the dire circumstances of scarcity and quality deterioration of freshwater in Asia-Pacific region, it is imperative that necessary steps are taken urgently and vehemently to address the issues at hand. This section talks about the potential responses to the situation by briefly discussing the technological and policy-based solutions encompassing a broad mix of the reduce, reuse, recycle (the 3R) strategies and principles to address the challenges in supply and demand side management of water resources as shown in **Figure 4-1**. The first 'R' of this hierarchical approach, *Reduce,* can lower the water demand in households, industries and agricultural farms brought about by the application of appropriate regulatory, economic, and technological interventions. The other two Rs, water *reuse* and *recycling* deal with the supply side of water management, which increases the supply of water through wastewater reclamation. On the whole, these strategies are aimed at fostering efficient use of water and reducing water footprint, handling and treatment of wastewater from municipal, industrial, and agricultural sectors for reuse and/or safe discharge to the environment. This holistic approach to water and wastewater management is also endorsed as a key step to attaining the SDGs. In addition, decentralised or on-site management of water and wastewater sources have been endorsed as the way forward in the long run in view of their economic benefit, and better operation and management controls. These strategies are followed by a description of the financing mechanisms and water governance and governmental schemes in countries of the Asia-Pacific region to manage water resources sustainably.

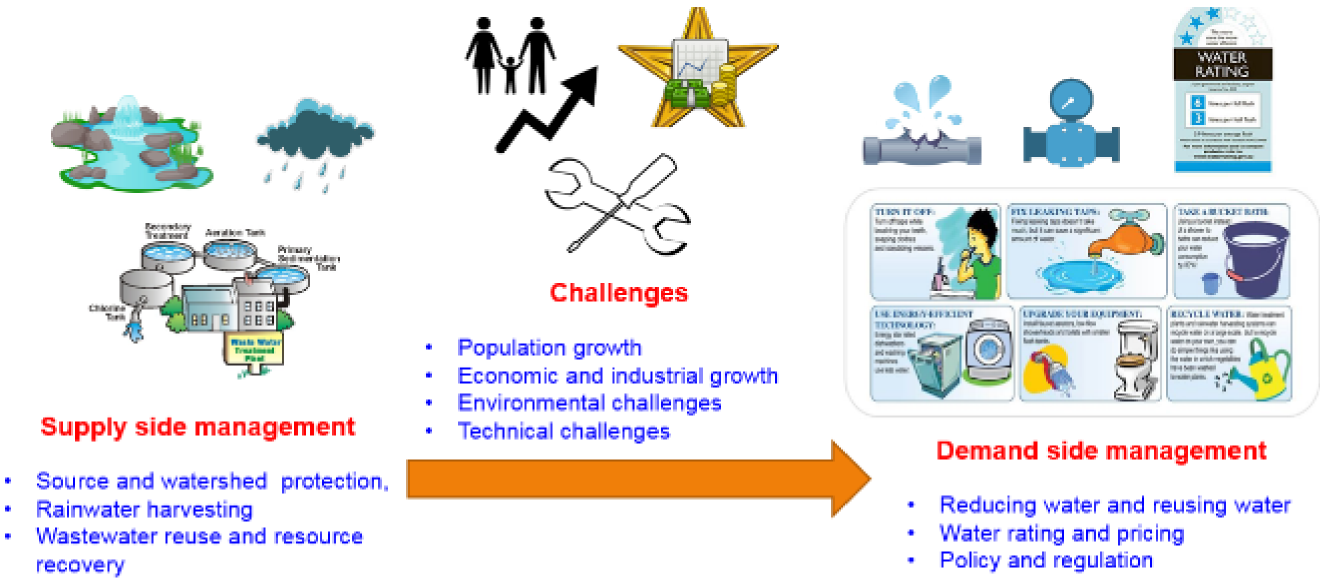


Figure 4-1: Overview of 3R strategies for water security

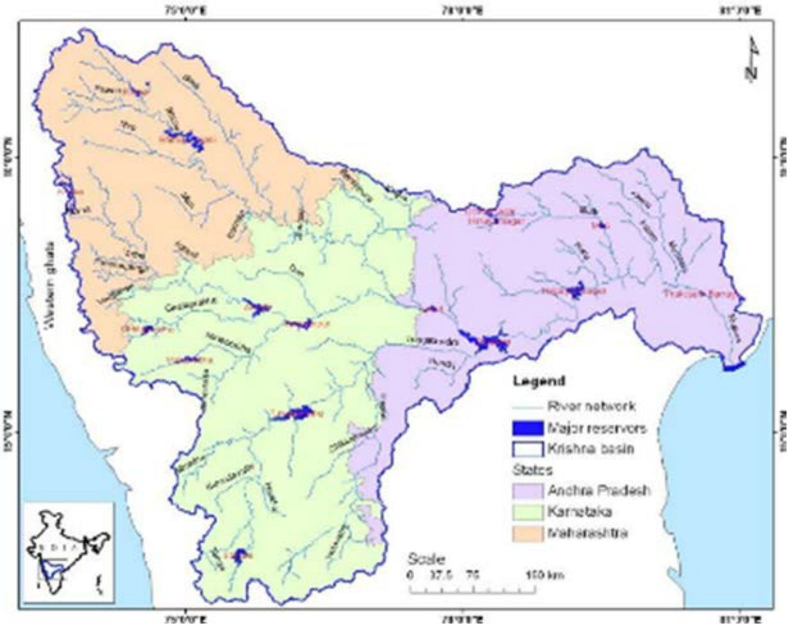
4.1 Water consumption reduction through demand management

Water demand management (WDM) stands out as the most obvious and appropriate option to tackle the current scenario of diminishing water supply, escalating water demand and heightening pollution of water sources. Furthermore, it is equally relevant to climate change adaptation and mitigation measures. Basically, WDM emphasises changing practices, cultures and attitudes to foster the rational and efficient use of water while also lessening its waste and misuse in households, industries and agricultural farms. It is much economical in comparison to supply-side management as it allows better allocation of scarce resources than building water infrastructures (Visvanathan, 2015). WDM can be both short and long-term measures depending on the needs of the community. In the following subsections, various efforts and interventions implemented by many cities and countries to reduce water demand have been presented.

4.1.1 Water conservation: upstream water and watershed management

Upstream water and watershed management strategies can result in reducing water consumption by improving irrigation practices, reducing paved areas and increasing pervious coverage. The practices such as proper stormwater management and infrastructure development, low impact development (LID), open space acquisition and greenways planning can contribute to identifying and evaluating opportunities for non-structural flood protection efforts as well as boosting waste management, pollution prevention and recycling efforts. An example of positive impacts of water conservation in Kothapally watershed has been depicted in **Box 4-1** which has highlighted the benefits such as improved groundwater recharge, higher employment opportunities and increased crop productivity among others.

Box 4-1: Watershed management for water conservation in Kothapally Watershed



Characterised by low productivity, low income and employment, and high incidence of poverty in 1999 and before, Kothapally watershed went through a major transformation after International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), in consortium with local partners (government agencies and NGOs), implemented an integrated watershed development programme. Both in-situ and ex-situ soil and water conservation practices such as integrated nutrient and pest management approach, use of good variety of seeds and fertilisers, use of proper cropping patterns, construction of check dam to reclaim gully formation and harvest substantial amount of runoff were implemented. After these interventions, groundwater recharge was increased from 7 to 32%, outflow reduced from 37 to 9% of total rainfall, crop yields increased by 2 to 5 times in monsoon season and irrigation potential increased from 13 % to 31 % compared to pre-development stage. The watershed management programme also resulted in improvement of lifestyle of the people through higher employment opportunities, reduced poverty and increased crop productivity.

Source: (Garg, Karlberg, Barron, Wani, & Rockstrom, 2012; Wani & Garg, 2009)

4.1.2 *Improving irrigation efficiency*

Considering that agricultural uses of water resources are largely responsible for the threats to finite freshwater resources, especially in developing countries of Asia Pacific region, it is only sensible that the efficacy of irrigation facilities are prioritised heavily. This is especially true because water extraction is often unregulated and unpriced in the region (in some places, it is even subsidised). **Table 4-1** enlists various on-farm water management strategies that result in improved irrigation. These strategies also ensure that in pursuit of sustainable use of water resources, the food security and livelihoods of the smallholders are not compromised. A study on the adoption of technologies such as drip and sprinkler irrigation has shown promising results in a reduction of the amount of excessive extraction of groundwater by two-thirds (Fishman, Devineni, & Raman, 2015). Thus, these strategies could be considered to potentially solve the water management problems in farms.

Table 4-1: On-farm water management strategies for improved irrigation

Strategies	Description
Precision land levelling	• Refers to levelling and smoothening surface to reduce time and water required to irrigate the field • Results in improved (uniform) distribution of water, better moisture environment of the crops, more uniform germination and growth of crops
Irrigation scheduling	• Proper scheduling of irrigation to crops using tools such as tensiometer to provide water to plants only at appropriate, required times
Improving conveyance efficiency	• Minimisation of losses due to seepage and evaporation during conveyance of water could be minimised using (underground) lining systems
Adopting improved irrigation methods	• Improved irrigation methods such as drip and furrow to lessen water losses by reducing wetted area, and evaporation and percolation from soil surface
Micro-irrigation	• Micro-irrigation methods such as microtubes and drip emitters to reduce water losses by reducing surface runoff and increasing soil penetration and absorption
Mulching	• Application of straw to improve water use efficiency by reducing evaporation losses, lessening damages from weed growth and improvement in soil structure

4.1.3 *Innovative water saving options in households*

Several innovative solutions have been applied that are aimed at saving water and managing wastewater at households. These options usually comprise installation of water saving appliances, and water efficiency labelling schemes. Both of these options regulate the supply and consumption of water in everyday domestic appliances by either using lesser volumes of water than other similar appliances or by reusing the (grey)water for various purposes. For example, toilets are now being gradually but increasingly retrofitted with low-flow sanitary equipment like low-/dual-flush toilets. Similarly, increasing number of households are using showerheads and faucet aerators that reduce the flow of water when inserted into taps. In another instance, wash basins in Japan are connected to commodes in which the water from 'hand wash' is used to flush the toilet. Singapore has also embraced this concept by mandating its people to install flow regulators for the non-domestic sector as well as all private residential apartments, failing of which results in penalties. In addition, it has been implementing mandatory water labelling of products since 2009 in which grades 0/1/2/3 are used to mark the efficiency of the products in terms of water use (Visvanathan, 2015). There are also regulatory instruments in place in some countries such as water-use limits, economic incentives and water pricing which has been described in Section 6.

4.1.4 Rainwater harvesting for potable use

Reusing rainwater has become a significant part of water management strategies in both urban and rural settings. Several communities have successfully harvested rainwater in parallel to municipal wastewater treatment for water reuse. In the past, rainwater harvesting facilities were mostly used for indirect non-potable use such as gardening or car washing. However, some facilities have now incorporated membrane-based technologies in order to obtain potable water. **Figure 4-2** below shows such a typical rainwater harvesting facility with membrane-based technologies. These designs with membranes systems often result in reduced capital costs and improved efficiencies.

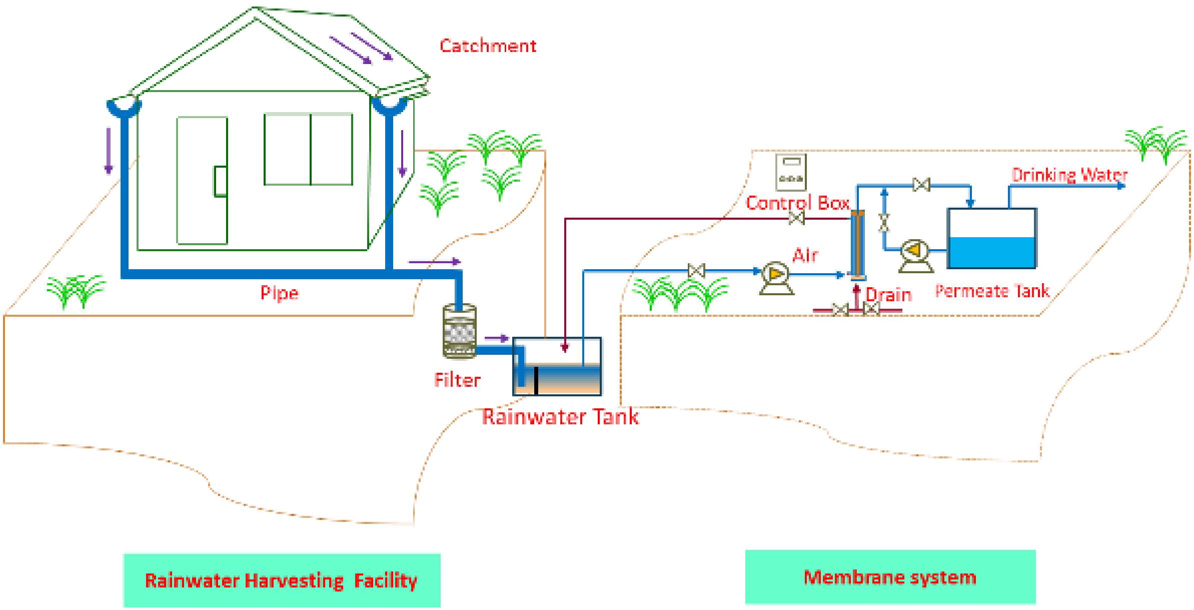


Figure 4-2: Rainwater harvesting for domestic use

Source: (Visvanathan, 2015)

4.1.5 Multiple Use Water Systems (MUS)

MUS is an improved approach to manage water resources by tapping and storing water efficiently and effectively to meet domestic and agricultural needs. There are two tanks in this system; one for domestic use which is directly filled from the source and the other tank which is used only for irrigation to hold the overflow from the first tank. In general, MUS is configured so as to provide water through gravity flow. However, for marginalised communities that are located in higher elevations than the source, solar-powered pumps are used to supply the water that is reported to lift 25 m^3/d of water. **Box 4-2** briefly describes the success story of application of MUS system in Nepal and India.

Box 4-2: Successful application of MUS in Nepal and India

With the support of INGOs such as International Water Management Institute (IWMI) and International Development Enterprises (IDE), MUS has been experimented with in selected locations of Nepal and India comprising both urban and rural settings. This technology (often incorporated with micro-irrigation technologies) has brought about better crop yield, better control over weed growth, higher food and water security, and various social benefits such as improvements in hygiene and sanitation and reduction of human labour. iDE Nepal has estimated that implementing a gravity-fed MUS costs approximately USD 95 per year per household. Furthermore, with an estimated increase in annual incomes of over USD 176, MUS has been proven to be beneficial to the families that have adopted this technology. It has further been estimated that the non-monetary benefits of this programme are even greater as surveys conducted by iDE have shown that girls are able to stay in school more than 76% of the time because of regular access of water. In addition, the health costs have gone down by 94%, and 62% of households have been able to invest in building toilets.

Source: (iDE , 2017)

4.2 Circular water economy through water and wastewater reuse and recycle

Considering the availability (or lack thereof) and scarcity of freshwater resources, the need to promote the other two Rs *reuse* and *recycle* of water cannot be overemphasised. In many parts of the world, improper use and inefficient management of wastewater have led to a multiplicity of lost opportunities and negative impacts. These consequences are generally intensified in impoverished communities of the developing countries. It is against this backdrop that the concept of circular water economy becomes relevant. The circular water economy improves upon the existing 'linear' water cycle that involves extraction of water upstream, treating it rigorously, using it and then treating it again before disposing it into water bodies. Circular water economy encourages industries and even domestic consumers to move to the 'take-make-reuse-repair-refurbish-and-recycle' model by including water component into the value chain and life cycle of a design/production/product distribution and use/service/recycle and a reuse cycle (Visvanathan, 2015). The concept of circular water economy is even more important today when the water demand is increasing rapidly to meet the demands of a growing population and the cities that are expanding to accommodate them. Other prominent drivers for transforming into the circular economy could be economic damages (water shortages holding back economic growth), climate change, water losses and structural waste, degraded natural systems, and even technological advances (smart sensors and remote sensing tools). Some countries have also proceeded towards circular economy due to regulatory pressures such as the goals to meet the SDGs.

While the pathway to attaining circular water economy can be considered broad and complex, it can more or less be generalised into four major steps, viz. holistic and systemic management of water resources, transformation towards closed-loop systems, valorisation of resources in sewage, and better understanding (and reducing) the embedded value of water in everyday products. In these approaches, decentralised or on-site systems are further emphasised where feasible and relevant since traditional, centralised systems are usually unable to cope with the diversity of wastewaters; they are also relatively expensive, and are also unable to meet the specific requirements of recovery and recycling processes. On the other hand, decentralised systems require less investment, are flexible to adapt to different site conditions, and are effective even in communities with the sparsely distributed population.

Municipal and industrial wastewater reclamation opportunities are not only used to meet the water supply-demand challenges but also to reap several economic and environmental benefits. In other words, treated wastewater can be alternative water resource with multi-use applications in drinking water supply, agricultural and industrial uses, urban and recreational uses and groundwater recharge, whereas the sludge from wastewater treatment can also be treated to recover important resources such as nutrients, fertilisers, energy, bio-solids etc. The case of pineapple industry as illustrated in section 4.2 is an example of circular water economy in industries. As shown in Error! Reference source not found., adopting the 3R strategies help attain the key principles of circular water economy: reduction of leakages and inefficient use of water, recovery of substances and energy from used water, and promoting water reuse and recycling.

The goal six of the SDGs reiterates the significance of wastewater management by targeting to halve the proportion of untreated wastewater and increasing recycling and safe reuse by 2030. Wastewater reclamation and reuse are vital to attaining circular water economy as they constitute closed-loop systems. Proper water and sanitation, and wastewater management have been better attributed to better lifestyles, increased levels of human health, reduced poverty levels, and increased opportunities for education and employment, resulting in overall national economic development. The applicability of wastewater reuse is governed by many environmental, financial, economic, legal, technical, social, political and institutional factors. In general, centralised reclaimed wastewater is widely used for agricultural and landscape irrigation, groundwater recharge, industrial uses and recreational activities. On-site wastewater reuse finds most applications in non-potable uses such as toilet flushing, garden watering and car washing.

The key to all wastewater reuse applications is the availability and innovations in wastewater treatment and recycling technologies. The decision on the selection of treatment technology type and scale of operation mainly depends on factors such as quality of the wastewater influents, the intended reuse options, and the wastewater generation (Visvanathan, 2015). The cost of the technology (investments, operation and maintenance) and availability of human resources also determine what technological interventions are appropriate and what not. Thus, the system of wastewater collection, conveyance, and treatment demands a well thought out plan before being put in place. Ultimately, it is expected that the treatment system contributes to prevent environmental pollution and circular economic utilization through resource (nutrient, water and energy) recovery, that too with minimum energy footprint of its own. Along with the choice of appropriate technology, it is also equally important to have an enabling policy environment and institutional framework in place.

Wastewater treatment technologies have advanced with the passage of time. The first generation wastewater recycling technologies were based on simple physical and chemical treatment processes whereas today, this sector is well equipped with advanced technologies such as the use of biological filters and activated sludge treatment, advanced oxidation processes, and membrane-based technologies. The primary treatment process comprises physical separation including mechanical screening and solids separation through sedimentation tanks or clarifiers. This is followed by the chemical separation that uses coagulants and flocculants to remove suspended and dissolved solids from the wastewater. The secondary treatment, based on biological processes, handles removal of BOD, COD, nitrogen, and phosphorous by activated sludge or fixed bed technology. The tertiary treatment involves advanced treatment processes for removal of nutrients and salts or suspended solids, filtration (surface, micro, ultra, nano), flocculation/precipitation, ion exchange, reverse osmosis; and disinfection by ozone, chlorine dioxide, chlorine gas, and UV radiation. **Figure 4-4** summarises the level of wastewater treatment technologies that are prevalent at present.

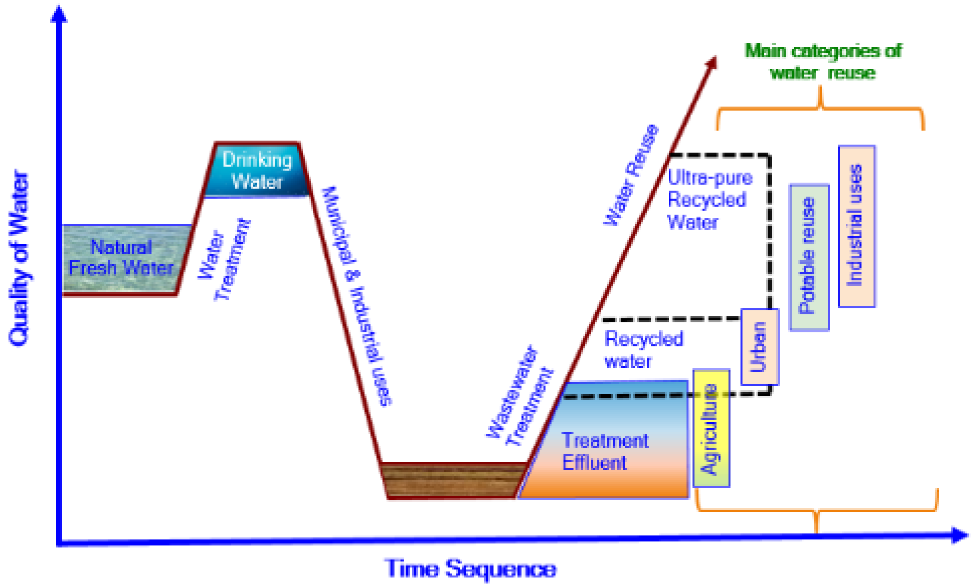


Figure 4-3: Maintaining water quality through wastewater reclaim and reuse

The principles of the circular economy mandates a considerable transformation from the traditional linear water systems, which, on the hindsight, is bound to create several business opportunities. Therefore, it can, and should, be considered as an investment rather than an expenditure. For example, in agriculture sector, efficient irrigation techniques, water efficient appliances and processes as depicted in **Table** 4-1 presents a good opportunity for private and public sectors to invest money to make profit while closing the water loop at the same time. This can also be relevant in cases of industries where technology plays a crucial role, thus providing ample opportunities for investors and innovators to exploit. Ideas as simple as efficient plumbing could attract individuals and small and medium enterprises (SMEs) to start their businesses in helping reduce water leakages or installing smart water reusing and harvesting systems in ordinary households. In advanced societies where technology already plays a significant role in water management, behavioural changes will have to have far more emphasis as these societies are often attributed with a higher water demand. However, this also warrants a significant consideration into developing a qualified workforce (adept in technology and knowledge) that are indispensable to the transition to circular water systems. This should be clearly understood, and reflected in any policy-making efforts, that the transition should go hand-in-hand with other efforts to build a skilled human resource that are able to deliver and exploit the transition.

5 Water governance and government initiatives

5.1 Progressive policies and government initiatives

Policies regarding promotions on water security, particularly wastewater reuse in Asia are mostly governed as per integrated water resources management (IWRM) strategies. In particular, policies to face water security issues have been initiated through national agendas so as to form a cohesive framework and achievable goals to guide all stakeholders concerned. The governments of several countries in the Asia Pacific region have promoted water security by putting forth water conservation, water and wastewater treatment, and sanitation schemes in the national agenda. Most countries have also promulgated water law to coordinate actions for sustainable water resources management. **Table 5-1** enlists and briefly describes such governmental initiatives. For instance, the Republic of Korea aims to secure 25.4 tonnes of alternative water resources by 2020 through its "National Wastewater Reuse Policy". This programme is expected to replace 1.1 billion tonnes of tap water annually (MoE, 2017). Similarly, People's Republic of China's "Water Ten Plan" aims to garner coordination and inputs from more than 12 ministries and governmental departments to reduce surface water pollution (improve water quality in 7 key rivers including Yangtze and Yellow river to Grade III[1] or above), improve the sources of drinking water quality (93% of urban drinking water sources to reach Grade III or above), and reduce groundwater over-extraction and control groundwater pollution (Han, Currell, & Cao, 2016). Another key intervention has been treating water as an economic entity by pricing water, for example, so as to put value and reflect its scarcity. By drawing water withdrawal permits, many countries have taken steps to create water rights. India has also taken an ambitious project called Clean India Mission (*Swachh Bharat Abhiyaan*) through which it aims to take up the challenges of water and wastewater management in the country. This project comprises several sub-projects such as ODF campaigns (by building sustainable latrines), sewerage and fecal sludge management, and river pollution control programmes as shown in **Table** 5-1.

5.2 Promoting social awareness and acceptance

The answers to the wastewater management problems should be socially and culturally appropriate and accepted since water and sanitation issues are deeply linked to local practices, culture and traditions, and often to religions. Many cultural practices and religious beliefs discourage the reuse of treated wastewater terming it as 'dirty' and 'unholy', which acts as one of the greatest barriers for wastewater reclamation and reuse. In addition, the socio-economic disparity in the urban population also creates a stigma that 'rich man's excreta and poor man's water' (Visvanathan, 2015). In most of the cities in the region, the economy gap has rendered people with low incomes have access to irregular supply, and at worse, no access to municipal water supply and sanitation services. On the other hand, people with high income have good coverage to piped water supply and sewerage. Many wastewater treatment projects also are established in low-lying areas and the water is distributed to urban poor. Such social disparity can be addressed by popularising the treated wastewater distribution equally to all city dwellers. In order to improve the social acceptance of reused wastewater, countries like Singapore and Australia have done exemplary jobs. For example, in Singapore, after having applied advanced tertiary treatment systems (including reverse osmosis and UV treatment), they mobilised media as a strategic partner to explain the details behinds NEWater's treatment process so as to build public confidence. The authorities were also conscious to avoid terminologies that bore negative connotations like the words 'sewage' and 'wastewater' and used words like water reclamation plant instead of sewage treatment plant.

[1] People's Republic of China ranks the water quality from Grades I to VI; VI being the most polluted

Table 5-1: Selected government initiatives to manage water and wastewater

Policies	Key milestones, visions, future goals and descriptions	References
National Wastewater Reuse Policy, the Republic of Korea	• "Promotion of and Support for Water Reuse Act" was established in 2010; "Water Reuse Master Plan (2011-2020)" was formulated in September 2011 to enforce this Act • Seeks to manage rainwater-using facilities, greywater systems, and the reuse facilities of treated effluents from wastewater treatment plants (WWTPs) under a single umbrella • Expected to secure 25.4 tonnes of alternative water resources by 2020 and to replace 1.1 billion tonnes of tap water annually	(MoE, 2017)
Water Ten China, People's Republic of China	• Coordination & inputs from more than 12 ministries and government departments • Aims to improve the quality of surface water, coastal bays, groundwater and drinking water supply in key cities and regions of China, • Also, aims to improve the overall quality of the ecological environment by 2030,	(Han, Currell, & Cao, 2016)
Clean India Mission, India	• Seeks to make India open defecation and filth free by 2019 • In urban regions: USD 9.7 billion has been allotted for establishment of 260,000 individual toilets and 250,000 community toilets in 4401 towns in India • In rural regions: USD 21 billion has been allotted to ensure that all households in all villages have functional water supply and toilet facilities, and also to make productive use of night soil as bio-fertilizers	(India Water Portal, 2015)
National Mission for Clean Ganga, India	• Namami Gange Programme: flagship programme of Mission Clean Ganga to accomplish the objectives of effective abatement of pollution, conservation and rejuvenation of the Ganga • 28 River-Front Development projects, 33 Entry level projects for construction, modernisation and renovation of 182 *Ghats* and 118 crematoria have been initiated • 63 sewerage management projects are under implementation in the States of Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal; 12 new sewerage management Projects launched in these states and works are in process to create a sewerage capacity of 1187.33 (MLD)	(India Water Portal, 2015)

6 Financing options in water management sector

6.1 Water pricing

Water pricing is often used as a financial regulatory option to reduce water demand and thereby promote sustainable water consumption. In general, this is done by managing water demand through a variety of volume based price structures that generally comprise penalising/disincentivising consumers for overuse. The fundamental working principle of this strategy is that the demand for water is like the demand for any other goods and that its use and demand will decrease if its price increases. Several cities, even in the Asia Pacific region, have adopted this strategy in two forms. The first is a flat rate charged based on the consumers' property value and irrespective of the volume of the water used. The second form prices water at a certain unit rate of the volume of water used. The rate is either constant or variable, in that it may contain some two or more pre-specified quantities (blocks) of water, with the price increasing with each successive block. On the other hand, the variable component covers the amount of the water consumed.

Singapore is an exemplary proponent of water pricing strategy to curb water demand. It has done so through a regulatory framework led by the Public Utilities Bureau and the Ministry of Finance by putting water conservation tax (WCT), sanitary appliance fee, and waterborne fee (WBF) into place. The revenue thus generated is used to fund governmental water conservation programmes such as research and development, retrofitting, operation and maintenance and so on. This is done in parallel to other strategies such as the installation of water saving devices (Luan, 2010). People's Republic of China has undergone several water reforms to systemise water pricing for agricultural, residential and industrial purposes. As a result, pricing strategies have now become more scientific: at present, the water volume quota system and a block rate structure mechanism governs the rate of water consumption in industries and domestic houses respectively (Che & Shang, 2015). The pricing accommodates resource value and waste treatment costs as well. Besides this, People's Republic of China has also launched multiple compulsive laws and regulations along with several other incentives that reward water-saving behaviours and practices.

6.2 Polluters Pay Principle

Polluters Pay Principle refers to the strategy involving the polluter to compensate for the expense associated with prevention of pollution and carry out measures for ensuring the acceptable state of the environment. The principle is directly associated with regulating pollution that affects water, air and land. In addition, it is also actively involved in charging organizations that lead to the emission of greenhouse gases causing climate change. In the context of water pollution, his principle mandates a significant amount to be fined, or forced to apply preventive measures against environmental pollution. **Box 6-1** depicts a classic case of this principle penalizing the polluter that had spilt oil into seawaters causing much harm to the water quality and marine lives. Thus, as a part of sustainable development, polluters pay principle deals with the elaboration of policies in absolute liability for harming the environment.

Box 6-1: Case of application of Polluters Pay Principle in India

As evidenced by the case in Samir Mehta v. Union of India, Principal Bench of the National Green Tribunal directed the Delta Group to pay a compensation of INR 1 billion (USD 15 million) due to oil spill caused by their ship. Also, as per the verdict, Adani Enterprises Limited also had to pay a sum of INR 50 million (USD 765, 000) due to dumping of cargo in the sea and failing to take any preventing measures. Thus, polluters pay principle intends to set environmental standards or use tradable permits and if not complied, the government imposes severe compensations that can later be used for infrastructure development in relevant field of environment. Hence, this principle offers financing options for development and management of improved water.

Source: (The Hindu, 2017)

6.3 Private Public Partnership (PPP)

Public-Private Partnership (PPP) is another option for financing the infrastructure development for improved water management. Some of the common modalities of PPP arrangement have been listed in **Table 6-1**. PPP represents a collaboration between a private company or organization and a government agency which share a common objective in building and operating projects that can be of public interests. Such projects have added advantages in lesser time to service delivery as well as decreased finance. Other indirect benefits include transparency, project bounding, deal flow, innovation, the involvement of third-party financiers, and public sector involvement. In most cases, the finances associated with the projects are gradually recovered from actual usage of service by the public through fees and tariffs. Private partners in such coalition are mainly interested in designing, implementing, funding and completing the project while public agencies involve themselves in defining and monitoring compliance with initial project objectives.

Table 6-1: Different arrangements of PPP strategy

Types of PPP		Description
Design-Build (DB)	:	Private Operator (PO) designs and builds the asset for a fixed price
Operation & Maintenance (O & M) Contract	:	PO operates asset for a specified term under contract
Design-Build-Finance-Operate (DBFO)	:	PO designs, builds, operates and transfers the asset under a long-term contract
Build-Own-Operate (BOO)	:	PO is in full ownership and control but is subjected to regulatory oversight
Build-Own-Operate-Transfer (BOOT)	:	PO builds and charges for use and then transfers ownership after agreed period
Buy-Build-Operate (BBO)	:	Asset is transferred to PO, improved and operated for an agreed term
Operation license	:	PO is licensed to operate a public service for an agreed term

The case of sustainable urban development in the People's Republic of China for wastewater treatment posits an example of PPP. The wastewater and drainage service project in Shanghai fall under the Shanghai Sewerage Company with an objective to increase wastewater collection and treatment ratio to 90% by 2020. The PPP between Shanghai Water authority and the Youlian Consortium (joint efforts of Youlian Development Company, Huajin Information Investment Ltd. Company and Shanghai Urban Construction Group) serves to provide wastewater treatment services with 35 percent funded by private consortium while remainder by bank loans. The gross benefits of the project can be displayed through minimised service fee at about 40% below government's costs to 23.5 million residents in an area of 107 sq. km.

7 Conclusions and the way forward

7.1 Conclusions

Asia's rapid growth and subsequent increases in economic activities such as industrialisation, modern agriculture and urbanisation have exacerbated water security issues in the region. To further aggravate the situation, the challenges in availability and accessibility of freshwater is being worsened by threats of increasing water pollution and lack of wastewater management. In addition, climate change induced disasters have further provided an impetus to highlight the issues of increasing challenges in this regard. Extensive planning and rigorous implementation of strategies to manage water resources are important because it also has close connections to socio-economic development issues such as gender equality, poverty reduction and food security. Furthermore, water security is also a transboundary and political issue as wars and conflicts have arisen over water rights. Water security is also an indispensable part of Sustainable Development Goal; Goal 6 is a standalone goal related to water security but it has close links with almost all other goals.

The potential and the need for the reuse of treated wastewater still remain underappreciated and unutilised in national strategies and policies on the water in Asia. This situation is marred by insufficient sanitation infrastructures such as proper sewerage systems, lack of (tertiary) treatment facilities, and failure to adequately estimate water demand and wastewater production. For example, despite regulations on the discharge of industrial wastewater, much of it is discharged directly into natural waterways in Asia. Similarly, rainwater is not adequately tapped in for reuse as a secondary source but is allowed to mix into the sewerage systems of the cities. These situations clearly mark the lack of enforcement of governmental policies and regulations, and also the lack of sense of responsibility and consumer-driven interventions. On the other hand, economic constraints such as investment funding and the long-term financial viability of different schemes (or lack thereof), fragmented institutional set-up and poor coordination among stakeholders, as well as the acceptance of treated water by the public are the bottlenecks in promoting and implementing water management plans.

It has long been understood that management of water and wastewater resources is as much a behavioural issue as it is physical. The key to addressing water security risks is not only sophisticated, large-scale projects but also small-scale, consumer-driven efforts. In this direction, water demand reduction, reuse and recycling of (waste)water should be recognised and endorsed as '3R' solutions meet the challenges of water security, particularly in the urban areas. In other words, it is imperative to apply 3R principles for wastewater reclaim and reuse in the integrated water management strategy along with water demand management to address local and global urban water scarcity. The strategies to reduce water demand could be holistic strategies such as overall watershed management comprising forest management and wetlands restoration which will, in turn, reduce the risk of flooding and prevent freshwater contamination. Likewise, atomistic strategies such as better irrigation planning, use of water saving appliances and rainwater harvesting should also be promoted to supplement holistic strategies. The programmes to attain wastewater reuse and recycle focus on circular water economy to harness natural water cycles and synchronise with the whole water/waste cycle including water supply, sanitation and wastewater reclamation, and reuse. The leadership of cities in water management can be demonstrated by promoting the circular economy of water through successful implementations of 3R strategies which require adequate infrastructure, technology, policy, finance, capacity, as well as social and cultural acceptance. These strategies usually envision and address potential future water demand, wastewater generation, as well as technological innovations in wastewater recycling. In this direction, it is important to break the existing institutional, policy, finance, technology, and behavioural barriers. Industries, on the other hand, should finance an on-site central wastewater treatment plant, or adopt zero liquid discharge (ZLD) production processes hence champion the closed-loop economy to save both environment and water charges, and promote sustainability. Such decentralised systems are preferred in other sectors for developing water infrastructures as they are economical and are suitable for different site conditions, and offer better control and easier operation over conventional centralised systems.

Even though the challenges are grave and plenty, or because they are so, national governments should take affirmative actions to increase water use efficiency, and increase investment not only in water supply infrastructure but also wastewater management. This can be done by developing national, regional, and local master plans for the reuse of reclaimed wastewater, as part of an integrated water resources management approach. These plans should be backed by the transfer of appropriate technology, institutional framework rearrangement, and capacity development. As for the financial arrangement, water infrastructures should be developed by partnering both private and public sectors (PPP model) which will help share risks between the public and private sectors, invite better and more efficient construction and operation of projects, and if regulated well, increase predictability, accountability and transparency of costs and funding. It is also imperative that the polluters are held responsible for their actions and made to pay for the damage done to the environment, particularly the water resources.

A wide range of stakeholders, from various sectors, needs to be engaged in policy formulation. Sub-national plans can be formulated according to their specific conditions, while also aligning with national policies. Coordination mechanisms need to be strengthened among involved institutions. Developing links between sectoral policies is important towards successful implementation of the national policy, since water has indispensable cutting influence with several of the developmental aspects. Long-term political commitment is needed towards strengthening 3R and circular economy policies. Capacity building and skill development of policy makers and the stakeholders are also crucial. Creating network of policy makers and stakeholders across different sectors is needed to develop and coordinate actions. Economic incentives and market based instruments are effective to strengthen policies and programmes. More and better research and innovation helps in improvement of strategies and actions.

To summarise, considering that water lies at the heart of all socio-economic, human and environmental development activities and vital to Asia's prospects of attaining the SDGs, it is essential that water system security and sustainability is prioritised by promulgating 3R strategies. To be specific, decentralised technologies to promote circular water economy should be at the forefront of all strategies and should be managed through a coordinated partnership between private and public entities.

7.2 The role of 3R Forum in Asia and Pacific in promoting 3Rs in water sector

Given the commitment to attain the SDGs, the countries in the Asia Pacific region should recognise and uphold the role of 3Rs for sustainable water resource management. In this direction, it is quintessential for the countries in the Asia and Pacific region to follow the progress of preceding declarations of Adelaide, Male, Hanoi and Surabaya on integrating "3R Concept" in relevant policies and programmes to make transformative strides towards a resource efficient society. With respect to wastewater management, this should be promulgated through coordinated application of innovative applications of new concepts and technologies geared at its long-term sustainability. Furthermore, it should be expedited by promoting research needed to develop and demonstrate these concepts and technologies. The Forum sheds light on technical, financial and social facets of implementing the steps required for efficient water and wastewater management. In particular, it is strongly recommended to consider the points listed below under four important sub-headings: circular water economy, technological strategies, policies and financial strategies, and institutional strategies. These points, among other things, emphasise the need to foster decentralisation of infrastructures and bring public interest and investment into the mix. Another crucial issue that needs to be addressed is the way to holistically approach the integration of 3R strategies in wastewater management, and the Forum paves the way by taking the lead in identifying the gaps and challenges, recognising the areas that require further research, and/or helping set-up direction to identify the policy, institution, technology, infrastructure and financing needs, barriers, and drivers, in municipal or national level water plans. The following are the key points for consideration:

Circular water economy

a. Apply systems thinking so as to consider water resource management holistically and in a systemic mindset
b. Move to closed loop systems in order to generate additional benefits beyond just reducing water consumption such as chemical products, heat for industrial purposes or fertilizers for agriculture.
c. Extract cascaded value in wastewater in which valuable products are extracted at a series of stages beginning with high value products such as specialist chemicals, followed by fertilizers, energy, water and bio-solids.
d. Invest in basin management such as forest management and wetlands restoration which will, in turn, reduce the risk of flooding and to prevent freshwater contamination
e. Monetise organic nutrient cycles as it would potentially replace scarcity of some nutrients with abundance and greatly reduce the resources needed to run the global water infrastructure

Technological strategies

f. Promote the use of decentralised technologies to promote (waste)water treatment, reusing and recycling activities at/near source
g. Employ innovative water saving appliances at households and cleaner technologies like Zero Liquid Discharge, lesser water intensive processes in industry, and identify possibilities of using advanced technologies to recover nutrient from wastewater
h. Execute Upstream water and watershed management to reduce the risk of flooding and to prevent freshwater contamination
i. Improve irrigation efficiency and promote multi-use water system (MUS)
j. Promote sustainable urban drainage systems (SUDS) for storm water management

Policies and financial strategies to support 3R strategies

k. Strengthen progressive policies and regulations supporting water demand side management through appropriate water pricing strategies, control of water losses, etc.
l. Form regulations to attract private sectors to invest in water systems development
m. Innovate financing through public private partnership, expanding reclaimed wastewater market, community financing/micro-credit schemes for decentralized water supply and wastewater treatment systems
n. Adopt 'Polluters pay' principles, economic incentivisation/disincentivisation
o. Foster social acceptance of consumption of safe reclaimed wastewater

Institutional strategies

p. Make country specific institutional arrangement such as inter-ministerial committee or commissions, or involve key or relevant ministry, to promote, coordinate and review the implementation of SDG 6
q. Ensure effective public administration, especially local governance

r. Establish independent framework for assessment of performance and results of policy implementation through regular and systematic monitoring and evaluation procedures
s. Consider establishing coordination mechanism within different ministries/ department/ levels of government and include participation of multiple stake holders like civil society, private sector, academia etc.,
t. Set up institutions for joint planning and monitoring mechanism of shared water resources for countries with trans-boundary river basins and aquifers.

Potential responses through 3R strategies and circular economic policy are water consumption reduction and water quality improvement. 'Reduce' of 3R approach at demand side water management reduces water consumption whereas the other two Rs, 'Reuse' and 'Recycle' at supply side water management increases water supply through wastewater reclamation.

In household, water consumption could be reduced by behavioural change to reduce water demand and use of water efficient appliances and technologies. In agriculture, water demand is reduced by efficient irrigation methods and use of water efficient and drought tolerant crops. In industry, water demand is reduced by Zero Liquid Discharge practices, less water intensive processes and water efficient equipment. Through this, wastewater generation is significantly lessened by reducing water consumption.

Reclamation of dying water bodies in our urban areas is a possible reality with circular economy as well as 3R strategies. Burning socio-political issues such as trans-boundary water disputes and farmer suicide due to crop failure could be significantly addressed. The urban centers could be made more resilient to climate change induced water disasters. Economic decline due to water insecurity could be prevented. To sum up, Circular Economy ensures water pollution reduction, wastewater treatment, reuse and resource recovery, and improves aquifer storage and recovery.

7.3 Important policy questions

The Forum addressed the following policy questions so as to come to a fruitful conclusion, to show the way forward and enable policy environment to promote the implementation of 3R principles in water sector in the Asia-Pacific.

a. Why Centralised plants for water and waste water treatment are continued to be planned and commissioned instead of more effective decentralised or on-site water and waste water management which are economical, suitable for different site conditions, and offer better control and easier operation? How can the transition from centralised to decentralised systems be made?
b. Is it right for water stressed Asia – Pacific countries to continue with 'Linear' cycle of water and waste water treatment instead of shifting to Circular Economy? How can the concept of circular water economy of water be applied to harness natural water cycles to regulate flow, maintain high quality and insure against disasters?
c. How can water security, which is an indispensable part of SDGs (as a standalone Goal 6), be linked to other goals to approach water management holistically as a development goal?
d. Are our urban areas climate change-resilient through proper water management? How can we make our cities more resilient to disasters?
e. With lack of availability of fresh water resources, shouldn't the 'Reduce' option be emphasised more, than 'Reuse' and 'Recycle' option by policy makers for water management?

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