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3R as the basis for Rural Resources and Waste Management for Regional Development- Implications towards SDGs

(Background Paper for Parallel Roundtable 3 of the Programme)

Final Draft

This background paper has been prepared by Prof. P. Agamuthu, for the Seventh 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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Background Paper
on

3R as the basis for Rural Resources and Waste Management for Regional Development- Implications towards SDGs

(FINAL DRAFT)
(Plenary Session-3)

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Prepared as an input for the Seventh Regional 3R Forum in Asia and the Pacific

Foreword

The Ha Noi 3R Forum (2013), Surabaya 3R Forum (2014) and Maldives 3R Forum (2015) recognized and highlighted the importance of sustainable resources use as an instrument to ensure prosperity and human development in Asia and the Pacific. There has been increasing realization on the importance of 3R and resource efficiency towards public health and social well-being, water security, and economics.

The Seventh Regional 3R Forum in Asia and the Pacific, under the overall theme "***Advancing 3R and Resource Efficiency for the 2030 Agenda for Sustainable Development***" aims to address the unsustainable consumption and production patterns, potential economic utilization of biomass and agricultural waste, and sustainable rural resources and waste management for regional development. The scope of the background paper will be focused primarily on (a) develop a new and innovative approach to achieve regional development through 3R policies and programs on rural resources and waste management; and (b) address the costs of inaction or loss of opportunities on rural waste, agricultural and biomass waste utilization and management.

This background paper will specifically look into regional development aspects through better utilization of rural waste, agricultural and biomass waste. This background paper provides guide and support to effective implementation of 3R policies and programs on rural resources for regional development and address the possible costs of inaction or lose of opportunities on agricultural and biomass waste management.

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Abbreviations and Acronyms

ADB	Asian Development Bank
bnl	billion liters
CO_2	Carbon Dioxide
GDP	Gross Domestic Product
FAOSTAT	Food and Agriculture Organization of the United Nations Statistic Database
GHG	Greenhouse Gas
Gm^3	Cubic gigametre
GNI	Gross national income
Gt	Gigatonne
FAO	Food and Agriculture Organization of the United Nations
MSW	Municipal Solid Wastes
MW	Megawatt
SDGs	Sustainable Development Goals
RDW	Rural domestic waste
UNEP	United Nations Environment Program
UNSD	United Nations Statistics Division

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1.0 Executive Summary

The Asia-Pacific region has continued to demonstrate rapid economic growth, mostly among several industrialized countries in the region, such as India and China, which have vast emerging economies. However, majority of the countries in Asia-Pacific still rely on agriculture sector. The agriculture sector contributed between 0.7% and 30% of total GDP for Asia-Pacific region. There is a huge economic potential from agricultural and biomass waste resource from Asia-Pacific region. Crop residues are generated from cultivation to post harvest processing, which means large amount of unutilized agriculture and biomass wastes are produced. In 2005, approximately 13 billion metric tonnes of biomass was harvested worldwide, of which food and feed accounted for about 82 percent, bioenergy 11 percent and biomaterials 7 percent[1]. Despite being renewable, biomass is a limited resource.

Agricultural waste and biomass production is implicit in a number of sustainable development goals for example, food security (goal no. 2), energy (goal no. 7), industrial development (goal no. 9), sustainable production and consumption (goal no. 12), climate change and its impact (goal no. 13), and protection of ecosystem (goal no. 15)[2]. The efficient utilization of biomass is important to meet basic human needs and achieve economic prosperity while enhance resource efficiency and safeguarding the environment and natural ecosystem. As the issue of sustainable rural resource and biomass waste plays an important role in achieving key objectives of the sustainable development goals, significant policy interventions are needed to ensure the effective implementation of 3R in the areas of rural resource and waste management.

Sustainable Development Goals (SDGs) has raised the concern of the wellbeing of rural development and sustainability challenges of environment management[3]. This paper highlights the role of 3R resource and biomass waste management in rural development. 3R for resources and biomass waste management in rural areas can contribute to sustainable Development Goals (SDG) such as:

- Goal 1. End poverty in all its forms everywhere
  - 3R of resource and waste management can provide alternate incomes for peoples in rural area.

- Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture
  - Reuse of biomass resource via composting provides low cost fertilizer for food crops which allows rural resident to have sustainable crop production and food source.

- Goal 3. Ensure healthy lives and promote well-being for all at all ages
  - 3R waste management enhanced accessibility of improved sanitization such as sanitary landfill which reduces the risk of disease and pathogen transmission.

[1] Wirsenius S. 2007. Global use of agricultural biomass for food and non-food purposes: Current situation and future outlook. Department of Energy and Environment. Chalmers University of Technology. Conference paper. http://www.sik.se/traditionalgrains.

[2] The role of biomass in the sustainable development goals: A reality check and governance implications. IASS, 2015. http://globalsoilweek.org/wp-content/uploads/2015/05/The-Role-of-Biomass_IASS_working_paper.pdf

[3] https://sustainabledevelopment.un.org/content/documents/6619132-Goetz-Sustainable%20Biomass%20Production%20in%20the%20Context%20of%20 Climate% 20Change%20and%20Rising%20Demand.pdf

- Goal 7. Ensure access to affordable, reliable, sustainable and modern energy for all
  - Waste to energy provides alternative energy in rural areas.

- Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
  - 3R resource and waste management provide jobs opportunity and alternative incomes in rural areas

- Goal 12. Ensure sustainable consumption and production patterns
  - Sustainable resource and waste management

- Goal 13. Take urgent action to combat climate change and its impacts
  - Contribute to GHG reduction with sustainable resource and waste management

- Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems
  - 3R of resource and waste reduces environment impact and ensure sustainable ecosystems via efficiency used of resources.

Regional development is a field of science that seeks to address community empowerment and capacity development while addressing regional disparities (such as urban versus rural) in many development sectors such as agriculture, industrialization, transport, education, employment, health and sanitation, waste management services, access to safe drinking water and related utilities. Regional development planning and programs are effective in addressing poverty reduction and improving social fairness and unity. It attempts to integrate economic growth, social development and environmental protection of sustainable development. It employs participatory planning, decentralized governance, and promotes dialogue among administrator in the same region to establish integrated solutions. Integrated regional development planning provides a cohesive package of solutions for sustainable rural and urban development. In a rapidly urbanizing environment in developing countries, disparities are increasing within and among cities and between urban and rural areas.

Rural areas have often suffered numerous development challenges mainly because most opportunities and provision of services favored towards cities, urban areas and large community. The emphasis on the growth of large urban areas has made appealing investment, creating jobs, meeting the housing demand, and providing access to key infrastructure and basic services. The higher incomes generating opportunity, employment availability, easier accessibility to infrastructure has increases the migration from rural to urban areas. All these have increased the challenge of development in sub-urban and rural areas. To this regard effective and economic utilization of agricultural and bio-mass waste in rural areas could be one of the vital contributing factor towards sustainable regional development in rural areas of Asia-Pacific region.

2.0 3R in Rural Resources and Waste Management

Waste management is one of the major problems for the environment, human being and society. Developing countries face major problem i.e. solid waste management in urban as well as in rural areas. In rural areas, open dumping is still the most common practice of solid

waste disposal.[4] The impact of open dumping is not restricted to a single location rather it covers all parts of the environment which leads to toxic pollutants. In rural areas, waste is a severe threat to the public health concern and cleanliness. Though, the composition of waste (both solid and liquid) generated in rural areas is predominantly organic and biodegradable which is becoming a major problem to the overall sustainability of the ecological balance. In India, close to 88% of the total disease load is due to lack of clean water and sanitation and the improper solid and liquid waste management which intensify the spread of disease. [5] It is reported 5 of the 10 top killer diseases of children aged 1-14 in rural areas are related to water and sanitation and almost 1500 children die every day from diarrheal diseases[5]

2.1 Current status of rural resources and waste management

The Asia-Pacific region has seen a very rapid growth in terms of waste generation during last decade, especially in the wake of overall population, rapidly growing urban population, and economic growth mainly due to industrialization [6]. The World Bank data showed Afghanistan, Bangladesh, Bhutan, Cambodia, Federated States of Micronesia, India, Kiribati, Lao PDR, Maldives, Myanmar, Pakistan, Papua New Guinea, Samoa, Sri Lanka, Solomon Islands, the Philippines, Tonga, Vanuatu, and Vietnam are the countries which have over 50% rural population over total country population in 2015 (Table 1). Majority of the countries in Asia Pacific have reduction in rural population over the year 2006 and 2015 except the Philippines, Samoa and French Polynesia.

Waste generation rate tends to be much lower in rural areas mainly because on average the residents are usually poorer, purchase fewer store-bought items (which results in less packaging), and have higher level of reuse and recycling.[7] In addition, the depopulation in rural areas due to urban city migration also contributed to decreasing of waste generation. However, the large rural population percentage in Asia and the Pacific regions indicates the significance of waste generation in rural areas. The waste generation rates vary between country, region, and even within county. [8] Based on the total rural population, it is estimated that the MSW generation and agriculture waste from rural area in Asia and the Pacific were 1,500,000 and 260,000 tonnes per day (Tables 2). Even though, the rural population of PR China is 44.4% of total population, the high population makes PR China the highest MSW generator with 620,630 kg day^{-1}. The second largest rural waste generator is India with 67.3 % of the total population is rural population which resulted in 299,785 kg day^{-1} of MSW generation. Waste generated in rural areas is very organic and less in quantity as compared to urban areas. Thus handling of rural waste becomes much easier. The composition of waste generated in rural areas is mainly from agricultural activities.[9] The organic wastes in rural areas are consumed by husbandry and in farms.[10]

[4] Ngoc, U. N., & Schnitzer, H. (2009). Sustainable solutions for solid waste management in Southeast Asian countries. Waste management, 29(6), 1982-1995.
[5] Patel, D., Brijesh, P., & Priyank, S. (2015). Solid and Liquid Waste Management in Rural Areas. International Journal for Innovative Research in Science and Technology, 1(12), 509-512.
[6] Lao, P. D. R. (2003). United Nations Economic And Social Commission For Asia And The Pacific.
[7] http://siteresources.worldbank.org/INTURBANDEVELOPMENT/Resources/336387-1334852610766/What_a_Waste2012_Final.pdf
[8] Ngoc, U. N., & Schnitzer, H. (2009). Sustainable solutions for solid waste management in Southeast Asian countries. Waste management, 29(6), 1982-1995.
[9] Ngoc, U. N., & Schnitzer, H. (2009). Sustainable solutions for solid waste management in Southeast Asian countries. Waste management, 29(6), 1982-1995.
[10] http://gujenvis.nic.in/PDF/waste.pdf

In rural areas, the environmental aspect of solid waste is virtually ignored and is considered largely a natural phenomenon. Dumping waste along the roadside or in other public places is a common practice in Asian developing countries. Street sweeping is one of the important activities in the waste-management system. The main disposal methods for municipal solid waste in Asian developing countries are open dumping and sanitary landfill.[11] In addition, waste scavenging is more positively viewed by the rural community. [12]

Table 1: Rural population (% of total population) and percentage or rural population growth between 2006 and 2015[13] (* Calculated as the difference between total population and urban population)

ASEAN+3 / EAS	2014*	2015*	Growth rate, %, 2006-2015
Brunei Darussalam	23.1	22.8	-0.03
Cambodia	79.5	79.3	-0.01
China	45.6	44.4	-0.12
Hong Kong SAR, China	0.0	0.0	0.00
Indonesia	47.0	46.3	-0.07
Japan	7.0	6.5	-0.06
Korea, Rep.	17.6	17.5	-0.01
Lao PDR	62.4	61.4	-0.10
Macao SAR, China	0.0	0.0	0.00
Malaysia	26.0	25.3	-0.07
Myanmar	66.4	65.9	-0.05
Philippines	55.5	55.6	0.02
Singapore	0.0	0.0	0.00
Thailand	50.8	49.6	-0.12
Timor-Leste	67.9	67.2	-0.06
Vietnam	67.0	66.4	-0.06
PIF			0.00
Australia	10.7	10.6	-0.01
Kiribati	55.8	55.7	-0.01
Marshall Islands	27.6	27.3	-0.02
Micronesia, Fed. Sts.	77.6	77.6	0.00
New Zealand	13.7	13.7	0.00
Samoa	80.7	80.9	0.02

[11] Organisation, Asian Productivity. "Solid Waste Management, Issues and Challenges in Asia." (2007).
[12] Chung, S. S., & Poon, C. S. (2001). A comparison of waste-reduction practices and new environmental paradigm of rural and urban Chinese citizens. Journal of Environmental Management, 62(1), 3-19.
[13] http://data.worldbank.org/indicator/SP.RUR.TOTL.ZS

Table 1: Rural population (% of total population) and percentage or rural population growth between 2006 and 2015[14] (* Calculated as the difference between total population and urban population) (Continued)

PIF	2014*	2015*	Growth rate, %, 2006-2015
Solomon Islands	78.1	77.7	-0.04
Palau	13.5	12.9	-0.08
Papua New Guinea	87.0	87.0	0.00
Tonga	76.4	76.3	-0.01
Tuvalu	41.2	40.3	-0.09
Vanuatu	74.2	73.9	-0.03
SAARC			0.00
Afghanistan	73.7	73.3	-0.03
Bangladesh	66.5	65.7	-0.07
Bhutan	62.1	61.4	-0.07
India	67.6	67.3	-0.03
Maldives	55.5	54.5	-0.11
Pakistan	61.7	61.2	-0.04
Sri Lanka	81.7	81.6	0.00
Others			0.00
American Samoa	12.7	12.8	0.01
Fiji	46.6	46.3	-0.03
French Polynesia	44.0	44.1	0.01
Guam	5.6	5.5	-0.01
Korea, Dem. People's Rep.	39.3	39.1	-0.01
Mongolia	28.8	28.0	-0.09
New Caledonia	30.3	29.8	-0.06
Northern Mariana Islands	10.7	10.8	0.00

[14] http://data.worldbank.org/indicator/SP.RUR.TOTL.ZS

Table 2: Total MSW and agriculture waste generation based on rural population 2015 [15]

ASEAN+3 / EAS	Rural population, 2015*	MSW Generation (kg capital^{-1} day^{-1}) [16]	Agricultural Waste Generation (kg capital^{-1} day^{-1}) [17]	MSW generation, 2015 (kg day^{-1})	Agriculture Waste generation, 2015 (kg day^{-1})
Brunei Darussalam	96,000	0.87	0.131	83.52	12.58
Cambodia	12,350,000	0.95	NA	11,732.50	NA
Indonesia	119,144,000	0.52	0.01	61,954.88	1,191.44
Lao PDR	4,175,000	0.7	0.105	2,922.50	438.38
Malaysia	7,672,000	1.52	0.228	11,661.44	1,749.22
Myanmar	35,519,000	0.44	0.066	15,628.36	2,344.25
Philippines	56,016,000	0.5	0.075	28,008.00	4,201.20
Singapore	-	1.49	0.224	-	-
Thailand	33,726,000	1.76	0.264	59,357.76	8,903.66
Vietnam	60,905,000	1.46	0.219	88,921.30	13,338.20
Timor-Leste	833,000	NA	NA	NA	NA
China	608,461,000	1.02	0.153	620,630.22	93,094.53
Hong Kong SAR, China	-	1.99	0.191	-	-
Macao SAR, China	-	1.47	0.228	-	-
Japan	8,246,000	1.71	0.257	14,100.66	2,119.22
Korea, Rep.	8,874,000	1.24	0.186	11,003.76	1,650.56

* Calculated as the difference between total population and urban population. Aggregation of urban and rural population may not add up to total population because of different country coverage.

[15] http://data.worldbank.org/indicator/SP.RUR.TOTL

[16] Hoornweg, Daniel; Bhada-Tata, Perinaz. 2012. What a Waste: A Global Review of Solid Waste Management. Urban development series;knowledge papers no. 15. World Bank, Washington, DC. © World Bank. https://openknowledge.worldbank.org/handle/10986/17388 License: CC BY 3.0 IGO.

[17] http://www.uncrd.or.jp/content/documents/2674Front%20cover%20for%20Background%20paper-%20PR-3-%20Prof.%20Agamuthu_merged.pdf

Table 2: Total MSW and agriculture waste generation based on rural population 2015 (Continued) [18]

PIF	Rural population, 2015	MSW Generation (kg capital^{-1} day^{-1})[10]	Agricultural Waste Generation (kg capital^{-1} day^{-1})[11]	MSW generation, 2015 (kg day^{-1})	Agriculture Waste generation, 2015 (kg day^{-1})
Australia	2,517,000	2.23	0.863	5,612.91	2,172.17
Micronesia, Fed. Sts.	81,000	NA	0.034	NA	2.75
Kiribati	63,000	NA	0.05	NA	3.15
New Zealand	624,000	3.68	0.45	2,296.32	280.80
Samoa	156,000	NA	0.065	NA	10.14
Solomon Islands	453,000	4.3	0.65	1,947.90	294.45
Palau	3,000	NA	0.038	NA	0.11
Papua New Guinea	6,628,000	NA	0.068	NA	450.70
Marshall Islands	14,000	NA	NA	NA	NA
Vanuatu	196,000	3.28	0.45	642.88	88.20
Tonga	81,000	3.71	0.525	300.51	42.53
Tuvalu	4,000	NA	0.065	NA	0.26
SAARC					
Afghanistan	23,841,000	NA	NA	NA	NA
Bangladesh	105,811,000	0.43	0.065	45,498.73	6,877.72
Bhutan	475,000	1.46	0.255	693.50	121.13
India	881,721,000	0.34	0.105	299,785.14	92,580.71
Maldives	222,000	2.48	0.33	550.56	73.26
Pakistan	115,701,000	0.84	0.158	97,188.84	18,280.76
Sri Lanka	17,044,000	5.1	0.765	86,924.40	13,038.66

* Calculated as the difference between total population and urban population. Aggregation of urban and rural population may not add up to total population because of different country coverage.

[18] http://data.worldbank.org/indicator/SP.RUR.TOTL

Table 2: Total MSW and agriculture waste generation based on rural population 2015 (Continued) [19]

PIF	Rural population, 2015	MSW Generation (kg capital^{-1} day^{-1})[10]	Agricultural Waste Generation (kg capital^{-1} day^{-1})[11]	MSW generation, 2015 (kg day^{-1})	Agriculture Waste generation, 2015 (kg day^{-1})
Others					
American Samoa	7,000	NA	0.149	NA	1.04
Fiji	413,000	NA	0.315	NA	130.10
French Polynesia	125,000	NA	NA	NA	NA
Guam	9,000	NA	NA	NA	NA
New Caledonia	80,000	NA	NA	NA	NA
Northern Mariana Islands	6,000	NA	0.42	NA	2.52
Korea, Dem. People's Rep.	9,842,000	NA	NA	NA	NA
Mongolia	827,000	0.66	0.143	545.82	118.26

* Calculated as the difference between total population and urban population. Aggregation of urban and rural population may not add up to total population because of different country coverage.

[19] http://data.worldbank.org/indicator/SP.RUR.TOTL

2.2 Importance of 3R in rural development

Regional development is effective program in addressing regional disparities between urban and rural areas by focusing on poverty reduction and improving social equity and cohesion. The development include broad range sector such as agriculture and industry, drinking water availability, utilities, transport, employment, education, health and sanitization, and waste management. The integration of economic, social and environment benefit is the main objective in regional development.

In rural areas, the environmental aspect of solid waste is virtually ignored and is considered largely a natural phenomenon. Dumping waste along the roadside or in other public places is a common practice in Asian developing countries. In addition, the lack of sanitation services and poor waste management facilities in rural areas has increased the amounts of waste disposed in open dumps. In addition, it often leads to waste disposal on the same sites over several years. [20] Thus, it is important to implement proper waste management such as 3R in rural areas in order to:
1) [21] [22] [23]

3R waste management improves accessibility of improved sanitization by reducing the risk of disease and pathogen transmission. The 3R waste and resource management able to achieve Goal 3 of SDGs which ensures healthy lives and promote well-being for all at all ages. The 3R resource and waste management offered new employment and business opportunities to rural poor. [24] In addition, it is an alternative source of income for peoples in rural area (Goal 1).

Agriculture sector is a primary GDP contributor in majority of the countries in Asia-Pacific. The agriculture sector contributed between 0.7% and 30% of total GDP for Asia-Pacific region. The rapid increased of world population and improved living standard has lead to expansion of intensive agriculture. This has resulted in increase of volume and types of agricultural biomass waste in rural which is becoming a burgeoning problem. Several environment issues relate to agriculture and biomass wastes:
1) Rotten agriculture and biomass wastes emits methane
2) Leachate from agriculture and biomass waste entering ecosystem
3) Open burning by the farmers to clear the land generates significant amount of CO_2 and other local pollutants

Hence improper management of rural waste is contributing towards climate change, water and soil contamination, and local air pollution. Thus, it is crucial to have a proper waste management system and program to ensure sustainable development in rural areas. The GHG emission reduction with sustainable resource and waste management will achieve Goal 13 of SDGs. In addition, the efficient 3R waste management ensures sustainability of ecosystem

[20] Apostol, L., & Mihai, F. C. (2012). Rural waste management: challenges and issues in Romania. Rural waste management: challenges and issues in Romania, Present Environment and Sustainable Development, 6(2), 105-114.
[21] http://www.academia.edu/11602704/Rural_Solid_Waste_Management_Issues_and_Action
[22] Patel, D., Brijesh, P., & Priyank, S. (2015). Solid and Liquid Waste Management in Rural Areas. International Journal for Innovative Research in Science and Technology, 1(12), 509-512.
[23] Apostol, L., & Mihai, F. C. (2012). Rural waste management: challenges and issues in Romania. Rural waste management: challenges and issues in Romania, Present Environment and Sustainable Development, 6(2), 105-114.
[24] http://www.uncrd.or.jp/content/documents/2695Plenary%20Session(1)-Presentation%20(5)-Tomoko%20Nishimoto.pdf

(Goal 15). It is estimated that the global 3R of waste able to: [25]

1) achieve global mitigation potential is 5,500-6,000 megatons of CO_2e / year by 2030
2) serve as potential of carbon sequestration
3) reduce methane (CH_4) emission.

In addition, the lack of access to adequate sanitation facilities has serious health implications for rural dwellers and can degrade the ecosystems.[26] This is considered a major factor that hampers the launch of the Millennium Development Goals (MDGs) of the United Nations.[27] The 3R waste management ensures sustainable consumption and production patterns via sustainable resource and waste management (Goal 12). Furthermore, this waste is of high value in respect to material and energy recovery.[28] The waste to energy able to provides sustainable energy in rural areas which ensure access to affordable, reliable, sustainable and modern energy for all (Goal 7). Treatment and reuse of organic waste generated in the breeding and cultivation processes also play an important role in reducing environmental pollution and improving public health. Other than that, reuse of resource via composting provides low cost fertilizer for food crops which allows rural resident to have sustainable crop production and food source (Goal 2). In terms of social aspects, the 3R approach also creates job opportunities, increased income, enhanced awareness in society, and reduces the cost in waste management.[29]

Several researches suggest that 3R waste management programs are suitable to implement in rural areas due to:[30]

i) Increased waste generation as a result of increase in population, consumerism and commercial activities. It is estimated that 0.3 to 0.4 million metric tons of solid waste are generated each day in rural areas. However, it is still relatively low compared with urban areas.[30]
ii) Small and strong community allows initiatives for waste management in rural areas relatively easier to implement compared with urban areas
iii) Land availability often is not a constraint for waste management in rural areas.
iv) More options in reuse of waste such as composting of biodegradable material, which can be used in kitchen gardens, agricultural fields, and etc.
v) A research in China, showed the support and the popularity of source separation of household waste is even more prominent in rural area compared to urban area. [31]

While there is much to be gained from the implementation of the SDGs, there are still

[25] http://www.uncrd.or.jp/content/documents/Session2_Agamuthu.pdf
[26] Guan, Y., Zhang, Y., Zhao, D., Huang, X., & Li, H. (2015). Rural domestic waste management in Zhejiang Province, China: Characteristics, current practices, and an improved strategy. Journal of the Air & Waste Management Association, 65(6), 721-731.
[27] Guan, Y., Zhang, Y., Zhao, D., Huang, X., & Li, H. (2015). Rural domestic waste management in Zhejiang Province, China: Characteristics, current practices, and an improved strategy. Journal of the Air & Waste Management Association, 65(6), 721-731
[28]
http://www.unep.org/ietc/Portals/136/Publications/Waste%20Management/WasteAgriculturalBiomassEST_Compendium.pdf
[29] Huynh, T. H., & Nguyen, T. A. T. (2010). Benefits of the 3R approach for agricultural waste management (AWM) in Vietnam: Under the framework of joint project on Asia Resource Circulation Research.
[30] http://www.mdws.gov.in/sites/default/files/Handbook%20on%20SLWM%20WSP%20final%20May%202012.pdf
[31] Chung, S. S., & Poon, C. S. (2001). A comparison of waste-reduction practices and new environmental paradigm of rural and urban Chinese citizens. Journal of Environmental Management, 62(1), 3-19.

challenges that need to be addressed. A critical component for implementation of the 2030 Agenda is the decisions taken by each country as it conducts national SDG implementation planning. The SDGs represent a break from traditional global approach to sustainable development and is a process to redefine national SDG plans towards new direction.[32] One of the main challenges is to ensure the focus of 3R management in the context of SDGs despite country and global challenges such as better livelihoods, gender equality, justice and security, inclusive decision-making, addressing the development dimensions of HIV and health, social protection, biodiversity, land degradation, disaster risk management, mitigating and adapting to climate change, and the links across these issues.[33] In addition, the question on how can the 3R and SDGs be translated into actions that rural communities which can be integrated into their own lives and communities is also one of the main issues.[34] It is crucial to design and implement development pathways that can address the connected issues of multidimensional poverty, inequality and exclusion, while enhancing productive capacities to reduce risks and sustain social and natural capital.

With the global campaign to combat climate change, countries are now looking for alternative sources of energy to minimize greenhouse gas (GHG) emissions. Biomass is identified as a renewable resource that has a steady and abundant supply, especially those biomass resources that are by-products of agricultural activity. However, the debate on food versus fuel has been intensified. Even though, biomass can provide added income to farmers and rural community, but the questions is how to ensure the increased use of biomass for bioenergy and biochemical is not compromising the food production.[35]

2.3 Current policy issues and gaps in rural waste management

The FAO estimates that 1.3 billion tonnes of food are wasted every year, either through post-harvest losses, including storage, pest management, transport, or food waste at the household level. Depending on the crop, between 15 and 35 percent of food may be lost before it even leaves the field. It is assumed that, by 2030, 38–45 percent of total biomass supply for energy purposes will be met by crop residues and other waste products, with the remainder met equally by crop production and forests. [36] Thus, successful circular economic utilization could relieve pressures on land and open up additional land for other uses, including the production of biomass for fuel and material purposes. This would be able to divert agriculture and biomass from wastage to economic product. There are two categories of biomass economic product: 1) convert agricultural biomass waste into energy products such as heat and steam, electricity, producer gas, synthetic fuel oil, charcoal, methane, ethanol, bio- diesel and methanol; (2) convert agricultural biomass waste into raw materials or non-energy products such as cordage, textiles, paper products, upholstery and packaging materials, animal feed, insulators and panel boards, among many others. Circular use of biomass waste will reduce food wastage, reduce competition with food production, land use and even contribute to country GDP. It is estimated that the utilization of food and biomass waste are able to reduce the global rate of food loss and waste by 50%.[37]

[32] http://sd.iisd.org/policy-updates/implementing-the-2030-agenda-and-its-sdgs-where-to-start/

[33] http://www.undp.org/content/dam/undp/library/SDGs/SDG%20Implementation%20and%20UNDP_Policy_and_Program_Brief.pdf

[34] https://www.unige.ch/gepp/files/5714/4890/1818/Resilient_Future_Conference_GEPP.pdf

[35] http://www.springer.com/us/book/9783319138466

[36] http://www.iass-potsdam.de/sites/default/files/files/working_paper_biomass.pdf

[37] http://www.cost.eu/download/44915.

The sustainable production and consumption of biomass is the prerequisite to continuously meeting basic human needs while safeguarding the environment. Therefore, the circular economic utilization plays an important role in achieving SDGs such as food security, energy security, biodiversity, and/or climate stability. The main challenges in establishing circular economy policies in rural regions is to ensure incorporation of resource efficiency, source-efficient and low-carbon economy within the global context of green economy into the current rural development policies.[38] Majority of the policies issued concentrate excessively in urban region while rural areas are neglected or receive only a small trickle of investment and the poor quality of human resources there comprises a barrier for catching up with opportunities that have become available through globalization. The development strategies focus on urbanization associated with industrialization, while ignoring the demands of the rural economy. Rural areas lack investments in infrastructure, education and skills development so that the development is inhibited and opportunities are forgotten.[39] In addition, there is increasing consensus that government administrative policies and procedures stress technical solutions to social, value based problems.[40] Rural areas often face serious problems in compliance of regulation on waste management. This is mainly due to higher share of rural population, lower living standards, and waste collection services are poorly-developed covering some rural regions. In addition, demographic factors, geographical and socio-economic context influence the disparities between within counties.[41] Waste generated and uncollected from rural areas have been disposed in improper dumpsites polluting the local environment; the rural areas are currently the most vulnerable to illegal dumping. Waste dumping is still an option for those rural localities that have limited access to sanitation services or poor waste management facilities.

Table 3 showed the existing 3R waste management in selected Asian countries which mostly focus on urban region development. In Vietnam the legal system is ineffective in terms of waste management mainly due to the legal documents for environmental protection is not comprehensive in so far as it lacks detail implementation plan and lacks obligatory regulations. Therefore it affects the behavior of individuals and organizations regarding environmental protection only to a limited degree. It is necessary to have obligatory regulations on infrastructure development, such as a requirement that relevant sewage systems and centralized wastewater treatment systems be completed before operations commence at an entity, or a regulatory obligation for entities to report regularly on wastewater and solid waste treatment activities.[42] Thus, the biggest challenges of the biomass market identified are the complex bureaucratic structure, logistic and unsystematic biomass market.[45] In order to close the gap between current policies in rural waste management, it is crucial to track and review the progress of national strategy, policy priorities, and local governmental efforts and could provide policy feedback and measure performance. In

[38] Scarlat, N., Dallemand, J. F., Monforti-Ferrario, F., & Nita, V. (2015). The role of biomass and bioenergy in a future bioeconomy: policies and facts. *Environmental Development*, *15*, 3-34.

[39] Huynh, T. H., & Nguyen, T. A. T. (2010). Benefits of the 3R approach for agricultural waste management (AWM) in Vietnam: Under the framework of joint project on Asia Resource Circulation Research.

[40] Morrissey, J. (1992, April). Waste management problems in rural areas: limits to citizen participation in decisionmaking. In First National Symposium on Rural Waste Management Issues, University of Tennessee. Retrieved November (Vol. 17, p. 2007).

[41] Apostol, L., & Mihai, F. C. (2012). Rural waste management: challenges and issues in Romania. *Rural waste management: challenges and issues in Romania, Present Environment and Sustainable Development*, *6*(2), 105-114.

[42] Huynh, T. H., & Nguyen, T. A. T. (2010). Benefits of the 3R approach for agricultural waste management (AWM) in Vietnam: Under the framework of joint project on Asia Resource Circulation Research.

addition, the administrative procedure is burdensome and the management system overlaps.[43]

Table 3: Existing national policy in Asia[44]

Country and Policy	Policy
Japan	Fundamental plan for establishing a sound material cycle society
Malaysia	Tenth Malaysia Plan 2011–2015
Philippines	Ecological Solid Waste Management Act
The People's Republic of China	Circular Economy
Viet Nam	National Strategy for Integrated Management of Solid Waste up to 2025

Policy interventions are needed to ensure the development of efficient and sustainable 3R in resource and waste. Biomass waste projects have a greater probability of being successfully developed in countries and regions with supportive policy frameworks. Although the policy environment for 3R agriculture biomass developments is less complex than that for bioenergy as a whole, most developing countries rarely see this opportunity and rather seek to promote 3R in agriculture biomass as part of a wider suite of policy measures aimed at promoting bioenergy. The introduction of industry friendly policies, feed in tariff, long term RE contracts, government project investment incentives, low price guaranteed, power purchase agreements, connection to national grid and tax exemption of related equipment by some of the countries accelerate the development of biomass utilization.[45] However, these policies mostly are industry oriented which has less impact on rural regions. Study suggests the lower income group such as rural community tended to do more recovery and it is likely that the monetary reward is the major motivation. Thus, good marketability for the recyclables is also essential for a successful community-wide waste-recycling program.[45] The main concern of policy maker in promoting circular economy in rural regions should not be on whether the public knows how to separate the waste but rather on how to motivate them to separate for the good of society.

2.4 Economic Potential of 3R in resource and waste management

Rural areas have often suffered numerous developmental challenges as opportunities and provision of services traditionally favored towards cities, urban areas and large agglomerations. The focus on the growth of large urban areas has made attracting investment, creating jobs, meeting the housing demand, and providing access to key infrastructure and basic services which increasing challenge the development in intermediate towns and rural areas. Rural areas are becoming depopulated due to rural to urban migration, which is often driven by lack of income generating opportunities, among other socio-economic factors. To

[43] http://www.uncrd.or.jp/content/documents/Hanoi%203R%20ForumPS4_IGES.pdf
[44] http://www.uncrd.or.jp/content/documents/Hanoi%203R%20ForumPS4_IGES.pdf
[45] Chung, S. S., & Poon, C. S. (2001). A comparison of waste-reduction practices and new environmental paradigm of rural and urban Chinese citizens. Journal of Environmental Management, 62(1), 3-19.

this regard effective and economic utilization of agricultural and bio-mass waste in rural areas could be one of the vital contributing factor towards sustainable regional development in Asia-Pacific region.

Generally, the agriculture sector has contributed 0.7 to 30% of total GDP for Asia Pacific countries. [46] This indicates that majority of Asia Pacific countries have the potential to utilize resources from agriculture waste. Expanding agricultural production has naturally resulted in increased quantities of livestock waste, agricultural crop residues and agro-industrial by-products. Among the countries in the Asian and Pacific Region, People's Republic of China produces the largest quantities of agriculture waste and crop residues followed by India. In People's Republic of China, some 587 million tonnes of residues are generated annually from the production of rice, corn and wheat alone[47]. Biomass and waste make up the vast majority of renewable energy production in Asia and the Pacific. [48]. Agricultural residues constitute a major part of the total annual production of biomass residues and are an important source of energy both for domestic as well as for industrial purposes. Biomass currently supplies about a third of the energy in developing countries. In addition, agricultural production is a significant employer in rural areas.[49] Thus the 3R of resource and waste will create job opportunity and also alternative income for rural community. The growth of agriculture sector will definitely benefit rural community. Challenges in mountain countries need special consideratios.

The circular economy is a concrete and ambitious program with measures covering the whole cycle: from production and consumption to waste management and the market for secondary raw materials. [50] The circular economy will contribute to "closing the loop" of product lifecycles through greater recycling and re-use, and bring benefits for both the environment and the economy. The circular economy offers an opportunity to reinvent rural economy, making it more sustainable and competitive. The economic and environmental effects of biomass production on the agricultural sector are diverse and location-specific. In addition, the growth and the economic utilization of biomass, for power generation as an alternative to fossil fuels have been on the rise and are being considered seriously. This will bring benefits for rural businesses, industries, and citizens alike. With this new plan to make rural economy cleaner and more competitive which cut resource use, reduce waste and boost recycling. The development of circular economy in rural areas contribute to fight against global warming, to ensure security of supply and integrated and efficient energy, stimulating research and innovation and promoting competitiveness and job creation.[51]

Circular use of biomass waste can benefit rural community even with low technology methods such as composting. Composting is considered one of the easiest 3R technologies to be implemented in rural regions due to the low volume of degradable matter, land availability with low cost and easy access to labor force.[52] However, expansion of bioenergy in Asia

[46] http://faostat3.fao.org/browse/rankings/commodities_by_country/E
[47] http://www.unescap.org/sites/default/files/CH08.PDF
[48] http://www.unescap.org/resources/statistical-yearbook-asia-and-pacific-2014
[49] Credit, C. P., & Foley, P. (2015). Economic Development Strategy for Regional NSW.
[50] http://ec.europa.eu/environment/circular-economy/index_en.htm
[51] http://www.r-e-a.net/resources/pdf/243/160510_REA_response_to_EU_sustainable_bioenergy_policy_for_the_period_after_2020_FINAL.pdf.
[52] Abduli, M. A., Samieifard, R., & Zade, M. J. G. (2009). Rural solid waste management.

Pacific rural regions has tremendous potential due to existing bioenergy production technologies and market. Several Asia Pacific countries are a key supplier of biomass feedstock to markets such as Europe and the United States but within the region, new opportunities and investments in biomass are emerging, particularly in Southeast Asia. PR China, Japan and The Republic of Korea currently lead the region in biomass projects due to a combination of a high level of technological capability and government targets on renewable energy sources.[53] The Southeast Asian biomass and waste-to-power market is in the growth stage. It is estimated that the region produced nearly 230 million tonnes of feedstock annually. The abundance of available feedstock is attracting investor interest. [54] In general, the renewable energy production in Asia and the Pacific region is much lower in comparison to Europe and Africa. In 2013, majority of solid biofuel production was from Africa while biogas production was from European countries (Figure 1). This indicates the potential of renewable energy market in Asia and the Pacific region. According to UN statistic, 39% the bagasse energy production was from South America and 42% from Asia (Figure 2). It is estimated in 2013, 50% of waste production was from Asia, 23% from Africa, 11 % from North America and 10% from Europe (Figure 2). This suggests that Asia Pacific regions has rooms for bioenergy development, especially rural regions as majority countries has 30 to 60% of rural populations. [55]

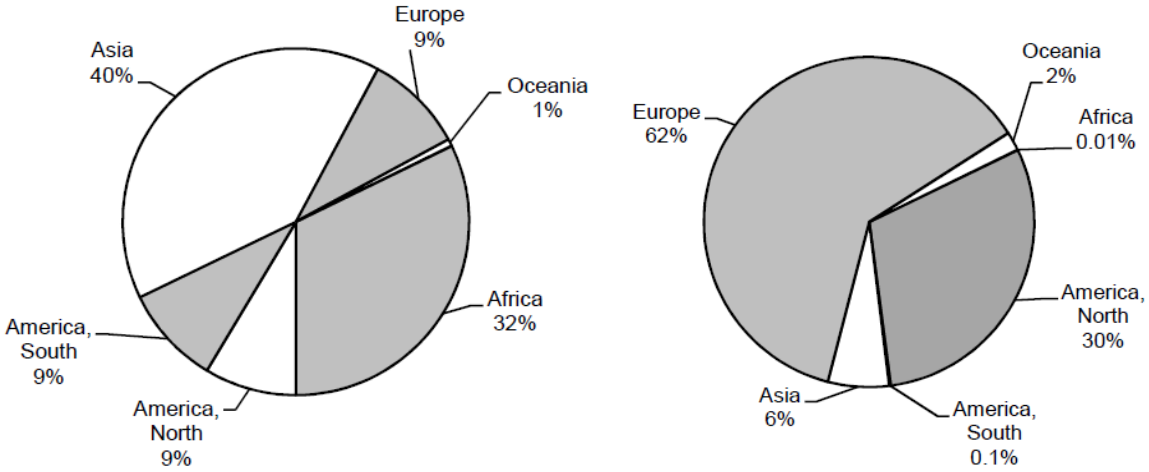

Figure 1: (Left) Total solid biofuels production by region, 2013, (Right) Biogases production by region, 2013[56]

[53] http://www.eco-business.com/news/southeast-asia-set-biomass-boom/

[54] http://www.prnewswire.com/news-releases/strategic-analysis-of-the-biomass-and-waste-to-power-market-in-southeast-asia-300104537.html

[55] http://data.worldbank.org/indicator/SP.RUR.TOTL.ZS

[56] http://unstats.un.org/unsd/energy/yearbook/2013/t12.pdf

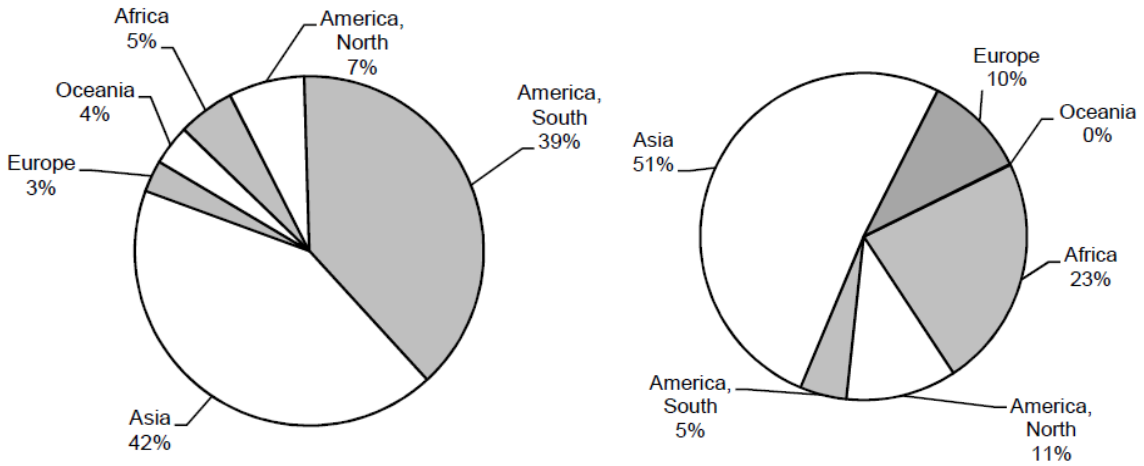

Figure 2: (Left) Bagasse production by region, 2013, (right) Energy production from wastes by region, 2013[18]

The circular economy can significantly contribute to the development to rural areas which suffered from declining economic activities. The circular economy encourages rural development by improving the competitiveness of farming and forestry, to protect the environment and the countryside, to diversify the rural economy and to support rural development. The circular economy would help shifting agricultural activities towards more sustainable and environmentally friendly activities, creating new supply chains for biomass feedstock for bio-based industries and developing agriculture infrastructures. The creation of new non-food markets for crops and biomass feedstock (including residues and waste), could provide alternative income sources for farmers.[57]

3.0 Cost of inaction or loss of opportunity

3.1 Social and environment impact

Asia is the world's driest continent and also one of the most water polluted regions, as rivers and lakes are becoming polluted due to the population influx. According to the Asian Development Bank report, three out of four countries in Asia are facing a severe lack of water, and some are in danger of a crisis unless steps are taken to improve water management.[58] In China, for example, 500 million people are without clean drinking water. Other countries in Asia like India, Pakistan, Bangladesh, Nepal and Cambodia are facing their own share of water shortage and pollution.[59] From China's yellow River to India's Yamuna River to Indonesia's Citarum River, Asia's rivers are increasingly polluted as untreated sewage and agricultural runoff discharges into the water. Given Asia's population and economic growth, the health of rivers is worsening, resulting in all kinds of waste from mills and factories, home waste and sewage pouring into the rivers almost every day, making their water unfit for human consumption. Improper waste management has major impact on social and environment. Rivers in Asia are highly polluted with domestic waste. Many of the

[57] Scarlat, N., Dallemand, J. F., Monforti-Ferrario, F., & Nita, V. (2015). The role of biomass and bioenergy in a future bioeconomy: policies and facts. Environmental Development, 15, 3-34.
[58] http://ejap.org/environmental-issues-in-asia/Water%20Pollution.html
[59] http://ejap.org/environmental-issues-in-asia/Water%20Pollution.html

region's rivers contain up to 3 times the world average of human waste derived bacteria (measured in faecal coliforms). Inadequate access to sanitation infrastructure (such as connections to public sewers and septic systems) is major contributing factor in rural regions.[60] Insect/mosquito breeding in stagnant water pools on waste sites and in canals and waterways blocked or constricted with waste resulting in the spread of disease. There are significant health risks due to the existence of vermin, insects, flies and scavenging animals particularly to workers and neighboring residents. Nuisance caused to the neighborhood due to odor and flies.[61]It is reported that the water pollution in rural areas is far worse than urban region of China.[62] More than 80% of China's underground water drawn from relatively shallow wells used by farms, factories and mostly rural households is unsafe for drinking because of pollution. [63]

One of the contributors in global greenhouse gas (GHG) emission is from the waste sector which includes municipal solid waste (MSW) and wastewater. In Malaysia, the contributions of GHG from waste sector are 18.64% and 11.83% in year 1994 and 2000 respectively. The global waste sector contribution to GHG is only 3% in year 2004. This disparity indicates that there are potential mitigation efforts to reduce the GHG from waste sector for Malaysia.[64] It is believed that 3R of waste management has a positive impact on environment. According to Asian Development Bank (ADB) effective utilization of agriculture and biomass waste contributed to greenhouse gas emissions mitigation. It is estimated that 3R of agriculture biomass has the potential to reduce emissions by 277 Mt CO_2-eq/year at carbon price of $20 per tonne, equivalent to a benefit of $5.5 billion a year. [65.] A simulation of waste recycling in rural area in Malaysia for rural area shows that by increasing the paper recycling rate from current 5% to 20%, the possible reduction in GHG ranges from 26 % to 50 % for year 2010 and 25.51 % to 49.68 % for year 2020, based on the estimated rural waste generation rate of 0.43 kg/day/cap for 2010 and 0.48 kg/cap/day for 2020.[66]

3.2 Economic opportunity

Briquette market is used as a benchmark to assess the potential economic value of agriculture and biomass waste generated from Asia Pacific countries. Briquette is chosen as the benchmark for several reasons: (1) briquetting technology is universally accepted, (2) there are a number of export-oriented briquette producers and buyers, (3) it is considered as an appropriate technology for indigenous production and for use in rural areas of developing countries.[67,68] Based on the biomass generation rate estimated in section 2.2, the biomass generation values in 2013 were converted into monetary value with the assumption that the

[60] Evans, A. E., Hanjra, M. A., Jiang, Y., Qadir, M., & Drechsel, P. (2012). Water pollution in Asia: The urgent need for prevention and monitoring. *Water Qual*, *9*, 1-4.

[61] http://www.fao.org/docrep/w7224e/w7224e0b.htm
[62] http://news.bbc.co.uk/2/hi/asia-pacific/4636371.stm
[63] https://www.theguardian.com/environment/2016/apr/12/four-fifths-of-chinas-water-from-wells-unsafe-because-of-pollution
[64] Chua, K. H., Sahid, E. J. M., & Leong, Y. P. (2011). Sustainable municipal solid waste management and GHG abatement in Malaysia. *ST-4: Green & Energy Management*, *4*(02).
[65] http://www.uncrd.or.jp/content/documents/Session2_Agamuthu.pdf
[66] Chua, K. H., Sahid, E. J. M., & Leong, Y. P. (2011). Sustainable municipal solid waste management and GHG abatement in Malaysia. *ST-4: Green & Energy Management*, *4*(02).
[67] http://www.fao.org/docrep/006/ad579e/ad579e00.pdf
[68] http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2010409

agriculture waste generated are used to produce low energy briquette (selling price = USD 150 per tonne) (Table 6)[69]. Countries like PR China, Kiribati, Samoa, Solomon Islands, Vanuatu, Tonga, New Zealand, Malaysia, Cambodia, Indonesia, Laos, Myanmar, Vietnam, Japan, Bangladesh, Nepal, Sri Lanka, The Philippines, Thailand, India, Pakistan, Fiji, Australia, Afghanistan, and Mongolia have the potential to generate millions of dollars just by producing briquette from a single major crop. It is estimated, that there is a total of 153 million tonnes of briquette (valued at USD 23 billion) produced from Asia Pacific region in 2013.[50] This estimation only takes into consideration one type of major agriculture produce from each country. The briquette market has lower financial return among the biomass product; therefore, the economic value of biomass will definitely increase for products such as ethanol, compost, pellets and fibers.[70]

[69] http://www.gvepinternational.org/sites/default/files/financial_institutions_market_study_in_east_africa_2010_gvep_international.pdf

[70] T http://www.oeaw.ac.at/forebiom/WS2lectures/02-01-TKMUN.pdf

Table 6: Estimated monetary value generated from biomass briquette production

	Biomass Source	Biomass Generation 2013, tonnes [a]	Briquette Production 2013, tonnes [b]	Monetary value of biomass generated, USD [c]
Australia	Wheat	12,913,400	2,934,864	440,229,560
Afghanistan	Wheat	2,920,618	663,777	99,566,515
Bangladesh	Paddy rice	31,930,000	7,256,818	1,088,522,727
Bhutan	Paddy rice	48,813	11,094	1,664,066
Brunei	Livestock waste	456	104	15,545
Cambodia	Paddy rice	5,821,800	1,323,136	198,470,455
Cook Islands	Coconut waste	833	189	28,381
East Timor	Paddy rice	53,940	12,259	1,838,864
Federated States of Micronesia	Coconut waste	25,650	5,830	874,432
French Polynesia	Coconut waste	36,900	8,386	1,257,955
Fiji	Sugar cane	448,000	101,818	15,272,727
Guam	Coconut waste	22,500	5,114	767,045
India	Sugar cane	95,536,000	21,712,727	3,256,909,091
Indonesia	Paddy rice	44,193,420	10,043,959	1,506,593,849
Japan	Paddy rice	6,669,960	1,515,900	227,385,000
Kiribati	Coconut waste	76,500	17,386	2,607,955
Laos	Paddy rice	2,117,300	481,205	72,180,682
Macau	Livestock waste	18	4	597
Maldives	Banana waste	46	11	1,575
Malaysia	Oil palm waste	96,215,331	21,867,121	3,280,068,102
Marshall Islands	Coconut waste	11,250	2,557	383,523
Mongolia	Wheat	208,134	47,303	7,095,482
Myanmar	Paddy rice	17,835,540	4,053,532	608,029,773
Nauru	Coconut waste	1,215	276	41,420
Niue	Coconut waste	1,440	327	49,091
Nepal	Paddy rice	2,792,792	634,725	95,208,813
New Caledonia	Coconut waste	8,550	1,943	291,477
New Zealand	Livestock waste	22,400,668	5,091,061	763,659,150

a: FAOSTAT(Source: 71)

b: Compaction ratio assumed to be 4.4 (Source: 72)

c: Briquette assumed to sell at USD100 (Source: 73)

[71] http://faostat3.fao.org/browse/G1/*/E
[72] http://article.sapub.org/10.5923.j.ijee.20120201.04.html
[73] http://www.biomassbriquettesystems.com/listings?country=121&state_province=All

Table 6: Estimated monetary value generated from biomass briquette production (Continued)

	Biomass Source	Biomass Generation 2013, tonnes [a]	Briquette Production 2013, tonnes [b]	Monetary value of biomass generated, USD [c]
Pakistan	Sugar cane	17,849,972	4,056,812	608,521,773
Papua New Guinea	Coconut waste	540,000	122,727	18,409,091
PR China	Maize waste	244,386,028	55,542,279	8,331,341,863
Samoa	Coconut waste	85,500	19,432	2,914,773
Singapore	Livestock waste	165	37	5,608
Solomon Islands	Coconut waste	184,500	41,932	6,289,773
Sri Lanka	Paddy rice	2,864,853	651,103	97,665,430
Thailand	Sugar cane	28,026,880	6,369,745	955,461,818
The Philippines	Sugar cane	8,924,720	2,028,345	304,251,818
Tokelau	Coconut waste	1,935	440	65,966
Tonga	Coconut waste	58,500	13,295	1,994,318
Tuvalu	Coconut waste	990	225	33,750
Vanuatu	Coconut waste	184,500	41,932	6,289,773
Vietnam	Paddy rice	27,304,361	6,205,536	930,830,474
Wallis and Futuna	Banana waste	2,086	474	71,100
Grand Total		**673,694,540**	**153,112,395**	**22,966,859,307**

a: FAOSTAT(Source: 74)

b: Compaction ratio assumed to be 4.4 (Source: 75)

c: Briquette assumed to sell at USD100 (Source: 76)

[74] http://faostat3.fao.org/browse/G1/*/E
[75] http://article.sapub.org/10.5923.j.ijee.20120201.04.html.
[76] http://www.biomassbriquettesystems.com/listings?country=121&state_province=All

4.0 Case study:

4.1 Vietnam

The average domestic waste in Vietnam is 12,800 t y^{-1} and 50% of the total are from rural area. Agriculture waste is a major waste type generated in rural region of Vietnam which is about 64,560 t y^{-1}. [77] The high percentage of agriculture wastes in rural areas highlights the potential in 3R of agriculture wastes. Vietnam is largely a rural agricultural economy with 75% of the population living in rural areas. Two-third of the population is currently dependent on agriculture for living. In Vietnam, the average waste collection rate in urban region is 70% while in rural region is only about 40%. [78]

Current waste management:

- Self-disposal is common in areas with no collection and disposal services.
- 8/63 provinces have composting factories;
- Incineration for hazardous waste treatment;
- There are 91 landfills for solid waste among which 17 are sanitary;
- 80% non-hazardous industrial waste is potentially recyclable
- The informal sector collects the majority of the recyclable and reusable waste in urban areas
- Many Craft Villages receive collected recyclable waste for recycling (Northern region);
- Small and medium scale enterprise working on recycling waste (Southern region);
- No large-scale systematic waste recycling facility

Challenges:

- Poor craft village planning
- Commune and villager's capacity is limited
- Overlaps in functions and responsibilities of relevant ministries and agencies
- Policies do exist but overlaps and conflicts still remain
- Waste is not separated at sources
- Recycling: small-sized, spontaneous, difficult to control, applying backward technologies (particularly in craft villages)

[77] http://www.env.go.jp/recycle/3r/en/forum_asia/results/pdf/20090629/13.pdf
[78] Doanh, L. Q. (2004). Participatory Rural Environmental Management: Synthesized Report. VIE/00/018/08. Vietnam Agricultural Science Institute, Hanoi, 76 pp. Available at http://www. fao. org/docrep/008/af329e/af329e00. htm (accessed December 29, 2014).

4.2 PR China

PR China is the largest developing country in the world, and the gross domestic product (GDP) of PR China has reached the second in the world. The social and economic development in rural areas in PR China is far behind the urban areas thus limited information available on the rural domestic waste management in PR China. This deficiency often leads to inappropriate handling and disposal of rural waste. The rural domestic waste (RDW) generation per capita between 2012 and 2020 is estimated to increase from 0.68 to 1.01 kg/d-cap. it is estimated that about 1 × 108 tons of rural wastes was abandoned carelessly without proper treatment. [79] [80] Rural waste compositions are:

- organic materials = 70%
- kitchen waste = 42.9%
- yard waste = 11.2%,
- plastics = 8.1%
- paper = 7.8%
- fibers = 5.6%

In general, 75.5% of rural waste is combustible wastes, 24.8% is recyclable wastes, and 54.1% is compostable wastes.

Current RDWM practices:

- Collection and transportation
    - collected first from individual villages, transferred to the county-designated disposal site by the responsible township (a town manages ~30 villages), and finally disposed of at the solid waste treatment facilities commissioned by the county government
- Disposal
    - The average disposal rate is 54.8 ± 26.7%, and the highest and lowest values are 94.8% and 7.3%, respectively.

Challenges:

- regular commercial collection of domestic waste could not be financially feasible
- no municipalities, waste collection and disposal services are unavailable and residents do not
- residents unwilling to pay for the waste management services.
- residents prefer to bury, burn, discharge waste onto river banks and dispose illegally in nearby landfills

[79] Guan, Y., Zhang, Y., Zhao, D., Huang, X., & Li, H. (2015). Rural domestic waste management in Zhejiang Province, China: Characteristics, current practices, and an improved strategy. Journal of the Air & Waste Management Association, 65(6), 721-731.
[80] Han, Z., Liu, D., Lei, Y., Wu, J., & Li, S. (2015). Characteristics and management of domestic waste in the rural area of Southwest China. Waste Management & Research, 33(1), 39-47.

5.0 Challenges of 3R waste management in rural areas and implications towards the SDG

There are several challenges of 3R waste management in rural areas and the main obstacle is the collection of waste in rural area.[81] The waste collection in rural area is a major challenge due to the fact that most rural settlement are located in remote areas and distributed widely. This increased the difficulty in waste collection and also increased transportation cost. Other than that, rural resident's willingness to participate in 3R recycling program is highly motivated by incentives instead of self-initiatives. The lists below are some of the major challenges in 3R waste management program in rural areas: [82] [83] [84]

- Fail to convince people to adopt safe waste management practices
- General public perceived waste management is irrelevant to own interest
- Residents unwilling to pay for the waste management services.
- Ineffective campaign and program
- Collection of MSW is inadequate in varying degrees – especially in the rural areas – waste is thrown directly into the river and waterways or is indiscriminately dumped by the roadsides. Residents prefer to bury, burn, discharge waste onto river banks and dispose illegally in nearby landfills
- Lack of finance - regular commercial collection of domestic waste could not be financially feasible
- Lack of awareness of the environmental
- Inadequate solid waste management - no municipalities, waste collection and disposal services are unavailable and residents do not
- Lack of enforcement
- Poor craft village planning
- Commune and villager's capacity is limited
- Overlaps in functions and responsibilities of relevant ministries and agencies
- Policies do exist but overlaps and conflicts still remain
- Waste is not separated at sources
- Recycling: small-sized, spontaneous, difficult to control, applying backward technologies (particularly in craft villages)

In addition, with regard to agriculture residues many factors will have to be considered:

- The agriculture wastes may be used for various purposes in the local community, even where residues have no monetary value. This can be one of the competing factors for further agriculture waste utilization.
- Seasonal production produces large quantities being available directly after the harvest.
- The ownership and access, fraction which can be recovered economically taking into account environmental considerations[85]

[81] Abduli, M. A., Samieifard, R., & Zade, M. J. G. (2009). Rural solid waste management.
[82] http://www.mdws.gov.in/sites/default/files/Handbook%20on%20SLWM%20WSP%20final%20May%202012.pdf
[83] Ngoc, U. N., & Schnitzer, H. (2009). Sustainable solutions for solid waste management in Southeast Asian countries. Waste management, 29(6), 1982-1995
[84] http://www.waikatoregion.govt.nz/PageFiles/30542/TR201455.pdf
[85] http://www.fao.org/docrep/006/AD576E/ad576e00.pdf.

In addition, there are concerns about harvesting crop residues from farm land which may lead to environmental impacts such as erosion, depletion of nutrient pool, and loss of soil organic matter which occurs when above ground portion of the plant is harvested. However, there are cases where due to high demand the price of the biomass increase to such a level that the money earned was more than what farmers had to pay for chemical fertilizers to replace the fertilizers and trace elements found in the crop residues.[86]

The main challenges in establishing circular economy policies in rural regions is to ensure incorporation of resource efficiency, source-efficient and low-carbon economy within the global context of green economy into the current rural development policies.[87] Majority of the policies issued concentrate excessively in urban region while rural areas are neglected or receive only a small trickle of investment and the poor quality of human resources there comprises a barrier for catching up with opportunities that have become available through globalization. The development strategies often focus on urbanization associated with industrialization, while ignoring the demands of the rural economy. Rural areas lack investments in infrastructure, education and skills development so that the development is inhibited and opportunities are forgotten.[88] In addition, there is increasing consensus that government administrative policies and procedures stress technical solutions to social, value based problems. [89] Rural areas often face serious problems in compliance of regulation on waste management. This is mainly due to higher share of rural population, lower living standards, and waste collection services are poorly-developed covering some rural regions. In addition, demographic factors, geographical and socio-economic context influence the disparities between within counties. [90] Waste generated and uncollected from rural areas have been disposed in improper dumpsites polluting the local environment; the rural areas are currently the most vulnerable to illegal dumping. Waste dumping is still an option for those rural localities that have limited access to sanitation services or poor waste management facilities.

6.0 The Way forward

Monetary incentive is identified as the key to success of 3R waste management program in rural areas. Thus, it is crucial to increase the marketability of the recyclables and to encourage the public to voluntarily source separate the recyclables, the following measures should be considered: establish codes of practice for the operators so that accountable and efficient recyclable business transactions are ensured; offer tax privileges similar to those offered to recyclers to the recyclable collectors; increase the number of waste depots and encourage announced scavengers to operate in strategic locations through city facility planning requirements and issuance of operation licenses; and introduce a variable charging rate in waste collection. [91] A systematic management and utilization approach applying the

[86] http://www.fao.org/docrep/006/AD576E/ad576e00.pdf

[87] Scarlat, N., Dallemand, J. F., Monforti-Ferrario, F., & Nita, V. (2015). The role of biomass and bioenergy in a future bioeconomy: policies and facts. *Environmental Development*, *15*, 3-34.

[88] Huynh, T. H., & Nguyen, T. A. T. (2010). Benefits of the 3R approach for agricultural waste management (AWM) in Vietnam: Under the framework of joint project on Asia Resource Circulation Research.

[89] Morrissey, J. (1992, April). Waste management problems in rural areas: limits to citizen participation in decisionmaking. In First National Symposium on Rural Waste Management Issues, University of Tennessee. Retrieved November (Vol. 17, p. 2007).

[90] Apostol, L., & Mihai, F. C. (2012). Rural waste management: challenges and issues in Romania. *Rural waste management: challenges and issues in Romania, Present Environment and Sustainable Development*, *6*(2), 105-114.

[91] Chung, S. S., & Poon, C. S. (2001). A comparison of waste-reduction practices and new environmental paradigm of rural

recent innovations will only help in maintaining rural areas clean but will also provide sufficient energy, manure and raw material for many industries. [92]

Policy interventions are needed to ensure the development of efficient and sustainable 3R in waste management. It is important to ensure circular economy policies incorporated resource efficiency, source-efficient and low-carbon economy within the global context of green economy into the current rural development policies. The introduction of industry friendly policies, feed in tariff, long term RE contracts, government project investment incentives, low price guaranteed, power purchase agreements, connection to national grid and tax exemption of related equipment by some of the countries accelerate the development of biomass utilization.[45] In addition, it is necessary to make the public aware of 3R's through active participation in the system. In practice, system efficiency is directly proportional to the number of participating citizens for 3R system. Without public participation, it may be difficult to maintain cleanliness in a city, and resource recovery systems may become less effective if wastes are poorly separated at the source.[93] The sustainable waste management technologies have brought about a positive change in the sanitation and hygiene, and behavioral changes in the rural people.[94] The authorities need to work in cooperation with the mass media in order to raise the public's awareness and knowledge. The government needs to consider support to improve people's lives in rural communities, eliminate the gaps between urban and rural areas, and reduce medical expenses by improving people's health and fostering a cleaner environment. Most rural areas are characterized by insufficient financial and technical support. Policies need to be developed on financial and technical assistance in order to control and address rural environment pollution in general. [95] The 3R waste management program in rural areas provides opportunity to promote rural development with technology transfer from urban areas or even more advance countries. Effective proliferation of 3R science and technologies , including high-end technologies such as bioenergy, green chemistry and nanotechnology, will require concerted efforts by the governments to identify opportunities for international cooperation and joint ventures, technical transfer and transfer of business models and to create green business. Cooperation between government, scientific and research organizations and private sector is crucial to ensure successful implementation of 3R waste management program in rural areas.

Last, the author would to ask the policy makers:

1) Does the current policy framework stimulate long-term investments on rural resource and waste management?
2) How to strengthen current policy framework, in order to promote 3R and resource efficiency in rural region in the context of 2030 Agenda for Sustainable Development?

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and urban Chinese citizens. Journal of Environmental Management, 62(1), 3-19.

[92] https://www.researchgate.net/publication/265413674_Rural_Solid_Waste_Management_Issues_and_Action

[93] Jibril1, J.D., Sipan, I.A., Shika, S.A., Aminu, D.Y., Abdullah, S. & Shahril Mohd A.R. (2009). Public awareness on 3r's system for an integrated solid waste management in kano state metropolis. Retrieved on 22/09/2016 from http://eprints.utm.my/37863/2/Ibrahim@AtanSipan2012_PublicAwerenesson3R'sSystem.pdf

[94] https://www.researchgate.net/publication/265413674_Rural_Solid_Waste_Management_Issues_and_Action

[95] Huynh, T. H., & Nguyen, T. A. T. (2010). Benefits of the 3R approach for agricultural waste management (AWM) in Vietnam: Under the framework of joint project on Asia Resource Circulation Research.