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SIXTH REGIONAL 3R FORUM IN ASIA AND THE PACIFIC,
16-19 AUGUST 2015, MALE, MALDIVES

Circular Economic Utilization of Agriculture and Biomass Waste – A Potential Opportunity for Asia and the Pacific

(Background Paper for Parallel Roundtable 3 of the Programme)

Final Draft

This background paper has been prepared by Prof. P. Agamuthu, for the Sixth 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.

Sixth Regional 3R Forum in Asia and the Pacific

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Maldives

Background Paper on

Circular Economic Utilization of Agriculture and Biomass Waste – A Potential Opportunity for Asia and the Pacific

(FINAL DRAFT)

Parallel Roundtable-2

Authors: Prof. P. Agamuthu, Institute of Biological Sciences, University of Malaya, Malaysia
Prepared as an input for the Sixth Regional 3R Forum in Asia and the Pacific.

Foreword

The Ha Noi 3R Forum (2013) and Surabaya 3R Forum (2014) organized by UNCRD, recognized the fact that sustainable resource use would be instrumental for Asia-Pacific to ensure prosperity and human development in which natural resources (virgin raw materials, water, minerals, timbers, etc.) are more constrained and the absorptive capacity of natural ecosystems is decreasing rapidly. 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 Sixth Regional 3R Forum in Asia and the Pacific, under the theme of "***3R as an Economic Industry ~ Next Generation 3R Solutions for a Resource Efficient Society and Sustainable Tourism Development in Asia and the Pacific***" will not only call for innovative, effective and smart solutions (policy, institution, technology, infrastructure, financing and partnerships) towards effective implementation of the Ha Noi 3R Declaration (2013-2023), but will also provide a unique opportunity to discuss various economic and employment opportunities in 3R areas keeping in mind the diverse socio-economic situation across the region. This platform is expected to facilitate a high-level policy deliberation and implementation.

The scope of the background paper will be focused primarily on (a) to develop a new and innovative approach to utilize the agricultural and biomass waste, and identify the benefits (environmental, economic and social benefits) of biomass utilization; (b) to suggest necessary policy, governance, financial, institutional, and technological interventions that could help countries harness potential economic utilizations of the agriculture and biomass waste; (c) draw from different international experiences on best practices and model cases and how they can be scaled up in Asia and the Pacific.

The background paper on 'Circular Economic Utilization of Agriculture and Biomass Waste – A Potential Opportunity for Asia and the Pacific' has been prepared and published by UNCRD as an input to the Sixth Regional 3R Forum in Asia and the Pacific at Male, Maldives on 16-19 August 2015. The paper will help drive better understanding of economic utilization of biomass waste through policy consultations.

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Abbreviations and Acronyms

ADB	Asian Development Bank
APEC	Asia Pacific Economic Cooperation
bnl	billion liters
CO2	Carbon Dioxide
CPO	crude palm oil
GDP	Gross Domestic Product
EBHK	Environment Bureau Hong Kong SAR China
EFB	empty fruit bunches
FAOSTAT	Food and Agriculture Organization of the United Nations Statistic Database
GHG	Greenhouse Gas
Gm^3	Cubic gigametre
GNI	Gross national income
GSDR	Global Sustainable Development Report
Gt	Gigatonne
FAO	Food and Agriculture Organization of the United Nations
MF	mesocarp fibre
MSW	Municipal Solid Wastes
MW	Megawatt
nes	Not elsewhere specified (FAO crop category)
OECD	Organisation for Economic Co-operation and Development
UNEP	United Nations Environment Programme
UNSD	United Nations Statistics Division
3R	Reduce, Reuse and Recycle
OPF	oil palm fronds
OPT	oil palm trunks
PKS	palm kernel shells
PKO	palm kernel oil
POME	palm oil mill effluent

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1.0 Executive Summary

Increasing demand and prices coupled with the growing concern on climate change of fossil fuel is likely to alter the current pattern of energy use to biomass energy. Biomass resources are potentially the world's largest and sustainable source of fuel and chemicals. There are concerns of land and resource competition between fuel crop and food crop cultivation. Thus, the utilization of agriculture and biomass waste can be a valuable alternative of fuel crop. The global population increment leads to rise of food demand resulting in increased agriculture production and also agriculture and biomass waste generation.
The Asia Pacific region has continued to demonstrate rapid economic growth, mostly among several industrialized countries in the region, such as Japan, Australia and Republic of Korea and also India and PR China, which have become vast emerging economies. However, majority of the countries in Asia Pacific still rely on agriculture sector. Agriculture sector contributed to more than 10% of GDP in: Afghanistan, Bangladesh, Bhutan, PR China, Fiji, Indonesia, India, Cambodia, Sri Lanka, Mongolia, Nepal, Pakistan, The Philippines, Palau, Thailand, Tuvalu, Vietnam, and Vanuatu. Thus, there is a huge potential of available agriculture and biomass waste resource from the Asia Pacific region. Crop residues are generated from cultivation to postharvest processing, which means large amount of unutilized agriculture and biomass wastes are produced. Based on the estimation in this paper, 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 has the potential to generates millions of dollars just by producing briquette from major crop wastes. It is estimated that there is a potential of 153 million tonnes of briquette (worth USD 23,000 million) from Asia Pacific region in 2013.

This paper examines the key indicators for agriculture and biomass waste generation and explores the economic utilization of agriculture biomass waste and policy consultation on 3R trend, issues and challenges for sustainable biomass- economic utilization in Asia Pacific countries. The objectives of this paper are:

- The generation and utilization of biomass waste and its economic opportunities
- An overview on agricultural and biomass waste management in Asia and the Pacific
- Composition Context: Component and Composition of agricultural waste in Asia and Pacific regions
- Role of 3R in balancing environmental conservation and economic growth through the effective use of agriculture and biomass waste
- A brief analysis on various case studies and model cases on economic utilization of agriculture and biomass waste management, including how various legislative framework, standards, laws and regulations, etc. have contributed in promoting 3Rs in agriculture and biomass waste utilization
- Effective utilization of agriculture and biomass waste in the context of climate change mitigation
- The Way Forward: How circular economic utilization of agriculture and biomass waste can make significant contribution in post-2015 development context

In preparing the paper in accordance with the Terms of Reference for the Consultancy, data were collected and information assembled from a number of departments and agencies, such as the Food and Agriculture Organization of the United Nations (FAO), Food and Agriculture Organization of the United Nations Statistics (FAOSTAT), Asia Pacific Economic Cooperation (APEC), World Bank, United Nations Environment Programme (UNEP), Organization for Economic Co-operation and Development (OECD), Asian Development Bank (ADB), OECD-FAO Agricultural Outlook, Asia Pacific country report, and Environment Bureau or Department of Environment of Asia Pacific countries.

In summary, Asia Pacific region has tremendous economic potential in 3R of agriculture biomass waste. The sustainable production and consumption of biomass is the prerequisite to continuously meeting basic human needs while safeguarding the environment. Policy interventions are needed to ensure the development of efficient and sustainable 3R in agriculture biomass waste. Biomass waste projects have a greater probability of being successfully developed in countries and regions with supportive policy frameworks.

2.0 Overview on Agricultural and Biomass Waste in Asia Pacific Countries

Globally, 998 million tonnes of agricultural waste is produced every year. According to the World Economic Forum, the sectors involved in biomass economy are chemical, oil, biotechnology, forestry, agribusiness, fragrances producers, textiles, building trade and carbon trade with an estimated total net worth over 17 trillion dollars[1]. Currently, the fast emerging biomass trades are woodchips, sawdust and pallets. Agriculture is an important part of the economy in most of the Asia Pacific countries. Besides the crops itself, large quantities of residues are generated every year. Rice, wheat, coconut, sugarcane, banana, cattle, maize, and livestock are just a few examples of crops that generate considerable amounts of residues[2].

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[3]. Biomass and waste make up the vast majority of renewable energy production in Asia and the Pacific[4]. 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. Although residues are used as fuel in some of these countries, but a large amount is just burnt in the field without any waste to wealth output[2].

2.1 Asia and Pacific country's agriculture and biomass waste generation

Virgin wood, energy crop, agriculture residues, food waste and industrial waste are the common biomass source. The composition and component of biomass generated from Asia Pacific varies from country to country. Table 1 shows the agriculture waste generation in Asia Pacific countries. The agriculture waste generated by each country is estimated with the assumption that 15% of total waste generated per capita per day is agriculture waste (Table 2). In some countries, food waste is classified as one of the biomass source generated from MSW. Generally, food waste composition in Asia Pacific countries ranged between 20% and 70% of total MSW composition (Table 2).

[1] http://cnmimarines.s3.amazonaws.com/static/DraftEIS/Appendices/App%20P%20Utilities%20Study/App%20P%20-%20Solid%20Waste%20Study.pdf
[2] http://www.fao.org/docrep/006/AD576E/ad576e00.pdf
[3] http://www.unescap.org/sites/default/files/CH08.PDF
[4] http://www.unescap.org/resources/statistical-yearbook-asia-and-pacific-2014

Table 1: Agriculture Waste Generation in Asia Pacific

Region/Country	Agricultural Waste Generation (kg/cap/day)	References	Region/Country	Agricultural Waste Generation (kg/cap/day)	References
ASEAN+3 / EAS			**PIF**		
Brunei	0.131	World Bank (2012)[i]	Solomon Islands	0.65	World Bank (2012)[i]
Cambodia	NA		Palau	0.038	ADB (2013)[ii]
Indonesia	0.010	World Bank (2012)[i]	Papua New Guinea	0.068	ADB (2013)[iii]
Laos	0.105	World Bank (2012)[i]	Marshall Islands	NA	
Malaysia	0.228	World Bank (2012)[i]	Vanuatu	0.45	World Bank (2012)[i]
Myanmar	0.066	World Bank (2012)[i]	Tonga	0.525	World Bank (2012)[i]
The Philippines	0.075	World Bank (2012)[i]	Tuvalu	0.065	ADB (2013)[iv]
Singapore	0.224	World Bank (2012)[i]	**SAARC**		
Thailand	0.264	World Bank (2012)[i]	Afghanistan	NA	
Vietnam	0.219	World Bank (2012)[i]	Bangladesh	0.065	World Bank (2012)[i]
East Timor	NA	UNSD (2013)[v]	Bhutan	0.255	World Bank (2012)[i]
PR China	0.153	World Bank (2012)[i]	India	0.105	World Bank (2012)[i]
Hong Kong SAR China	0.191	EBHK (2013)[vi]	Maldives	0.33	World Bank (2012)[i]
Macau	0.228	Jin, et al. (2006)[vii]	Pakistan	0.158	World Bank (2012)[i]
Japan	0.257	World Bank (2012)[i]	Sri Lanka	0.765	World Bank (2012)[i]
The Republic of Korea	0.186	World Bank (2012)[i]	**Others**		
PIF			American Samoa	0.149	Malua[viii]
Australia	0.863	ABS (2010)[ix]	Fiji	0.315	World Bank (2012)[i]
Federated States of Micronesia	0.034	KSG (2011)[x]	French Polynesia	NA	
Kiribati	0.050	Karak et al. (2012)[xi]	Guam	NA	
Nauru	NA		New Caledonia	NA	
New Zealand	0.45	World Bank (2012)[i]	Northern Mariana Islands	0.42	DAN (2014)[xii]
Cook Islands	NA		The Republic of Korea	NA	
Niue	NA		Wallis and Futuna	NA	
Tokelau	NA		Mongolia	0.143	World Bank (2012)[i]
Samoa	0.065	ADB (2013)[xiii]			

NA- Data not available

Table 2: IPCC Classification of MSW Composition[5]

Region	Food Waste	Paper/ Card-board	Wood	Textiles	Rubber/ Leather	Plastic	Metal	Glass	Other
Asia									
Eastern Asia	26.2	18.8	3.5	3.5	1	14.3	2.7	3.1	7.4
South-Central Asia	40.3	11.3	7.9	2.5	0.8	6.4	3.8	3.5	21.9
South-Eastern Asia	43.5	12.9	9.9	2.7	0.9	7.2	3.3	4	16.3
Western Asia & Middle East	41.1	18	9.8	2.9	0.6	6.3	1.3	2.2	5.4
Africa									
Eastern Africa	53.9	7.7	7	1.7	1.1	5.5	1.8	2.3	11.6
Middle Africa	43.4	16.8	6.5	2.5		4.5	3.5	2	1.5
Northern Africa	51.1	16.5	2	2.5		4.5	3.5	2	1.5
Southern Africa	23	25	15						
Western Africa	40.4	9.8	4.4	1		3	1		
Europe									
Eastern Europe	30.1	21.8	7.5	4.7	1.4	6.2	3.6	10	14.6
Northern Europe	23.8	30.6	10	2		13	7	8	
Southern Europe	36.9	17	10.6						
Western Europe	24.2	27.5	11						
Oceania									
Australia & New Zealand	36	30	24						
Rest of Oceania	67.5	6	2.5						
America									
North America	33.9	23.2	6.2	3.9	1.4	8.5	4.6	6.5	9.8
Central America	43.8	13.7	13.5	2.6	1.8	6.7	2.6	3.7	12.3
South America	44.9	17.1	4.7	2.6	0.7	10.8	2.9	3.3	13
Caribbean	46.9	17	2.4	5.1	1.9	9.9	5	5.7	3.5

2.2 Identification of the top 10 potential agriculture produce and 10 years generation trend of agriculture biomass from Asia Pacific countries

From a business point of view, supply chain is one of the crucial factors for commercialization of agriculture waste besides technology viability. The biomass generation trend will provide a snapshot of the annual available stock. A country's agriculture GDP is one of the good indicators for agriculture biomass generation. Generally, the agriculture sector has contributed 0.7 to 30% of total GDP for Asia Pacific countries (Table 3). Table 3 showed countries such as Afghanistan, Bangladesh, Bhutan, PR China, Fiji, Indonesia, India, Cambodia, Sri Lanka, Mongolia, Nepal, Pakistan, The Philippines Thailand Tuvalu, Vietnam, and Vanuatu have more than 10% contribution to total GDP and this indicates that majority of Asia Pacific countries have the potential to utilize resources from agriculture waste [6]. Only countries like Brunei Darussalam, Hong Kong SAR China, and Singapore have less than 1% of GDP contribution from agricultural sector. This indicated that agriculture is one of the key economic sectors in most Asia Pacific countries. Unfortunately, the potential of using agricultural by-products in developing countries remains largely untapped. [7] Expanding agricultural production has naturally resulted in increased quantities of livestock waste, agricultural crop residues and agro-industrial by-products which has a huge potential for economic use.

[5] http://www.ricardo-aea.com/cms/assets/Blog-files--images/whatawaste.pdf
[6] http://data.worldbank.org/indicator/NV.AGR.TOTL.ZS
[7] http://www.fftc.agnet.org/library.php?func=view&id=20110720170759&type_id=1

Table 3: Agriculture GDP (% of total GDP) (World Bank Statistics)[6]

Country Name	Agriculture GDP (% of total GDP), 2013	Country Name	Agriculture GDP (% of total GDP), 2013
Afghanistan	23.97	Marshall Islands	NA
American Samoa	NA	Mongolia	16.47
Australia	2.45	New Caledonia	NA
Bangladesh	16.28	Nepal	35.10
Brunei Darussalam	0.73	New Zealand	NA
Bhutan	17.08	Northern Mariana Islands	NA
PR China	10.01	Pakistan	25.11
Fiji	12.22	The Philippines	11.23
Micronesia, Fed. Sts.	NA	Palau	5.33
Guam	NA	Papua New Guinea	NA
Hong Kong SAR, China	0.06	Korea, Dem. Rep	NA
Indonesia	14.43	. French Polynesia	NA
India	17.95	Singapore	0.03
Japan	NA	Solomon Islands	NA
Cambodia	33.52	Thailand	11.98
Kiribati	NA	Timor-Leste	NA
Korea, Rep.	2.34	Tonga	NA
Sri Lanka	10.76	Tuvalu	22.16
Macao SAR, China	NA	Vietnam	18.38
Maldives	NA	Vanuatu	27.98
Malaysia	9.31	Samoa	NA

NA- Data not available

Based on FAOSTAT, the top 10 commodities produced by countries in Asia Pacific are listed in Table 4, which acts as an indicator for potential available biomass source for 3R use[8]. The biomass source listed in Table 4 is ranked from 1 to 10 based on production value. The top 10 commodities ranking by countries show that major agriculture commodities in Asia Pacific regions are rice, wheat, coconut, sugarcane, banana, cattle, maize, and livestock. These are the potential biomass for economic utilization with suitable technology.

[8] http://faostat3.fao.org/browse/rankings/commodities_by_country/E

Table 4: Top 10 Country's highest agriculture producer (Continued)

ASEAN+3 / EAS	Top 10 country's highest agriculture producer*
Brunei	**Meat indigenous, chicken**; Eggs, hen, in shell; Vegetables, fresh nes; Fruit, fresh nes; Cassava; Cucumbers and gherkins; Rice, paddy; Vegetables, leguminous nes; Pineapple; Banana
Cambodia	**Rice, paddy**; Cassava ; Maize; Vegetables, fresh nes; Sugar cane; Banana; Soybeans; Meat indigenous, pig; Beans, dry; Fruit, fresh nes
Indonesia	**Rice, paddy**; Sugar cane; Oil, palm; Cassava; Coconut; Maize; Palm kernels; Banana; Fruit, tropical fresh nes; Rubber, natural
Laos	**Rice, paddy**; Maize; Cassava; Sugar cane; Vegetables, fresh nes; Banana; Watermelons; Coffee, green; Sweet potatoes; Meat indigenous, pig
Malaysia	**Oil, palm**; Palm kernel; Rice, paddy; Meat indigenous, chicken; Rubber, natural; Sugar cane; Eggs, hen, in shell; Coconut; Vegetables, fresh nes; Banana
Myanmar	**Rice, paddy**; Sugar cane; Vegetables, fresh nes; Beans, dry; Maize; Fruit, fresh nes; Groundnuts, with shell; Milk, whole fresh cow; Onions, dry; Meat indigenous, chicken
The Philippines	**Sugar cane**; Rice, paddy; Coconut; Banana; Maize; Vegetables, fresh nes; Fruit, tropical fresh nes; Pineapple; Cassava; Meat indigenous, pig
Singapore	**Eggs, hen, in shell**; Vegetables, fresh nes; Spinach; Eggs, other bird, in shell; Cabbage and other brassicas; Lettuce and chicory; Coconut; Mushrooms and truffles; Tomatoes; Meat indigenous, cattle
Thailand	**Sugar cane; Rice, paddy**; Cassava; Maize; Rubber, natural; Mangoes, mangosteens, guava; Pineapples; Fruit, tropical fresh nes; Oil, palm; Banana
Vietnam	**Rice, paddy; Sugar cane**; Cassava; Vegetables, fresh nes; Maize; Meat indigenous, pig; Fruit, fresh nes; Banana; Sweet potatoes; Coffee, green
East Timor	**Rice, paddy; Maize**; Roots and tubers, nes; Vegetables, fresh nes; Cassava; Meat, nes; Sweet potatoes; Beans, dry; Meat indigenous, pig; Coconut
PR China	**Maize; Rice, paddy**; Vegetables, fresh nes; Sugar cane; Wheat; Potatoes; Sweet potatoes; Watermelons; Tomatoes; Meat indigenous, pig
Hong Kong SAR China	**Spinach**; Vegetables, fresh nes; Meat, game; Meat indigenous, pig; Lettuce and chicory; Onions, shallots, green; Fruit, fresh nes; Cucumbers and gherkins; Spices, nes; Cabbages and other brassicas
Macau	**Meat indigenous**, chicken; Eggs, hen, in shell; Pepper (piper spp.); Meat indigenous, cattle; Meat indigenous, pig
Japan	**Rice, paddy**; Milk, whole fresh cow; Sugar beet; Vegetables, fresh nes; Eggs, hen, in shell; Potatoes; Cabbage and other brassicas; Meat indigenous, chicken; Meat indigenous, pig; Sugar cane

*In sequence from highest to lowest

Table 4: Top 10 country's highest agriculture producer (Continued)

PIF	Top 10 country's highest agriculture producer*
Australia	**Wheat**; Sugar cane; Milk, whole fresh cow; Barley; Rapeseed; Meat indigenous, cattle; Sorghum; Cottonseed; Grapes ; Potatoes
Federated States of Micronesia	**Coconut**; Cassava; Vegetables, fresh nes; Sweet potatoes; Banana; Meat indigenous, pig; Plantains; Fruit, fresh nes; Meat indigenous, cattle; Eggs, hen, in shell
Kiribati	**Coconut**; Roots and tubers, nes; Banana; Vegetables, fresh nes; Taro (cocoyam); Fruit, tropical fresh nes; Meat indigenous, pig; Meat indigenous, chicken; Eggs, hen, in shell; Nuts, nes
Nauru	**Coconut**; Vegetables, fresh nes; Fruit, tropical fresh nes; Meat indigenous, pig; Eggs, hen, in shell; Meat indigenous, chicken
New Zealand	**Milk, whole fresh cow**; Meat indigenous, cattle; Potatoes; Wheat; Apple ; Meat indigenous, sheep; Barley; Kiwi fruit; Grapes; Onions, shallots, green
Cook Islands	**Coconut**; Roots and tubers, nes; Vegetables, fresh nes; Cassava; Sweet potatoes; Papaya; Meat indigenous, pig; Fruit, fresh nes; Mangoes, mangosteen, guava; Tomatoes
Niue	**Coconut**; Taro (cocoyam); Fruit, fresh nes; Sweet potatoes Yams; Vegetables, fresh nes; Fruit, tropical fresh nes; Lemons and limes; Banana; Meat indigenous, pig
Tokelau	**Coconut**; Roots and tubers, nes; Fruit, tropical fresh nes; Meat indigenous, pig; Banana; Eggs, hen, in shell; Meat indigenous, chicken
Samoa	**Coconut**; Banana; Taro (cocoyam); Fruit, tropical fresh nes; Pineapples; Meat indigenous, pig ;Mangoes, mangosteen, guava; Papayas; Roots and tubers, nes; Yams
Solomon Islands	**Coconut**; Sweet potatoes; Yams; Taro (cocoyam); Oil, palm; Fruit, fresh nes; Palm kernels; Pulses, nes; **Vegetables**, fresh nes; Cocoa, beans
Palau	NA
Papua New Guinea	**Coconut**; Banana; Fruit, fresh nes; Sweet potatoes; Oil, palm; Meat, game; Yams; Sugar cane; Roots and tubers, nes; Vegetables, fresh nes
Marshall Islands	**Coconut**
Vanuatu	**Coconut**; Roots and tubers, nes; Banana; Vegetables, fresh nes; Fruit, fresh nes; Meat indigenous, pig; Milk, whole fresh cow; Meat indigenous, cattle; Groundnuts, with shell; Cocoa, beans
Tonga	**Coconut**; Pumpkins, squash and gourds; Cassava; Sweet potatoes; Vegetables, fresh nes; Yams; Taro (cocoyam); Plantains; Roots and tubers, nes; Lemons and limes
Tuvalu	**Coconut**; Vegetables, fresh nes; Fruit, tropical fresh nes; Banana; Roots and tubers, nes; Meat indigenous, pig; Meat indigenous, chicken; Eggs, hen, in shell; Honey, natural

*In sequence from left to right: highest to lowest

Table 4: Top 10 country's highest agriculture producer (Continued)

SAARC	Top 10 country's highest agriculture producer*
Afghanistan	**Wheat**; Milk, whole fresh cow; Grapes; Vegetables, fresh nes; Barley; Rice, paddy; Maize; Potatoes; Melons, other (inc.cantaloupes); Milk, whole fresh sheep
Bangladesh	**Rice, paddy**; Potatoes; Sugar cane; Milk, whole fresh goat; Jute; Vegetables, fresh nes; Maize; Onions, dry; Fruit, tropical fresh nes; Wheat
Bhutan	**Rice, paddy**; Maize; Oranges; Potatoes; Milk, whole fresh cow; Roots and tubers, nes; Apples Fruit, citrus nes; Sugar cane; Areca nuts
India	**Sugar cane**; Rice, paddy; Wheat; Milk, whole fresh buffalo; Milk, whole fresh cow; Potatoes; Vegetables, fresh nes; Banana; Maize; Tomatoes
Maldives	**Banana**; Coconut; Vegetables, fresh nes; Fruit, fresh nes; Roots and tubers, nes; Nuts, nes; Papayas; Meat, nes; Chillies and peppers, green; Tomatoes
Nepal	**Rice, paddy**; Vegetables, fresh nes; Sugar cane; Potatoes; Maize Wheat; Milk, whole fresh buffalo; Fruit, fresh nes Milk, whole fresh cow; Millet
Pakistan	**Sugar cane**; Milk, whole fresh buffalo; Wheat; Milk, whole fresh cow; Rice, paddy; Maize; Cottonseed; Potatoes; Cotton lint; Mangoes, mangosteen, guava
Sri Lanka	**Rice, paddy**; Coconut; Sugar cane; Plantains; Tea Cassava; Milk, whole fresh cow; Maize; Rubber, natural; Onions, dry
Other	
American Samoa	**Taro (cocoyam)**; Coconut; Yams; Banana; Cucumbers and gherkins; Pineapples; Meat indigenous, pig; Cabbages and other brassicas; Vegetables, fresh nes; Eggplants (aubergines)
Fiji	**Sugar cane**; Coconut; Cassava; Taro (cocoyam); Milk, whole fresh cow; Meat indigenous, chicken; Sweet potatoes; Meat indigenous, cattle; Vegetables, fresh nes; Eggs, hen, in shell
French Polynesia	**Coconut**; Fruit, fresh nes; Roots and tubers, nes; Pineapples; Cassava; Sugar cane; Eggs, hen, in shell; Fruit, tropical fresh nes; Meat indigenous, pig
Guam	**Coconut**; Roots and tubers, nes; Watermelons; Vegetables, fresh nes; Fruit, fresh nes; Eggs, hen, in shell; Cucumbers and gherkins; Banana; Melons, other (inc.cantaloupes); Tomatoes
New Caledonia	**Coconut**; Yams; Vegetables, fresh nes; Meat indigenous, cattle; Eggs, hen, in shell; Meat indigenous, pig; Fruit, fresh nes; Sweet potatoes; Potatoes; Cassava
Wallis and Futuna	**Banana**; Fruit, tropical fresh nes; Coconut; Cassava; Taro (cocoyam); Roots and tubers, nes; Vegetables, fresh nes; Yams; Meat indigenous, pig; Fruit, fresh nes
Mongolia	**Wheat**; Milk, whole fresh cow; Potatoes; Milk, whole fresh goat; Meat indigenous, sheep; Meat indigenous, cattle; Meat indigenous, goat Milk, whole fresh sheep; Carrots and turnips; Vegetables, fresh nes

*In sequence from left to right: highest to lowest

2.2.1 Biomass generation trend, 2003 to 2013

Constant supply of biomass is crucial, e.g. Biomass-based power systems require a constant supply of the appropriate type of biomass fuel over the project life to ensure constant supply of electricity to the consumer. Thus, one of the factors which decides whether the biomass is suitable for economic use is the trend of generation rate. Based on the top 10 agriculture commodity production listed in Table 4 above, the number one agriculture production (Table 4 highlight in **bold**) is chosen to showcase the 10 years biomass generation trend between 2003 to 2013. Basically, the main agriculture productions in Asia pacific are paddy rice, wheat, coconut, sugarcane, banana, cattle, maize, and livestock.

Banana

Banana cultivation is the main agriculture production in Maldives and Wallis and Futuna. The main biomass generated from the banana sector is rejected fruits, peels and pseudostems. The biomass generated from banana cultivation is estimated by multiplying waste generation ratio in Table 5 with yearly coconut production (Figure 1). The banana waste generation from Maldives is on a decreasing trend which indicates that there may be a concern with constant supply of biomass.

Table 5: Banana biomass waste generation ratio

RESIDUE	RATIO
Rejected fruits, the peels and the pseudostems	30% of the total production[9]

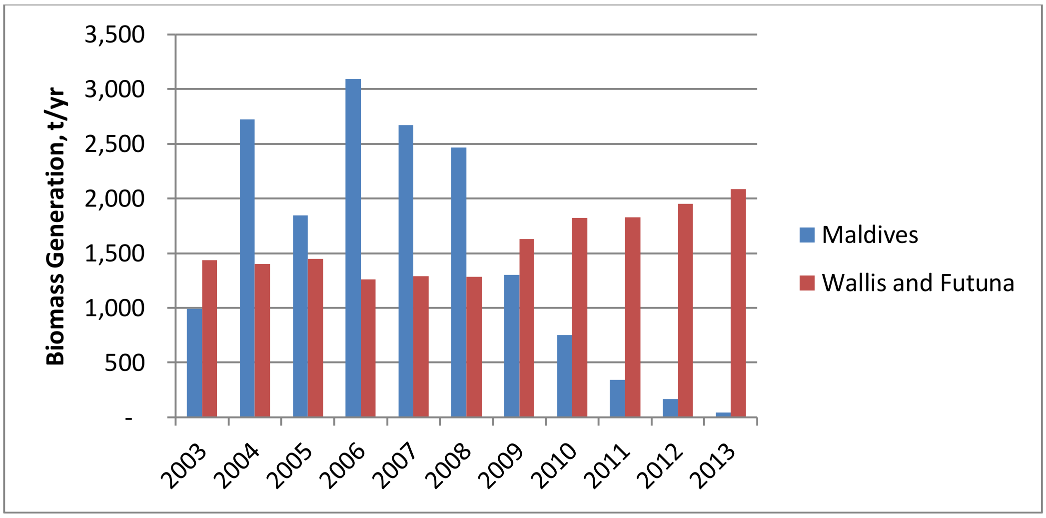

Figure 1: Banana Biomass Generation in Maldives and Wallis and Futuna

Coconut

According to FAOSTAT, in 2012 coconut production was the highest agriculture producer in Federated States of Micronesia, Kiribati, Nauru, Cook Islands, Niue, Tokelau, Samoa, Solomon Islands, Papua New Guinea, Marshall Islands, Vanuatu, Tonga, Tuvalu, French Polynesia, Guam, and New Caledonia. The main biomass generated from coconut sector was coconut husk and shell. The biomass generated from coconut plantation is estimated by multiplying the husk and shell ratio (Table 6) with yearly coconut production (Figure 2).

[9] http://www.sciencedirect.com/science/article/pii/S136403210900241X

Table 6: Coconut biomass waste generation ratio	
RESIDUE	**RATIO**
Husk	33% of coconut wet weight[10]
Shell	12% of coconut wet weight[9]

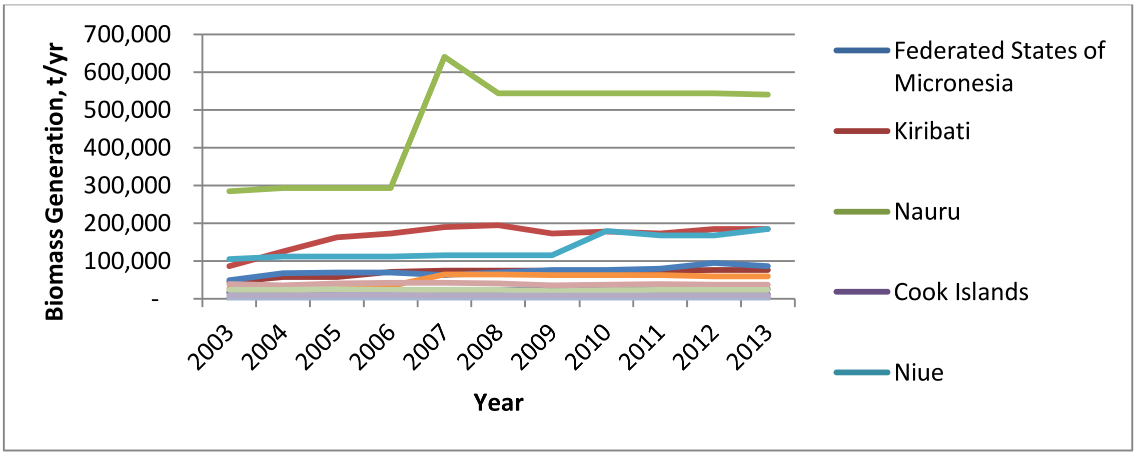

Figure 2: Coconut Biomass Generation in Federated States of Federated States of Micronesia, Kiribati, Nauru, Cook Islands, Niue, Tokelau, Samoa, Solomon Islands, Papua New Guinea, Marshall Islands, Vanuatu, Tonga, Tuvalu, French Polynesia, Guam, and New Caledonia

Livestock

According to FAOSTAT, in 2012 livestock production was the highest agriculture producer in Brunei, Singapore, Macau, and New Zealand. The top agriculture production in Brunei is chicken for meat consumption while in Singapore it is chicken for egg consumption. Therefore, the manure accumulation rate varies due to the different farm management. The biomass manure generated from livestock is estimated by multiplying manure accumulation rate (Table 7) with yearly livestock population (Figure 3). The manure generation rate from Brunei, Singapore and Macau are relatively low and this indicates that only small scale biomass utilization can be developed in these countries.

Table 7: Livestock manure generation ratio

Animal	Manure Accumulation, tonnes per animal per year
Cattle	2.2[11]
Chicken (Broiler)	0.024[12]
Chicken (Layer)	0.047[11]

[10] http://www.fao.org/docrep/006/AD576E/ad576e00.pdf
[11] http://nutrients.soil.ncsu.edu/manures/Final-Tables-%28Ag-Chem-Manual-Version%29.pdf
[12] http://ipmwww.ncsu.edu/agchem/chptr10/1011.pdf

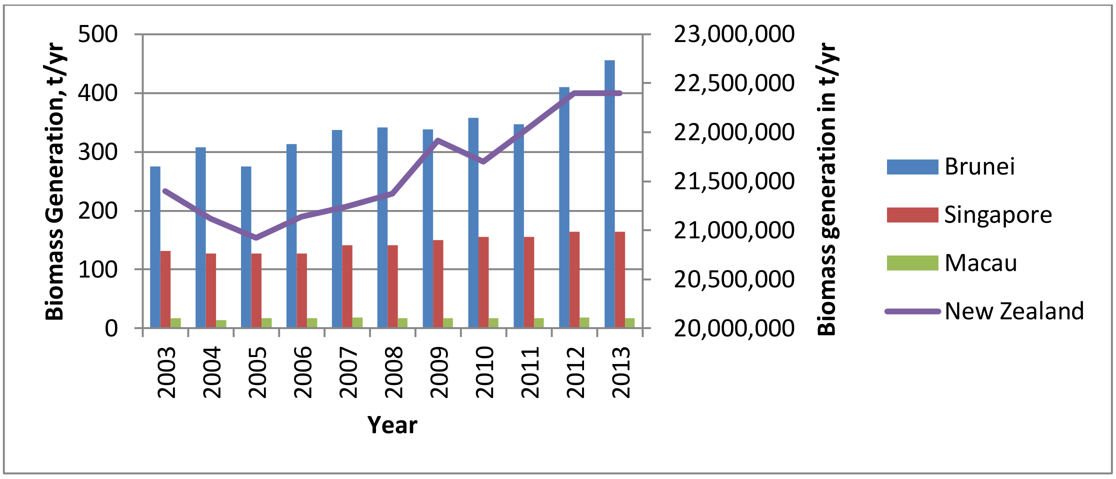

Figure 3: Livestock Biomass Generation in Brunei (Broiler Chicken), Singapore (Layer Chicken), Macau (Broiler Chicken), and New Zealand (Cattle).

Maize

According to FAOSTAT, in 2012 maize production was the highest agriculture producer in PR China. The biomass generated from maize cultivation is stalk, leaf, cob and husk. The biomass generated from maize cultivation is estimated by multiplying crop residues ratio (Table 8) with yearly maize planting area (Figure 4).

Table 8: Maize biomass waste generation ratio

RESIDUE	RATIO
Stalk, leaf, cob, and husk	An acre yielding 120 bushels of corn will produce 6,000 pounds of residue[13]

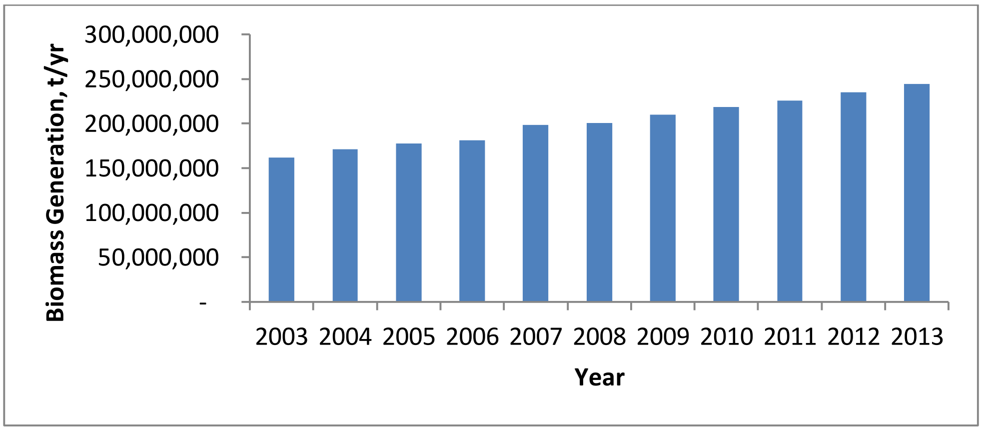

Figure 4: Maize Biomass Generation in PR China

Oil Palm

Six types of oil palm biomass are produced as by-products of the palm oil industry: oil palm fronds (OPF), oil palm trunks (OPT), empty fruit bunches (EFB), palm kernel shells (PKS), mesocarp fibre (MF) and palm oil mill effluent (POME). In the plantations, oil palm fronds (OPF) are available throughout the year as they are regularly cut during harvesting of fresh fruit bunches (FFBs) and pruning of the palm trees. Additional fronds as well as oil palm trunks (OPT) become available in the plantations during the replanting of oil palm trees every

[13] http://ohioline.osu.edu/anr-fact/0010.html

25 to 30 years. In the mills, empty fruit bunches (EFBs) remain after the removal of the palm fruits from the fruit bunches. Mesocarp fibre (MF) and palm kernel shells (PKS) are recovered during the extraction of crude palm oil (CPO) and palm kernel oil (PKO), respectively. In addition, palm oil mill effluent (POME) accumulates as a liquid biomass at the mills[14].

The biomass generated from oil palm sector is estimated by multiplying residue ratio (Table 9) with yearly oil palm FFB production. In this estimation only EFBs, PKS, MF and POME is considered. The estimation excluded OPF and OPT as the vast majority of the oil palm biomass (especially OPF and OPT) being generated today is returned to the field to release its nutrients and replenish the soil. The biomass returned to the field as organic fertilizer plays an important role to ensure the sustainability of FFBs yields[13]. However, to estimate of how much biomass is generated from pruning activities, the amount of pruned OPF is determined. According to MPOB, 12 tonnes of dry OPF is generated per hectare, 75% of oil palm planted areas in Malaysia required pruning and only 50% were removed from the plantation. Based on this, the OPF generated from year 2001 to 2013 was calculated based on the total plantation acreage every year. Figure 5 showed the total biomass generation from oil palm in Malaysia.

Table 9: Biomass Waste Generation Ratio

RESIDUE	RATIO
EFB	21.14% of FFBwet weight[15]
MF	12.72% of FFB wet weight[14]
PKS	5.67% of FFB wet weight[14]
POME	67% of FFB wet weight (Source from MPOB)

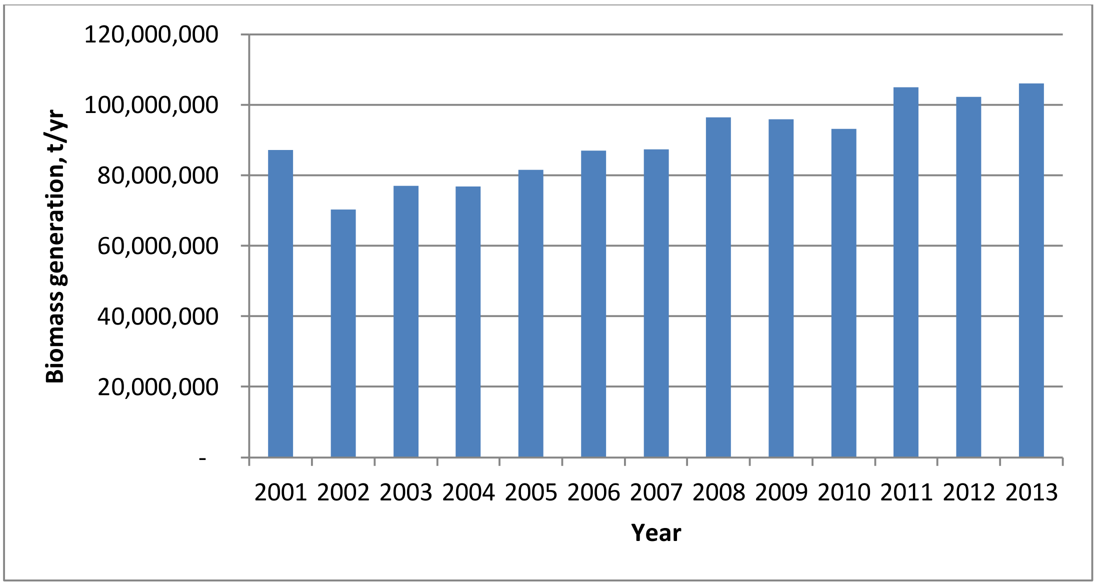

Figure 5: Oil Palm Biomass Generation in Malaysia (Source from MPOB)

Paddy Rice

According to FAOSTAT, in 2012 rice production was the highest agriculture producer in Cambodia, Indonesia, Laos, Myanmar, Vietnam, East Timor, Japan, Bangladesh, Bhutan, Nepal and Sri Lanka. Rice husk is the major potential source for biomass in Asia Pacific. Paddy straw and rice husk are the main residues from paddy cultivation that are generated

[14] http://www.sciencedirect.com/science/article/pii/S1364032112004248.
[15] http://library.utem.edu.my/index2.php?option=com_docman&task=doc_view&gid=3287&Itemid=342

during the harvesting and milling processes[16]. The paddy straw is left in the paddy field and rice husk is discharged by landfill and open burning. The biomass generated from paddy sector is estimated by multiplying husk and straw residue ratio (Table 10) with yearly paddy production (Figure 6).

Table 10: Rice biomass waste generation ratio

Residue	**Ratio**
Rice Husk	22% of paddy wet weight[17]
Straw	40% of paddy wet weight [15]

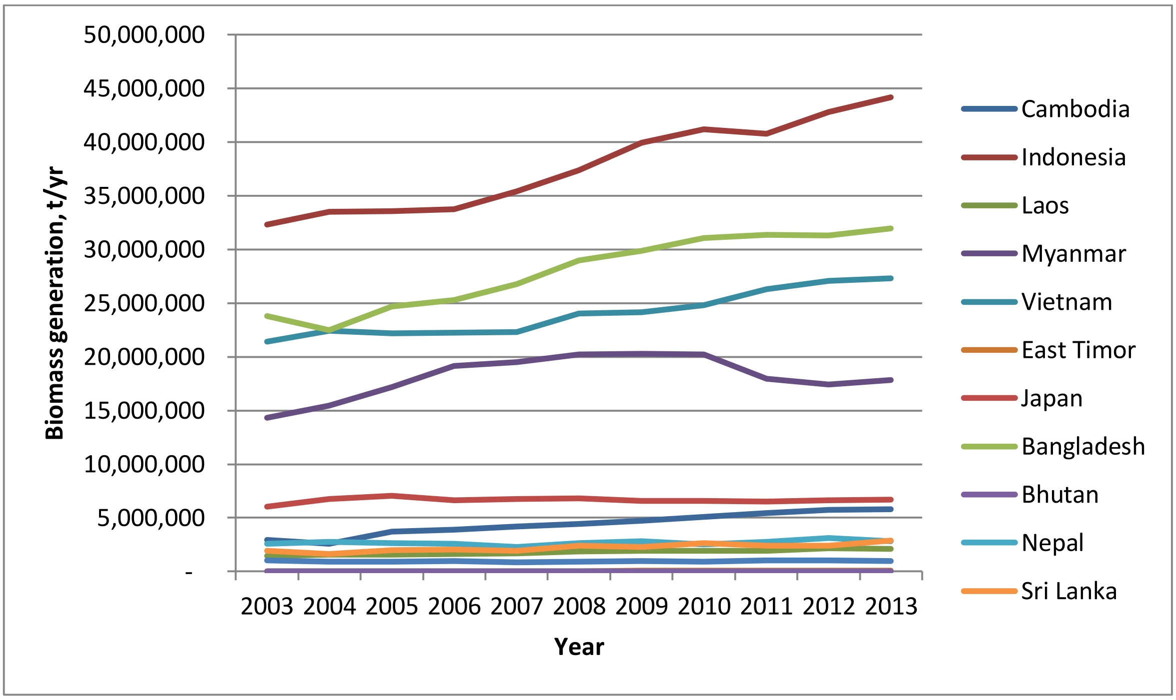

Figure 6: Paddy Rice Biomass Generation in Cambodia, Indonesia, Laos, Myanmar, Vietnam, East Timor, Japan, Bangladesh, Bhutan, Nepal and Sri Lanka

Sugarcane

According to FAOSTAT, in 2012 sugar cane production was the highest agriculture producer in The Philippines, Thailand, India, Pakistan and Fiji. Sugarcane cultivation produced granulated sugar, bagasse and dry leaves and cane tops. Dry leaves and cane tops waste were often left in the field to replenish the soil nutrient. Sugarcane bagasse is the fibrous waste that remains after recovery of sugarcane juice via crushing and extraction[18]. The biomass generated from sugarcane sector is estimated by multiplying the bagasse ratio (Table 11) with yearly sugarcane production (Figure 7).

Table 11: Sugarcane biomass waste generation ratio

RESIDUE	**RATIO**
Bagasse	28% of sugarcane wet weight[19]

[16] http://www.sciencedirect.com/science/article/pii/S1364032112004248.
[17] http://www.doa.gov.my/c/document_library/get_file?uuid=8b3bb7ed-4363-4471-b760-6f528e6273dc&groupId=38371
[18] http://www.sciencedirect.com/science/article/pii/S1364032112004248.
[19] http://www.doa.gov.my/c/document_library/get_file?uuid=6e657e5c-21c4-4967-8e84-8b3a67dae933&groupId=38371

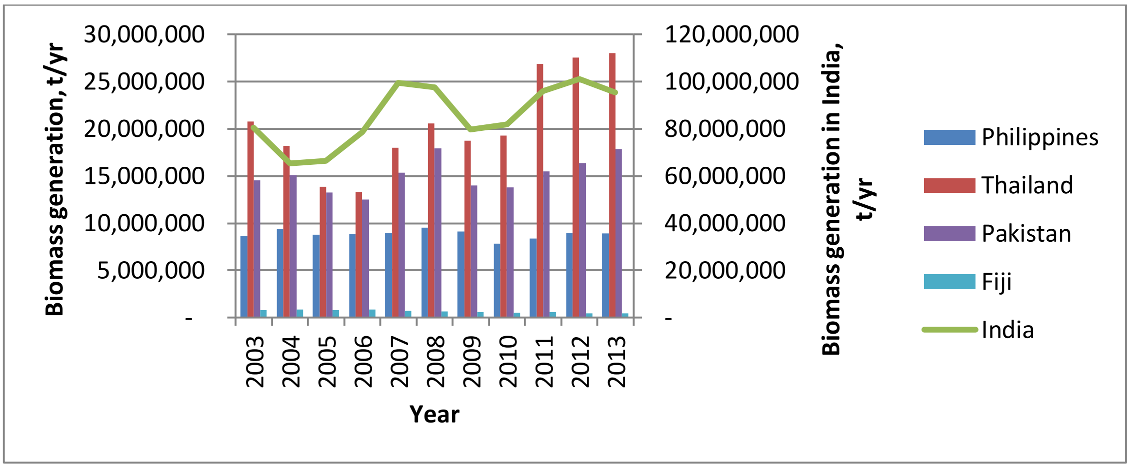

Figure 7: Sugarcane Biomass Generation in The Philippines, Thailand, India, Pakistan and Fiji

Wheat

According to FAOSTAT, in 2012 wheat production was the highest agriculture producer in Australia, Afghanistan, and Mongolia. The main residue from wheat cultivation is wheat straw. The biomass generated from wheat sector is estimated by multiplying straw to grain ratio (Table 12) with yearly wheat production yield (Figure 8).

Table 12: Wheat biomass waste generation ratio

RESIDUE	RATIO
Wheat straw	Straw to Grain Ratio 1.30: 1.0[20]

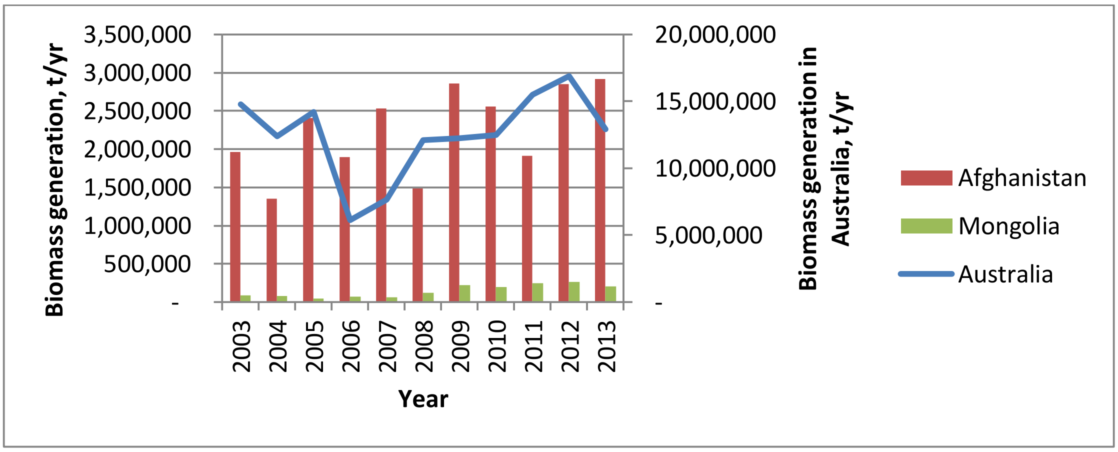

Figure 8: Wheat Biomass Generation in Australia, Afghanistan, and Mongolia

[20] http://www.gov.mb.ca/agriculture/business-and-economics/financial

2.3 Monetary value generated from biomass utilization

Briquette market is used as a benchmark in this paper 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[21,22]. 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 agriculture waste generated are used to produce low energy briquette (selling price = USD 150 per tonne) (Table 13)[23]. 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. 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[24].

Table 13: 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]**
Maldives	Banana waste	46	11	1,575
Wallis and Futuna	Banana waste	2,086	474	71,100
PR China	Maize waste	244,386,028	55,542,279	8,331,341,863
Federated States of Micronesia	Coconut waste	25,650	5,830	874,432
Kiribati	Coconut waste	76,500	17,386	2,607,955
Nauru	Coconut waste	1,215	276	41,420
Cook Islands	Coconut waste	833	189	28,381
Niue	Coconut waste	1,440	327	49,091
Tokelau	Coconut waste	1,935	440	65,966
Samoa	Coconut waste	85,500	19,432	2,914,773
Solomon Islands	Coconut waste	184,500	41,932	6,289,773
Papua New Guinea	Coconut waste	540,000	122,727	18,409,091
Marshall Islands	Coconut waste	11,250	2,557	383,523
Vanuatu	Coconut waste	184,500	41,932	6,289,773
Tonga	Coconut waste	58,500	13,295	1,994,318
Tuvalu	Coconut waste	990	225	33,750

[21] http://www.fao.org/docrep/006/ad579e/ad579e00.pdf
[22] http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2010409
[23] http://www.gvepinternational.org/sites/default/files/financial_institutions_market_study_in_east_africa_2010_gvep_international.pdf
[24] T http://www.oeaw.ac.at/forebiom/WS2lectures/02-01-TKMUN.pdf

French Polynesia	Coconut waste	36,900	8,386	1,257,955
Guam	Coconut waste	22,500	5,114	767,045
New Caledonia	Coconut waste	8,550	1,943	291,477
Brunei	Livestock waste	456	104	15,545
Singapore	Livestock waste	165	37	5,608
Macau	Livestock waste	18	4	597
New Zealand	Livestock waste	22,400,668	5,091,061	763,659,150
Malaysia	Oil palm waste	96,215,331	21,867,121	3,280,068,102
Cambodia	Paddy rice	5,821,800	1,323,136	198,470,455
Indonesia	Paddy rice	44,193,420	10,043,959	1,506,593,849
Laos	Paddy rice	2,117,300	481,205	72,180,682
Myanmar	Paddy rice	17,835,540	4,053,532	608,029,773
Vietnam	Paddy rice	27,304,361	6,205,536	930,830,474
East Timor	Paddy rice	53,940	12,259	1,838,864

a: FAOSTAT(Source: 25)

b: Compaction ratio assumed to be 4.4 (Source: 26)

c: Briquette assumed to sell at USD100 (Source: 27)

Table 13: 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]**
Japan	Paddy rice	6,669,960	1,515,900	227,385,000
Bangladesh	Paddy rice	31,930,000	7,256,818	1,088,522,727
Bhutan	Paddy rice	48,813	11,094	1,664,066
Nepal	Paddy rice	2,792,792	634,725	95,208,813
Sri Lanka	Paddy rice	2,864,853	651,103	97,665,430
The Philippines	Sugar cane	8,924,720	2,028,345	304,251,818
Thailand	Sugar cane	28,026,880	6,369,745	955,461,818
India	Sugar cane	95,536,000	21,712,727	3,256,909,091
Pakistan	Sugar cane	17,849,972	4,056,812	608,521,773
Fiji	Sugar cane	448,000	101,818	15,272,727
Australia	Wheat	12,913,400	2,934,864	440,229,560
Afghanistan	Wheat	2,920,618	663,777	99,566,515
Mongolia	Wheat	208,134	47,303	7,095,482
Grand Total		**673,694,540**	**153,112,395**	**22,966,859,307**

a: FAOSTAT(Source: 28)

b: Compaction ratio assumed to be 4.4 (Source: 29)

c: Briquette assumed to sell at USD100 (Source: 30)

[25] http://faostat3.fao.org/browse/G1/*/E
[26] http://article.sapub.org/10.5923.j.ijee.20120201.04.html
[27] http://www.biomassbriquettesystems.com/listings?country=121&state_province=All
[28] http://faostat3.fao.org/browse/G1/*/E
[29] http://article.sapub.org/10.5923.j.ijee.20120201.04.html.
[30] http://www.biomassbriquettesystems.com/listings?country=121&state_province=All

3.0 Economics of Biomass Utilization/ Business opportunity

Agriculture waste and biomass utilization is identified as a counter measure against climate change. The growth and the economic utilization of biomass, for power generation as an alternative to fossil fuels has been on the rise and is being considered seriously. The economic and environmental effects of biomass production on the agricultural sector are diverse and location-specific. Generally, there are two types of biomass utilization: energy utilization and material utilization via varies technologies (Figure 9) [31]. In Asia Pacific region biomass is often used as a fuel (e.g. firewood, bio-diesel, bio-kerosene, and ethanol) and as raw material for pulp and paper, lumber, furniture, fodder, fertilizer, fiber, feedstock and construction industries. Other examples of current biomass utilization are as follows:

i. Coconut coir dust used to retain moisture in the soil, straw as a growing medium for mushroom, coconut husks as a growing medium for orchids, packing material
ii. Rice husk can be burned as fuel with the ash being used by the steel industry as a source of carbon and as insulator
iii. Rice straw can be used as animal bedding (fiber) and subsequently as part of compost (fertilizer)
iv. Crop waste can be used as a feedstock for biogas generation (fuel), with the sludge being used as fertilizer.

Conventional crops such as corn and sugarcane are unable to meet the global demand of bioethanol production due to their primary value of food and feed. Therefore, lignocellulosic substances such as agricultural wastes are attractive feed stocks for bioethanol production.[32] Rice straw is one of the abundant lignocellulosic waste materials in the world. Rice production is a major commodity in Asia Pacific. In Asia rice straw is a major field-based residue that generated about 667.59 million MT yearly which potentially produce 281.72 billion litres. Ethanol from biomass has become an increasingly popular alternative to gasoline. The high cellulose and hemicellulose content in rice straw that is readily hydrolyzed into fermentable sugars make it a potential feedstock for fuel ethanol production.[33] Other than producing ethanol from rice straw, it is often used for fuel, feedstuff, fertilizer, fiber board, energy generation, conversion to sugar syrup, yeast protein, paper pulp and industrial raw material.[34]

It must be emphasized; biomass production for energy should avoid any competition with food production. The efficacy, safety and cost-efficiency of biomass production for fuel products must be considered, keeping a balance between energy production and food production. The use of agricultural wastes for biomass conversion to energy, especially in many developing countries in Asia, must be explored fully to benefit the region's mostly agricultural producing countries that generate lots of agricultural wastes.[35]

[31] http://www.toyo-eng.com/jp/en/products/environment/baiomass/
[32] Sarkar, N., Ghosh, S. K., Bannerjee, S., & Aikat, K. (2012). Bioethanol production from agricultural wastes: An overview. Renewable Energy, 37(1), 19-27.
[33] Binod, P., Sindhu, R., Singhania, R. R., Vikram, S., Devi, L., Nagalakshmi, S., ... & Pandey, A. (2010). Bioethanol production from rice straw: an overview. *Bioresource technology*, *101*(13), 4767-4774.
[34] http://www.carrb.com/84rpt/StrawUses.htm
[35] http://www.fftc.agnet.org/activities.php?func=view&id=20110719095639

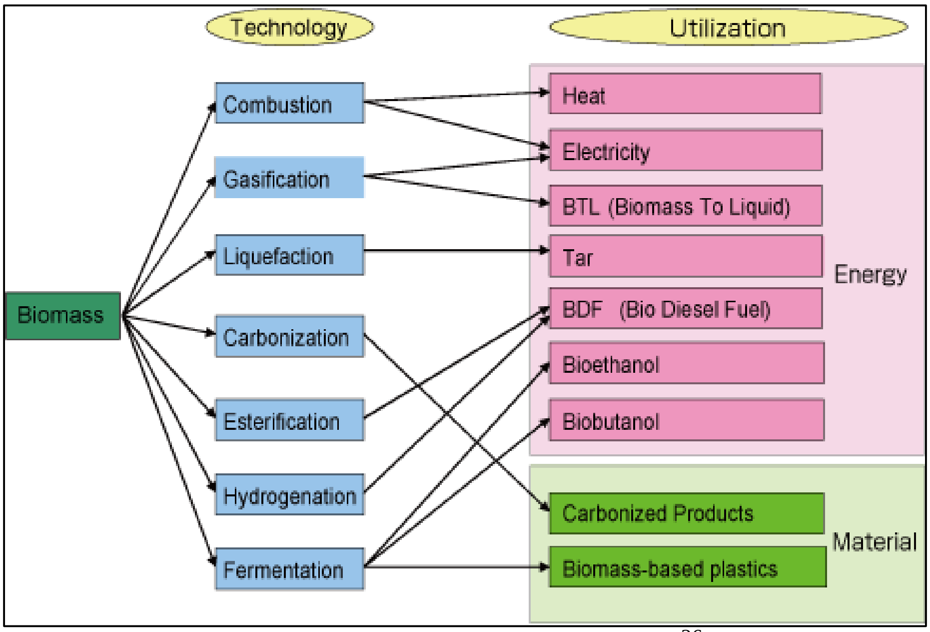

Figure 9: Major biomass utilization[36]

The chemical, physical and biological variations of different types of agriculture waste have become one of the key factors that determine the economic potential of biomass (Table 14). Biomass characteristic, technology availability, financial support, and government policy are the key factors in implementing recycling of agriculture and biomass waste. Thus, the biomass utilization varies from country to country. The governments and local authorities especially in developing countries are largely unaware of the immense potential of converting waste agricultural biomass into energy. While agriculture is a major economic sector in most developing countries, the potential of using agricultural by-products remains largely untapped. For example, in one country there was a policy related to distribution of subsidized fertilizer which required farmers not to remove the waste agricultural biomass from the fields.[37] In addition to this, technical knowledge and capacity are also lacking. Good technologies have been developed for converting waste agricultural biomass into a source of energy, but most of these technologies have not been demonstrated in developing countries. Hence there are concerns about their suitability and workability. Thus it is important to have government programs that ensure a balance between biomass production and food production. In addition, government incentives and policy advocacies are necessary to advance R&D initiatives especially on bioenergy.[38]

[36] http://www.toyo-eng.com/jp/en/products/environment/baiomass/
[37] www.unep.org/ietc/Portals/136/Other documents/PolicyBriefs/10052013_WAB Policy brief.pdf
[38] http://www.fftc.agnet.org/library.php?func=view&id=20110720170759&type_id=1

Table 14: Potential economic products from biomass waste[39]

Conversion Process	Biomass Waste	Product
Bio-reduction	Pineapple leaves Sugarcane residues Wheat straw Cotton gin	Animal feed, industrial absorbents and additives for beverages Wheat straw polypropylene Pelletized feedstock, fertilizer
Bio-refinery system	Rice husk	Silica, Metal Finishing, Water Soluble Oil & Synthetic Lubricant
	Sugarcane bagasse Wheat straw	Lumber materials Panel boards
Decortication	Abaca Leaves Coconut husk Pina leaves	Fiber craft, cordage, textile and fabrics, pulp, and specialty papers, Coconut fiber Rope and twine, brooms and brushes, doormats, rugs, mattresses and upholstery, often in rubberized coir pads Elegant pina cloth
Hot melt process	Kenaf Fibers, Sugarcane bagasse	Paper and packaging materials
Hydro-separation	Sugar mill boiler ash from bagasse	Filtration materials and absorbent products
Molding	Oil Palm fruit residues Sugarcane bagasse	Biodegradable packaging materials Paper and paper wares
Pulping	Kenaf Fibers	Soundproofing systems, thermal insulators
Tuxying	Abaca leaves	Abaca leaf sheath
Twining	Coconut Coir	Coconut twines

Currently biomass provides approximately 10 percent of the global energy supply, of which two-thirds is used in developing countries for cooking and heating[40]. Figure 10 shows the global fuel mix for decade. Generally, it is forecasted that biomass fuel growth will remain constant until 2040. In Asia Pacific, only 7% of total energy used is from biomass (Table 15). This forecast was made after the Rio 20+ meeting and the future outlook for biomass fuel is not very bright compared to nuclear and other renewable energy. However, it is estimated that by 2020 biomass economy will be worth about 300 billion dollars worldwide[41].

[39] http://www.toyo-eng.com/jp/en/products/environment/baiomass/
[40] http://biomassmagazine.com/articles/9444/iea-task40-biomass-provides-10-percent-of-global-energy-use
[41] http://www.uncrd.or.jp/content/documents/Hanoi%203R%20Forum%20RT2_Agamuthu.pdf

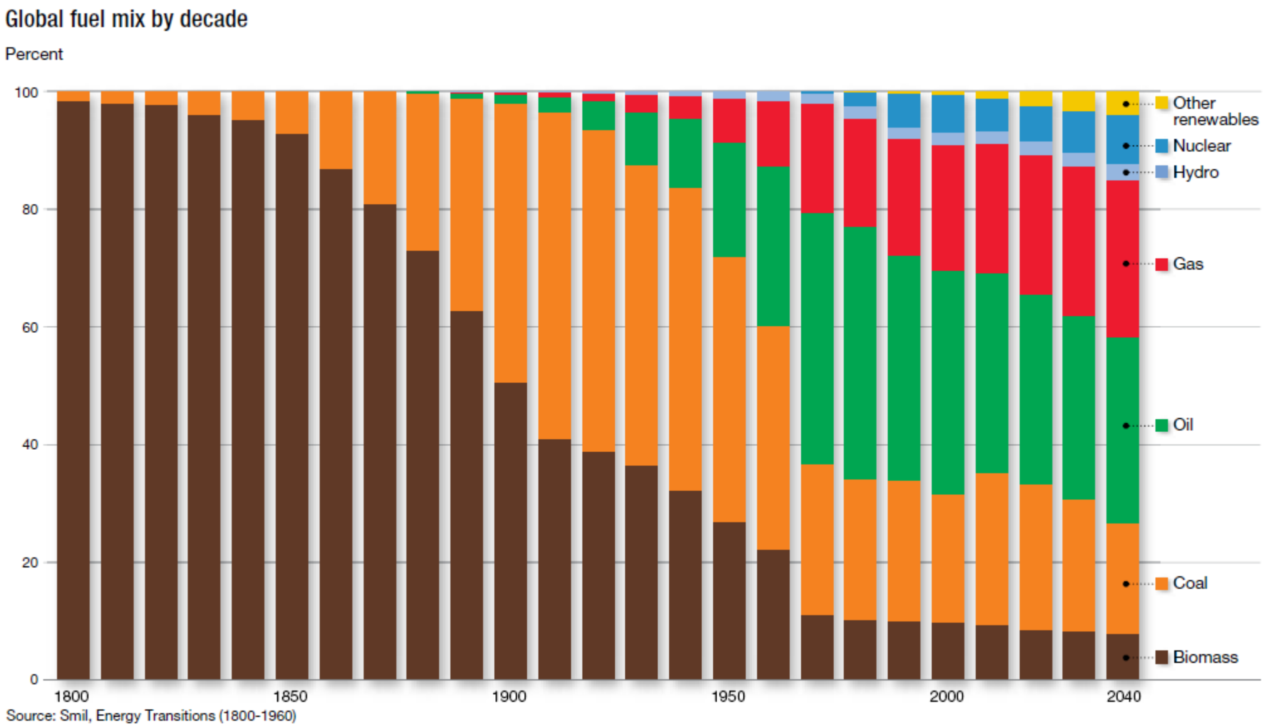

Figure 10: Global Fuel Mix by Decade[42]

Table 15: Asia Pacific Energy Demand[37]

Regions	Energy Demand (Quadrillion BTUs unless otherwise indicated) 1990	2000	2010	2025	2040	Average Annual Change 2010-2025	2025-2040	2010-2040	% Change 2010-2025	2025-2040	2010-2040	Share of Total 2010	2025	2040
ASIA PACIFIC														
Primary	90	125	201	289	316	2.5%	0.6%	1.5%	44%	10%	58%	100%	100%	100%
Oil	28	43	56	77	88	2.2%	0.9%	1.5%	39%	14%	58%	28%	27%	28%
Gas	6	12	22	42	57	4.5%	2.1%	3.3%	94%	36%	164%	11%	14%	18%
Coal	32	42	89	118	102	1.9%	-0.9%	0.5%	33%	-13%	15%	44%	41%	32%
Nuclear	3	5	6	14	27	5.9%	4.3%	5.1%	136%	89%	345%	3%	5%	9%
Biomass/Waste	19	21	23	25	23	0.7%	-0.5%	0.1%	11%	-7%	3%	11%	9%	7%
Hydro	1	2	4	6	8	3.5%	1.5%	2.5%	69%	25%	110%	2%	2%	2%
Other Renewables	0	1	2	6	11	7.2%	3.8%	5.5%	184%	74%	394%	1%	2%	3%
End-Use Demand (including electricity)														
Total End-Use	76	98	151	213	228	2.3%	0.5%	1.4%	41%	7%	52%	100%	100%	100%
Residential/Commercial	29	33	42	54	58	1.7%	0.5%	1.1%	30%	7%	39%	28%	26%	26%
Transportation	11	18	26	42	53	3.1%	1.6%	2.4%	59%	27%	102%	17%	20%	23%
Industrial	36	47	82	117	117	2.3%	0.0%	1.2%	41%	0%	42%	55%	55%	51%
Memo: Electricity Demand	7	12	24	43	54	3.9%	1.6%	2.7%	77%	27%	125%	16%	20%	24%
Electricity Generation Fuel	23	41	77	122	146	3.2%	1.2%	2.2%	60%	19%	90%	38%	42%	46%
CO_2 Emissions, Billion Tons	5.3	7.4	13.2	18.2	18.1	2.2%	-0.1%	1.1%	38%	-1%	37%			

Recently, global attention has been focused on the production and the use of bioethanol and biodiesel from biomass as promising carbon-neutral fuels. There are competing uses for biomass resources because of their economic and environmental value for a variety of purposes. During the past few years, there has been increased interest in biomass resources as a feedstock for transportation fuel. The production of biomass energy is also raising farm income and revitalizing rural communities.[43] However, the use of agricultural resources for biomass production, particularly bio-fuel, competes with their use for food output and can

[42] http://www.exxonmobil.com/Corporate/Files/news_pub_eo2013.pdf
[43] http://www.oecd.org/greengrowth/sustainable-agriculture/48289829.pdf

negatively affect land use patterns, food supply, food security and food prices. Due to a surge in food price caused by biofuel production in the initial stages, recent biofuels are developed not to compete with food resources which highlight the potential of 3R in agriculture waste.[44] Agriculture waste is the byproduct from agriculture production that can be diverted from landfill, farm land, or even burning activities to valuable economic product and at the same time not compete with food production.

The flow chart (Figure 11) shows the major conversion technologies available for converting biomass waste to energy while Table 16, shows the biofuel production from agriculture waste in Asia Pacific country (Figure 11).[45] APEC report shows that potentially 1.7 billion tonnes of agriculture and biomass waste is available for biofuel production, which is equivalent to 245 million tonnes of gasoline (Table 16).

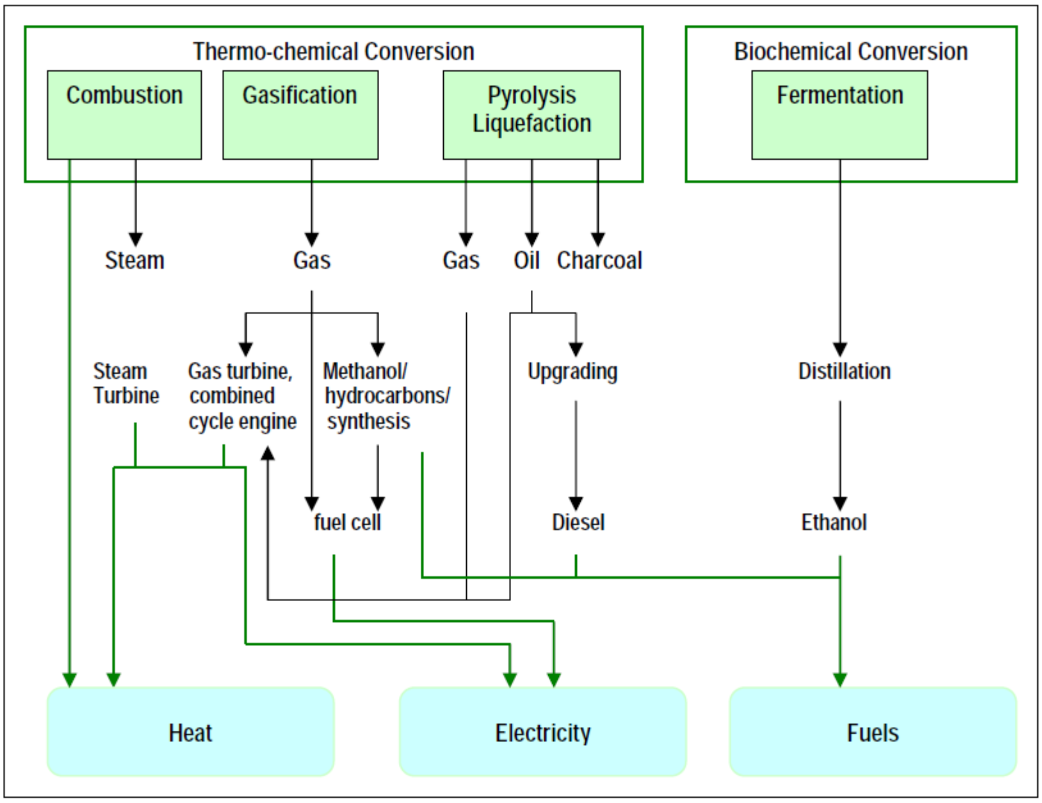

Figure 11: Conversion routes for agricultural biomass waste to energy (does not include the routes for energy crops and animal husbandry waste) [42]

[44] http://www.toyo-eng.com/jp/en/products/environment/baiomass/
[45] http://www.unep.org/ietc/Portals/136/Publications/Waste%20Management/WasteAgriculturalBiomassEST_Compendium.pdf

Table 16: Asia Pacific biofuel production from various types of feedstock [46]

Economy	Feedstock Type	Resource Availability ('000 tonnes)	Ethanol Potential (hm3)	Gasoline Equivalent ('000 tonnes)	Gasoline Consumption ('000 tonnes)*	Share of Gasoline Consumption (%)	Crude Oil Import ('000 tonnes)*	Share of Crude Oil Import (%)
Australia	crop, forest, and primary mill residues; urban wood waste	36,700	11.0	5,299	14,520	36.5	20,070	26.4
Brunei					196			
Canada	crop, forest, and primary mill residues; hog fuel piles	71,000	21.3	10,261	29,751	34.5	45,336	22.6
Chile	primary mill residues	3,254	0.9	434	2,081	20.8	10,219	4.2
China	crop, forest, and primary mill residues	788,000	236.0	113,689	46,097	246.6	126,817	89.6
Hong Kong					325		352	
Indonesia	crop residues; sugar cane bagasse; oil-palm, rubber, and coconut residues	74,000	22.2	10,695	12,942	82.6	20,829	51.3
Japan	crop and forest residues; urban wood waste	15,000	4.5	2,168	44,391	4.9	207,266	1.0
Korea	crop and forest residues	13,100	3.9	1,879	6,969	27.0	113,234	1.7
Malaysia	crop residues; sugar cane bagasse; oil-palm and wood-processing residues	32,392	9.7	4,673	7,756	60.2	7,885	59.3
Mexico	crop, logging, and primary mill residues	74,500	22.4	10,767	27,704	38.9		
New Zealand	crop, logging, and primary mill residues; horticultural and urban wood waste	5,500	1.7	795	2,325	34.2	4,488	17.7
PNG	logging, oil-palm, and coconut residues; sugar cane bagasse	N/A	N/A	N/A	N/A	N/A	435	N/A
Peru	crop, logging, and oil-palm residues; sugar cane bagasse	N/A	N/A	N/A	771	N/A	4,809	N/A
The Philippines	crop, logging, and coconut residues; sugar cane bagasse	18,000	5.4	2,601	4,111	63.3	10,681	24.4
Russia	crop and forest residues	100,000	30.0	14,452	26,260	55.0		
Singapore					727		54,786	
Chinese Taipei	crop residues	1,900	0.6	275	7,845	3.5	54,035	0.5
Thailand	crop residues; sugar cane bagasse; oil-palm and coconut residues	47,800	14.3	6,889	5,280	130.5	39,815	17.3
United States	crop, forest, primary mill, and secondary mill residues; urban wood waste	324,448	97.3	46,873	373,930	12.5	538,651	8.7
Viet Nam	crop, wood-processing, and coconut residues; sugar cane bagasse	93,000	27.9	13,440	2,546	527.9		
APEC Total		**1,698,594**	**509.0**	**245,189**	**616,527**	**39.8**	**1,259,708**	**19.5**

Note: Possible additional resources from dedicated energy crops are not included.

Biofuel production from agriculture waste

World ethanol price increased by more than 30% in 2010, in the context of new commodity price spike for ethanol feedstock, mainly sugar and maize, and firm energy prices. Similarly, the world biodiesel price also increased in 2010 due to rising rapeseed and other vegetable oil price and high crude oil price. It is estimated that Brazil, India and PR China, will account for 85% of the 71 billion liters (bnl) ethanol production in the developing world by 2020[38]. PR China, Mexico, Thailand, Australia, and Indonesia are well established sugar cane producers and among the top 10 suppliers in the world. Indonesia, Malaysia, and Thailand are the world's largest palm oil producers. The Philippines is the world's largest coconut oil producer. Given the favourable climate conditions and significant labour supply, Southeast Asian economies have announced feedstock production expansion and large-scale biofuel

[46] http://www.nrel.gov/docs/fy09osti/43710.pdf

programs.[38]

In PR China, the much of ethanol produced is used for non-fuel use in the food and chemical industry. Asia could also become a notable ethanol producer. In Thailand, production is expected to grow by 1.5 bnl to reach about 2.2 bnl by 2020. The biodiesel production in Malaysia should further increase to about 1.3 bnl in 2020. Other East Asian countries like Thailand, Indonesia and India will also significantly increase their domestic biodiesel production, each to about 1-1.5 bnl. However, most of this would be for domestic consumption due to ambitious domestic biodiesel blending targets.[47] The projection of increased biodiesel and bioethanol production indicates the increased demand for biomass feedstock (Table 17 and 18). Besides oil crops, agriculture waste is identified as a good alternative feedstock for bioethanol production (Table 19).[48]

Table 17: Regional ethanol production, use and trading projection

	PRODUCTION (MN L)		Growth (%)[1]	DOMESTIC USE (MN L)		Growth (%)[1]	FUEL USE (MN L)		Growth (%)[1]	SHARE IN GAZOLINE TYPE FUEL USE(%)				NET TRADE (MN L)[2]	
										Energy Shares		Volume Shares			
	Average 2008-10est.	2020	2011-20	Average 2008-10est.	2020	2011-20	Average 2008-10est.	2020	2011-20	Average 2008-10est.	2020	Average 2008-10est.	2020	Average 2008-10est.	2020
NORTH AMERICA															
Canada	1 483	2 359	3.08	1 530	2 408	0.57	1 324	2 202	0.66	2.2	3.4	3.3	5.0	-48	-49
United States	42 857	63 961	1.89	44 663	73 474	3.32	42 338	70 484	4.13	5.3	8.4	7.7	12.1	-1 806	-9 514
of which second generation	3	4 368	..	..	..	..	..	..	..	..	..	..	..	..	..
WESTERN EUROPE															
EU(27)	5 651	16 316	10.50	7 186	18 690	7.31	4 687	16 173	8.09	2.3	8.2	3.4	11.8	-1 536	-2 374
of which second generation	0	1 626	..	..	..	..	..	..	..	..	..	..	..	..	..
OCEANIA DEVELOPED															
Australia	299	492	0.75	299	492	0.75	299	492	0.75	1.0	1.6	1.5	2.3	0	0
OTHER DEVELOPED															
Japan	307	946	13.28	704	1 715	5.81	90	1 687	18.26	0.0	0.0	0.0	0.0	-398	-769
of which second generation	0	593	..	..	..	..	..	..	..	..	..	..	..	..	..
South Africa	384	421	0.44	93	47	0.07	0	0	4.62	0.0	0.0	0.0	0.0	291	374
SUB-SAHARIAN AFRICA															
Mozambique	25	59	6.17	21	29	0.56	0	9	1.48	0.0	3.3	0.0	4.8	4	29
Tanzania	29	55	7.14	33	52	5.97	1	19	37.15	0.1	2.7	0.2	4.0	-4	3
LATIN AMERICA AND CARRIBBEAN															
Argentina	303	470	2.20	240	402	0.97	110	272	1.47	1.6	3.4	2.3	5.0	63	68
Brazil	26 091	50 393	5.98	22 589	40 695	5.15	21 061	38 383	7.28	47.3	67.1	57.2	75.3	3 502	9 698
Columbia	310	587	5.63	353	385	-1.20	315	347	-1.33	4.5	5.6	6.6	8.1	-44	202
Mexico	64	90	2.29	168	275	2.29	0	0	..	0.0	0.0	0.0	0.0	-104	-184
Peru	71	217	2.55	25	175	1.47	20	174	1.48	1.1	8.2	1.7	11.7	46	41
ASIA AND PACIFIC															
China	7 189	7 930	0.71	7 041	6 685	0.18	2 024	2 975	4.34	1.8	1.5	2.6	2.3	148	1 246
India	1 892	2 204	1.78	2 109	2 818	1.48	183	800	1.48	0.9	3.0	1.4	4.5	-217	-614
Indonesia	210	248	0.99	169	168	0.15	0	0	6.77	0.0	0.0	0.0	0.0	41	80
Malaysia	66	74	0.80	87	85	0.09	0	0	5.38	0.0	0.0	0.0	0.0	-21	-11
Philippines	118	603	12.74	263	450	3.49	193	350	-0.30	2.1	3.0	3.1	4.4	-144	153
Thailand	672	2 111	9.32	599	1 602	8.72	424	1 389	4.54	3.8	11.2	5.6	15.9	73	509
Turkey	64	88	0.98	108	142	3.43	50	87	5.23	0.6	0.9	0.9	1.3	-44	-54
Viet Nam	150	423	4.75	95	334	14.84	8	255	25.87	0.1	3.5	0.2	5.1	55	90
TOTAL	**91 657**	**154 962**	**3.98**	**91 821**	**155 983**	**3.95**	**73 742**	**136 123**	**4.45**	**5.3**	**8.8**	**7.7**	**12.6**	**3 792**	**11 012**

1. Least-squares growth rate (see glossary).
2. For total net trade exports are shown.

.. Data not available.

Source: OECD and FAO Secretariats.

StatLink http://dx.doi.org/10.1787/888932427664

[47] http://www.fao.org/fileadmin/user_upload/newsroom/docs/Outlookflyer.pdf

[48] http://www.sciencedirect.com/science/article/pii/S0961953403001375

Table 18: Regional biodiesel production, use and trading projection

	PRODUCTION (MN L)		Growth (%)[1]	DOMESTIC USE (MN L)		Growth (%)[1]	SHARE IN DIESEL TYPE FUEL USE(%)				NET TRADE (MN L)[2]	
							Energy Shares		Volume Shares			
	Average 2008-10est.	2020	2011-20	Average 2008-10est.	2020	2011-20	Average 2008-10est.	2020	Average 2008-10est.	2020	Average 2008-10est.	2020
NORTH AMERICA												
Canada	236	594	6.57	202	672	3.65	0.4	1.6	0.5	2.0	34	-78
United States	1 658	4 002	2.24	909	4 757	5.39	0.3	1.3	0.4	1.6	748	-755
WESTERN EUROPE												
European Union	9 184	17 610	5.17	10 802	19 794	4.75	3.9	6.6	4.9	8.1	-1 619	-2 184
of which second generation	0	2 190	..	..	..	..	..	..	..	..	..	..
OCEANIA DEVELOPED												
Australia	627	719	1.14	627	719	1.14	2.7	2.7	3.4	3.3	0	0
OTHER DEVELOPED												
South Africa	57	100	3.65	57	100	3.66	0.0	0.0	0.0	0.0	0	0
Sub-Saharian Africa												
Mozambique	51	80	1.85	0	32	1.47	0.0	0.0	0.0	0.0	51	48
Tanzania	50	61	-0.13	0	58	159.22	0.0	0.0	0.0	0.0	50	3
LATIN AMERICA AND CARIBBEAN												
Argentina	1 576	3 231	3.36	247	656	2.13	1.9	4.0	2.3	5.0	1 329	2 576
Brazil	1 550	3 139	2.66	1 550	3 139	2.66	2.7	4.0	3.4	5.0	0	0
Columbia	302	768	4.88	228	430	4.77	1.6	4.0	2.0	5.0	75	338
Peru	174	130	3.74	174	315	4.35	1.6	4.0	2.0	5.0	0	-185
ASIA AND PACIFIC												
India	179	3 293	26.87	241	3 291	26.87	0.0	0.1	0.0	0.1	-61	2
Indonesia	369	811	6.65	272	1 100	14.37	1.3	5.7	1.7	7.0	98	-289
Malaysia	765	1 331	3.96	206	500	8.35	1.6	4.0	2.0	5.0	559	831
Philippines	158	271	3.97	158	200	1.70	0.0	0.0	0.0	0.0	0	71
Thailand	584	1 697	8.15	561	1 200	5.67	1.9	4.0	2.3	5.0	24	497
Turkey	62	52	5.54	62	187	3.39	0.0	0.0	0.0	0.0	0	-135
Viet Nam	8	100	17.76	0	100	17.93	0.0	0.0	0.0	0.0	8	0
TOTAL	**17 608**	**41 917**	**5.99**	**16 314**	**40 938**	**6.44**	**2.0**	**3.8**	**2.5**	**4.7**	**2 111**	**2 737**

1. Least-squares growth rate (see glossary).
2. For total net trade exports are shown.
.. Data not available.

Source: OECD and FAO Secretariats.

StatLink http://dx.doi.org/10.1787/888932427683

Table 19: Regional potential bioethanol production

Potential bioethanol production

	Africa	Asia	Europe	North America	Central America	Oceania	South America	Subtotal
From waste crop (GL)								
Corn	2.17	6.82	1.09	0.21	1.21	0.01	2.87	14.4
Barley	0.12	0.83	1.35	0.005	0.01	0.13	0.03	2.46
Oat	0.002	0.04	0.30	0.01	0.0004	0.001	0.03	0.38
Rice	0.71	14.4	0.02	0.63	0.05	0.02	0.93	16.8
Wheat	0.55	6.78	2.70	0.02	0.16	0.54	0.60	11.3
Sorghum	1.55	0.37	0.003	—	0.09	0.0004	0.12	2.14
Sugar cane	0.23	0.82	—	—	0.18	0.0001	0.37	1.59
Subtotal (A)	5.33	30.1	5.45	0.87	1.70	0.70	4.95	49.1
From lignocellulosic biomass (GL)								
Corn stover	—	9.75	8.23	38.4	—	0.07	2.07	58.6
Barley straw	—	0.61	13.7	3.06	0.05	0.60	0.09	18.1
Oat straw	—	0.07	1.79	0.73	0.009	0.12	0.06	2.78
Rice straw	5.86	186.8	1.10	3.06	0.77	0.47	6.58	204.6
Wheat straw	1.57	42.6	38.9	14.7	0.82	2.51	2.87	103.8
Sorghum straw	—	—	0.10	1.89	0.31	0.09	0.41	2.79
Bagasse	3.33	21.3	0.004	1.31	5.46	1.84	18.1	51.3
Subtotal (B)	10.8	261.0	63.8	63.2	7.42	5.70	30.2	442.0
Total (A+B)	16.1	291.1	69.2	64.0	9.12	6.39	35.1	491.1

Business opportunities
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. [49] The Southeast Asian biomass and waste-to-power market is in the growth stage. It is estimated that the region produces nearly 230 million tonnes of feedstock annually. The abundance of available feedstock is attracting investor interest. One of the main drivers in biomass market is the increased concerns on agriculture waste management. [50] 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, the biggest challenges of the biomass market identified are the complex bureaucratic structure, logistic and unsystematic biomass market.[45]

For instance, Thailand was an early mover in identifying the biomass business opportunities and had formulated policies to encourage biomass projects through the Very Small Power Producers (VSPPs) scheme introduced in 2001 by providing adder price of 0.3 Baht/kWh (1 USD ≈ 35 Baht).[51] In 2004, the Small Power Producers Program (SPP) was initiated by National Energy Policy Council which allowed small rural industries engaged in power production to sell excess energy generation back to electric grid. The country has set an ambitious target to achieve 3.7 gigawatts (GW) of biomass capacity by 2022.[45] Sugar cane, rice, oil palm and wood are four major biomass wastes in Thailand with potential yield of 80 million tonnes per year. The biomass is commonly used generate energy to meet rural household energy needs, processing industries and liquid biofuel production. [52] Rice straw burning is a common traditional management of rice waste. However, with the establishment of National Fire and Haze Control Plan of Action for 2013 had promoted the alternative use of rice straw.[53] Even though, Thailand is the leader in biomass investments in Southeast Asia; however, by 2019, Indonesia is anticipated to race ahead with large-scale biomass projects.[46] In Indonesia, power companies from other countries have been entering the local biomass power market. In 2012, the Indonesian state-owned public power corporation PLN agreed to construct a biomass power plant that would generate power by incinerating wood chips in Sumatra together with the US company General Electric (GE).[45] The Philippines government also aims to encourage more biomass-based projects by introducing a slew of policies and schemes to boost the industry.

Another country that shows interest in biomass business is Malaysia which aims to become the biomass hub for the region. The palm oil industry contributed to RM 90 billion to the country's gross national income (GNI) generating around 83 million dry tonnes of biomass in 2012.[45,54] There are existing markets between Malaysia and countries like Japan, PR China, Thailand and Europe in exporting Palm Kernel Shell (PKS) for power generation purpose. The demand for PKS is high within the domestic market as it is the main feedstock for bioenergy within local industries. With the latest biomass policy- *National Biomass Strategy 2020: New wealth creation for Malaysia's palm oil industry*, there are increasing number of international investors and technology partners who are interested in developing bio-pellets

[49] http://www.eco-business.com/news/southeast-asia-set-biomass-boom/
[50] http://www.prnewswire.com/news-releases/strategic-analysis-of-the-biomass-and-waste-to-power-market-in-southeast-asia-300104537.html
[51] http://www.sciencedirect.com/science/article/pii/S0306261909002566
[52] http://www.aist-riss.jp/old/lca/ci/activity/project/biomass/report/041028_paper/thailand_paper.pdf
[53] http://www.nies.go.jp/chiiki/tsukuba_workshop_files/2nd_06272013/402_thongboonchoo.pdf
[54] http://www.mybiomass.com.my/biomass-in-malaysia/

(made primarily of a biodegradable polymer), bioethanol, and others. Majority of the biomass in Malaysia are for export instead of domestic use.[55, 56] Most of the local oil palm plantation still returns the raw biomass back into the field for nutrient replenishment. There are a few biomass power plants that are burning Empty Fruit Bunches (EFB) and Palm Kernel Shell (PKS) to generate electricity but majority are for the use within the oil palm mill. Other uses that exist on a small scale today include composting, wood products, animal feed, long dried fibers and eco-paper.

In 2002 the Singapore government laid out the Singapore Green Plan 2012, which aims to achieve a sustainable society.[57] Singapore identified clean technology as a key driver of economic growth. Between 2007 and 2011, the government allocated S$895 million to fund R&D, innovation and manpower development in the sector. The country launched a woody biomass and steam cogeneration plant (fired by 20 % biomass and 80% coal) in Jurong Island which can generate roughly 60 tonnes of process steam per hour under the first phase of the project. [58,59] The plant also used palm kernel shells left over after the palm oil has been squeezed out for the biomass. The second phase of the project is estimated to be completed in 2016, which will be the largest energy-from-waste plant in Singapore, and will be capable of producing 140 tonnes per hour of steam using industrial and commercial waste. The main challenge faced is the limited available feedstock which Singapore has and to rely on importing biomass from Malaysia and Indonesia. According to Singapore's National Environment Agency the electricity generated will feed into Singapore's electricity grid.

Countries like Thailand, The Philippines, Malaysia and Singapore have established the basic policy structure for the utilization of biomass for energy use which provides a platform for investor to tap into the biomass market. Some of the identified business opportunities:

- Supply of conversion technologies for agriculture biomass. Simple combustion technologies or cogeneration is suitable especially at rural region.
- Support / consultancy for companies that want to invest. Many companies are unaware of the opportunities they have with their waste materials and residues. Consultancy companies can easily support these feasibility studies and fund requests from banks or other funders.
- Material handling technology and knowledge transfer of biomass handling (logistics and pre-treatment of biomass).

Challenges in agriculture waste utilization:
It is clear that with regard to 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[60]

[55] https://biobs.jrc.ec.europa.eu/sites/default/files/generated/files/policy/Biomass%20Strategy%202013.pdf
[56] http://biomass-sp.net/about/biomass-in-malaysia/
[57] http://www.asiabiomass.jp/english/topics/1111_03.html
[58] http://www.eco-business.com/news/southeast-asia-set-biomass-boom/
[59] http://www.sembcorp.com/en/esg-edsc-green_solutions-eefr.aspx
[60] http://www.fao.org/docrep/006/AD576E/ad576e00.pdf.

4.0 Case study

Box 4.1 Cambodia Case Study[61]

Rice husk biomass energy project
Cambodia is an "agricultural based economy" and the main production is paddy rice. It is estimated that Cambodia has the potential to generate 18,852 GWh/year through biomass energy. Cambodia has a low level of electrification. In 2011, the electricity consumption reached 190kWh per capita. Cambodia has significant biomass energy resources (2000MW) from a variety of agricultural residues such as rice husk, acacia, *Cassava luscenia*, and coconut. Of these, only 17MW are under current utilization. The major sources of biomass are the rice husk and sugarcane. Rice straw and husks offer an immense potential to generate bioenergy in Cambodia. Cambodia installed its first biomass demonstration plant in 2003. At present there are about 55 biomass gasification plants in Cambodia, of which the majority are small and medium enterprises operating in the range from 200kW to 600kW and use producer gas and diesel in dual fuel mode, replacing about 75% of the diesel usage. The power plant is executed and operated on the self-financing basis or from facile credit from the financing institutions. These power plants are generating power for the rice mills machinery as well providing power to the people living in the neighbouring villages/rural areas at affordable tariff. Grid like power is now available to rural population without any subsidy.

Under the Renewable Electricity Action Plan (REAP) 2002-2012, the Cambodian government has been encouraging private sector investments in renewable and more affordable power resources, including support for rice husk power generation plants. Currently, there are 11 districts in Cambodia with biomass power generation plants that supply power to villages, households, rice mills, cashew processing plants, ice factories, noodle factories, and garment industries. The benefit of the biomass energy project

- Reduced imports of fossil fuels,
- Create new employment and business opportunities,
- Improved rural livelihood by providing new income opportunities to farmers,
- Ensure community energy cooperation and country's energy security

Research and development, demonstration plants and technology dissemination work are mainly carried out by private organization and NGOs with the support of government policy such as Rural Electrification Strategy (RES) and Wood and biomass energy strategy (2012). Some of the challenges of the biomass energy projects are:

- Lack of technology development within the country
- Some demonstration plants have been scaled up from university pilot plants but have unfortunately failed after scaling up.
- Treatment of waste generated by the plant
- Lack of availability of technical expertise and training and awareness programs for plant operators

[61] http://www.sciencedirect.com/science/article/pii/S1364032115000283

Cambodia Biomass Policy Overview[47, 48]

Main policies guiding the Cambodia energy sector include National Sustainable Development Plan (NSDP 2009-2013), Rural Electrification Master Plan, the Renewable Energy Action Plan (REAP) and, the Cambodia Climate Change Strategic Plan (CCCSP). [62] The REAP and the Rural Electrification Master Plan are the key strategies in which the role of renewable energy are expressed from a strategic point of view. The REAP (REAP) is an initiative of the World Bank to assist in the adoption of renewable energy technologies by the government of Cambodia, through its Ministry of Industry, Mines and Energy. The REAP began activities in 2001, with establishment of Rural and Renewable Electrification Fund (REF). The REF provides subsidies for promotional and technical assistance activities, as well as for investments in renewable electricity projects. Some of the major issues faced during the implementation of the policies are:

- Low awareness of RE among policy makers, private sector firms, and society. For instance, solar panels are only exceptionally considered for water supply applications and off-grid lighting.
- Low exploration of the RE potential due to a lack of knowledge and understanding of such technologies.
- Lack of clear action plan where adequate manpower and budget for information and promotion, government agencies involved in renewable energy are unable to provide support to stakeholders, supply companies and policy makers.
- Lack of an integrated approach in energy planning and development. There is a need for better inter and intra-agency coordination and cooperation to ensure that renewable energy be developed in a cross-sectoral manner.
- No specialized training program or training facility for human resources development. The government personnel responsible for renewable energy development lacking technical capacity and work experience are limited.
- Lack of private companies that commercialized renewable energy and energy efficiency equipment.
- Local people cannot afford the initial investment required for even the smallest renewable energy home systems.
- Low market demand and purchasing power imply low profitability for distributors and manufacturers of renewable energy equipment.
- Weak financial status of Cambodia government which leads to lack of financial support and incentive for project development
- High tariff of 35% on import of RE equipment making such technologies is considered a luxury product that the majority of consumers cannot afford. [63]

[62] http://www.se4all.org/wp-content/uploads/2014/01/Cambodia-Rapid-Assessment-Gap-Analysis.pdf
[63] http://www.camdev.org/uploads/1/6/7/3/16732806/bioenergy_-_crcd_-_tdl_-_december_2003.pdf

Box 4.2 Malaysia Case Study[64, 65, 66, 67, 68]

Oil Palm Biomass Energy Project

Malaysia currently generates about 11 per cent of GNI from agricultural sector. This process had generated significant amount of biomass, and palm oil sector is identified to generate the largest amount of biomass, estimated at 80 million dry tonnes in 2010. This is expected to increase to about 100 million dry tonnes by 2020, primarily driven by increase in yield. It is estimated almost 1.2 million tonnes of agricultural waste is disposed into landfills annually. On 21st November 2012, a new *National Biomass Strategy 2020: New wealth creation for Malaysia's palm oil industry* was launched. In addition, government policies such as The Renewable energy policy & act, National biotechnology policy, Green technology policy, Palm oil industry biogas power generation, Biomass industry strategic action plan, National biomass strategy and National Biomass Strategy 2020: New wealth creation for Malaysia's palm oil industry contributes in promoting economic biomass utilization. In 2009, there are 14 biomass based power generation plant which has a total capacity of 300MW. Most of these power plant are generates electricity for oil palm mill. The benefit of the projects:

- Improvement of biomass waste management in the oil palm mill
- Improvement of current palm oil mill effluent (POME) wastewater treatment
- Allow oil palm mill to be self-sustain
- Reduce production cost of oil palm mill
- Mitigation measures of greenhouse gases emission
- Generation of renewable energy from methane
- Promote sustainable development of palm oil industry

The main government strategy is focused on biomass utilization for renewable energy. The government's vision in turning Malaysia into a humane industrialized country by the year 2020 will have a great impact on the usage of energy in this country. Malaysia plans to establish itself in a manner a contributor to the scientific and technological needs of the future. Universities and Institutions are consolidating their effort to undertake research on energy and its conservation to attain increased efficiency and better productivity through reduction of waste.

Some of the challenges in biomass utilization:

- Limited incentives available for biomass utilization
- There is no reliable data on actual potential of biomass
- Slow implementation of 5th Fuel Policy (RE, including biomass)
- Limited effort to regulate and enforce biomass programs
- Current technologies are inefficient and polluting
- High initial investment with poor financial support,
- No record on biomass industry
- Limited local technologies and equipment
- Limited coordination among the local agencies
- Unwillingness of the industry to change and to be proactive

[64] innovation.my/pdf/1mbas/National_Biomass_Strategy_Nov_2011_FINAL.pdf
[65] http://archive.mpoc.org.my/Malaysia_to_See_More_Investment_Potential_in_Biomass.aspx
[66] http://www.theedgemalaysia.com/in-the-financial-daily/196589-national-biomass-strategy-to-generate-rm30b-by-2020.html
[67] http://www.amrenewables.com/biomass-energy/biomass-energy-benefits.php
[68] www.jie.or.jp/pdf/16.Prof.Hassan.pdf

Malaysia Biomass Policy Overview

In the earlier stage, the biomass related policies in Malaysia were focused on the utilization for renewable energy. Malaysia began incorporating Renewable Energy (RE) into its energy supply mix in the 1980s with the introduction of stand-alone solar photovoltaic systems (PV) for rural electrification. In 2001, the importance of RE was formally recognized with adaptation of the Five-Fuel Policy under the Eighth Malaysia Plan where RE sources such as biomass, biogas, mini-hydro and solar PV have been identified as alternative fuel sources for power generation. However, the progress of RE development in the country has been quite minimal. These results provide a valuable lesson in identifying the policy implementation barriers such a 'business-as-usual' approach is not sustainable, appropriate or productive. Ten years later, the National Renewable Energy Policy and Action Plan (NREPAP) under the 10th Malaysia Plan (2010) were established to provide a more comprehensive and effective renewable energy policy to accelerate renewable energy contribution into the national power generation mix. The NREPAP enabled the formulation of two acts, the Renewable Energy Act 2011 and the Sustainable Energy Development Authority Act 2011, which forms the basis for the feed in tariff (FIT) mechanism implementation in Malaysia.[69] The Renewable Energy Policy and Action Plan sets a target of 4,000 megawatts of installed renewable energy capacity for 2030, raising the total installed capacity to 17 percent from less than 1 percent today. This target covers five individual types of renewable energy: biogas, biomass, solid waste, small hydro and solar photovoltaic (PV).[70]

Malaysian government is fully aware of the potential of biomass market and thus announced its first National Biomass Strategy (NBS) in November 2011[63]. The 1Malaysia Biomass Alternative Strategy (1MBAS) was initiated on March 2012, to strengthen the execution of the NBS and expand the strategy to other sources of the Malaysian biomass[71]. The 1MBAS initiatives aim to incorporate all activities for all Malaysian biomass, to ensure smooth delivery through close collaboration with Ministries, Agencies, Academia and Industry. A cross-agency 1MBAS taskforce has been formed to be a one-stop point of contact for all biomass utilisation activities and to monitor and help execute initiatives and Entry Point Projects (EPPs) related to biomass utilisation. In the same year Malaysia launched the Oil Palm Biomass Centre (OPBC) under 1MBAS. OPBC is a Malaysian public-private partnership aiming to accelerate technology development, testing and demonstration for utilization of oil palm biomass. Current trend of biomass economic in Malaysia[64]:

- Migration from bio fuels to biochemical oriented market in view of huge potential. Malaysia's biochemical share in chemicals sales is projected to increase from 5% in 2010 and 20% in 2020
- Backward integration by companies to secure renewable feedstock and forward integration with chemical companies for marketing.
- Opportunity for significant economic value from oil palm by utilizing waste generated at plantation and mill level for production of higher-value bio-based chemicals
- Green Chemistry trend such as minimizing waste in chemical production processes, going for less toxic alternatives in place of existing products, and the shift to renewable fossil fuel replacement feedstock

One of the main challenges in the implementation of energy policy in Malaysia is that the

[69] http://aperc.ieej.or.jp/file/2014/6/2/PRLCE_Report_Malaysia_Endorsed_by_EWG_20140526.pdf
[70] https://biobs.jrc.ec.europa.eu/sites/default/files/generated/files/policy/Biomass%20Strategy%202013.pdf
[71] https://sembangahad.wordpress.com/2013/01/26/1malaysia-biomass-alternative-strategy-green-futures-promotes-new-economic-opportunity-and-sustainability/

policies are not centralized under the energy ministry. Various ministries and government agency are given the right to implement different aspects of the policies which is difficult to prioritize the RE effort of the national energy policies. Another challenge is the different juridical power between the federal government and state government. This is especially true with Sabah and Sarawak states where the state has the right to administer the utilization of forests, land and water within their boundaries. This means the state authorities have jurisdiction for issuing land conversion approvals, water abstraction rights and permissions, planning permissions and access to reserve lands. Environmental impact assessments (EIA) approval is required to any RE project implementation and the project basis evaluation and lengthy procedures can be a challenge due to bureaucratic procedures. The RE stakeholders in Malaysia appear to be less organized compared with other APEC ASEAN economies. With the exception of the solar photovoltaic (PV) industry, there seems to be no associations of stakeholders for other RE resources to represent their collective views and interests. [72]

[72] https://sembangahad.wordpress.com/2013/01/27/1malaysia-biomass-alternative-strategy-1mbas-initiative-encourages-investment-and-establish-partnerships-in-the-biomass-industry/

Box 4.3 India Case Study[73, 74,75 ,76,77]

Household biogas stove project
India has limited conventional energy supply and is therefore forced to look for alternate and renewable energy routes to foster its development programmes, especially in rural India where more than 70% of the population live. Currently fuel wood is the dominant energy source for cooking. Cooking accounts for 60% of the overall energy and 80% of the non-commercial energy used in rural India. The Indian Government's National Biogas and Manure Management Programme (NBMMP) seeks to deliver renewable energy services to households across the country by facilitating the deployment of family-sized (<6 m^3) anaerobic (biogas) digesters. NBMMP policy is implemented at three levels, from government and state modal agency, via private contractors to households or creating multiple institutional arrangements. NBMMP disseminate and popularize family-size biogas plants (2-4 m^3 gas/day) which use bovine dung as the major feedstock (generated by the family bovine stock). One successful case is found in Sirsi of Uttara Kannada district of Karnataka state in South India. Gas production rates of the biogas plants were over 200 litres (l)/capita/ day which is able to meet normal cooking energy needs. More than 40% of the total population in the villages currently depends on biogas plants for its daily cooking energy needs. The available dung is fed to biogas plants at an average of nearly 5 kg dung/ capita/ day.

The use of biogas for cooking and heating water provides household monetary savings in the cost of fuel wood to power biomass stoves, as well as, forest conservation benefits, improved indoor air quality and associated health benefits. India has a long history of energy planning and programme interventions such as The Energy Survey Committee Report which was delivered in 1964, the national biomass policy (1970s), The Fuel Policy Committee (FPC) (1974), Working Group on Energy Policy (WGEP) (1979), The National Programme on Bagasse based Co-generation (1994), Biomass Policies under the Ninth Plan (April 1997 to March 2002). Some challenges faced during the projects:

- Biomass supply chain/biomass availability
- Biomass price increase after commissioning of power project
- Lack of mechanization in Indian Agriculture Sector
- Defragmented land holdings
- Most of the farmers are small or marginal
- Government policy leads to lack of investment in bio-power sector in states
- Transportation cost

[73] http://www.sciencedirect.com/science/article/pii/S0301421513013128
[74] http://www.sciencedirect.com/science/article/pii/S0973082609600193
[75] http://www.sciencedirect.com/science/article/pii/S0960148101001276
[76] http://www.decisioncraft.com/energy/papers/ecc/re/biomass/bpi.pdf
[77] http://www.bioenergyconsult.com/author/achal/

India Biomass Policy Overview

Despite fast growth of commercial energy, biomass remains the principle energy source in rural and traditional sectors and contributes a third of India's energy. Technologies like biogas and improved cook-stoves exist in India since half a century. The national biomass policy however has two decades of history, originating from the rural energy policies. In mid 1970s, India faced rural energy crisis due to high oil price, population growth and depletion of wood fuel resources. High oil imports led to growing trade deficit and balance of payment crisis. Majority of the rural household cannot afford the commercial fuels. Policy makers declared that biomass is the potential energy alternative that could relieve the crisis.

The biomass strategy focused on improving competence of traditional technologies, improving supply of biomass, introducing modern biomass technologies to provide reliable energy services at inexpensive prices and establishing institutional support. In 1982, the Department of Non-Conventional Energy Sources (DNES) was established to implement the decentralized renewable power projects for biogas and improved cook stoves at rural areas. The economic reform has shifted the policies to more market oriented where the DNES reform into MNES (Ministry of Non- Conventional Energy Sources) in 1992. The Ministry of New and Renewable Energy as realized the potential and also initiated national grid connected power program such as Biomass Power and Cogeneration Programme to promote the optimum use of biomass resources for grid power generation.[78] The bagasse based cogeneration in sugar mills and biomass power generation are some of the participation of the program. The biomass power generation in India is generating more than 5000 million units of electricity and yearly employment of more than 10 million man-days in the rural areas. [73]

The national biofuel policy of India adopted in December 2009 aims at facilitating development of indigenous biomass feedstock for production of biofuels. The Indian approach to biofuels is based solely on non-food feedstock where plants such as jatropha and karanjia cultivate on degraded/waste lands that are not suitable for agriculture. This is to avoid land and food competition. The new policy offers financial incentives such as subsidies and grants for biofuels production apart from declaring Minimum Support Price (MSP) for non-edible oil seeds. In addition, the establishment of The National Biodiesel Commission and Ethanol Blending Program (EBP) was aimed to achieve 10% and 20% ethanol and biodiesel blending from *Jatropha curcas* feedstock and also 5% blend of ethanol derived from sugar molasses with petrol.[79]

The overall impact of biomass programs on the Indian energy scene is marginal. There are several issues during the implementation of the policy: [73]

- The policy perspective was too narrow and supply dominated.
- Biomass program were confined to traditional applications.
- Market was given little role in energy supply as well as conversion.

In general, the vital subject in the policy making is to develop the market for biomass energy services by ensuring reliable and enhanced biomass supply, removing the tariff distortions favoring fossil fuels and producing energy services reliably with modern biomass technologies at competitive cost.[80]

[78] http://mnre.gov.in/schemes/grid-connected/biomass-powercogen/
[79] http://www.eai.in/ref/ae/bio/pol/biomass_policies.html
[80] http://www.decisioncraft.com/energy/papers/ecc/re/biomass/bpi.pdf

Box 4.4 PR China Case Study[81, 82,83]

People's Republic of China's efficient utilization of Agriculture Wastes Projects

PR China has in recent years introduced a large number of policy initiatives relevant to increasing resource efficiency. The Renewable Energy Law of the People's Republic of China (PRC) and its amendments in 2009 addressed the need for developing rural household biodigesters. The Circular Economy Promotion Law of PRC adopted on 1 January 2009 encouraged the use of agricultural waste in eco-farming to produce green energy. The ADB project "People's Republic of China: Efficient Utilization of Agricultural Wastes Project was strongly aligned with the government's environmental policy. The main constraints of this projects biomass are:

- Shortage of credit facilities
- Weak institutional and technical expertise
- Inadequate service infrastructure
- Lack of environmental awareness
- Very few incentives.

Farmers were facing constraints in obtaining access to credit for the adoption of biomass-based renewable energy systems. The low interest rates created excess demand within the country which overshadows the needs to invest in rural area. As a consequence, farmers were not able to access longer term loans for rural capital investments. In addition, the commercial financial institutions and banks were not certain about the viability of biogas systems and did not provide longer term credit to many small farmers.

The project financed the construction of household biodigesters and the integration of biogas generation with farmers' livelihoods, and piloted medium-scale biogas plants, which were highly relevant to rural biogas development. The projects resulted in significant reductions in the use of traditional rural energy sources (coal and firewood) and chemical fertilizer, and a decline in emissions of carbon dioxide, sulfur dioxide, and nitrogen dioxide. Soil samples showed that project farm soils contained higher qualities of the minerals and metals that crops need than non-project farm soils. Compared with non-project residences, the indoor air quality of project households were of better quality, indicating better living conditions for project farm families. The project also contributed to a decline in poverty. The percentage of the absolute poor declined from 15% in 2003, to 11.25% in 2006, and further to 6% in 2007. The percentage of those categorized as poor were 9.25% in 2003, 6.75% in 2006, and 2.5% in 2007. The project strengthened the institutional capacity of implementing agencies in biomass technology adoption and efficient use of agricultural wastes. It provides environmental monitoring and training stations in the four provinces with monitoring equipment and technical training. Another important finding from this project is the importance of strong government ownership and commitment to the success and sustainability of the project. The success of the project is largely contributed by the strong support of the government policy. What sets it apart from recent efforts in other countries is that it is largely seen as an economic approach and is managed not under environmental protection agencies, but under the National Development.

[81] http://www.adb.org/documents/people-s-republic-china-efficient-utilization-agricultural-wastes-project
[82] http://adb.org/projects/details?page=overview&proj_id=33443-013
[83] http://www.thegef.org/gef/sites/thegef.org/files/repository/China_Efficient_Utilization_of_Agricultural_Wastes.pdf

PR China Biomass Policy Overview

Environmental objectives are integrated into several national policies and regulations, including the Circular Economy Promotion Law and the Cleaner Production Promotion Law. Sustainable consumption and production (SCP) principles are also integrated into PR China's Five-Year Plans for Social and Economic Development. The Five-Year Plans for Social and Economic Development (FYPs) form the basis for coordinating Chinese national public policy priorities. Several policies have been implemented to address the serious waste problems in PR China. These include the Law on the Prevention and Control of Environmental Pollution Caused by Solid Waste (1995), the Measures for the Management of Municipal Domestic Waste; and the PR China Waste Electrical and Electronic Equipment (WEEE) Regulation (2011). The renewable Energy Law of the People's Republic of China issued in 2005 is the first law on energy in PR China. The basic framework of PR China's biomass energy development policy takes the Renewable energy law as the basis. These laws encourage and support the use of biomass energy clean, efficient development and utilization of the biomass fuels. In addition it also encourages the development of energy crops. One of the efforts in promoting biomass energy is providing network entry when operating enterprise complies with the network technology standard of city gas pipeline network and heat pipe network. In addition, the Circular Economy Promotion Law came into force in 2009 which further encouraged the 3R in agriculture waste. It is a comprehensive framework law which aims to improve resource efficiency, protect the environment and achieve sustainable development. PR China is one of the first countries to embrace the circular economy (CE) approach as a new paradigm for economic and industrial development. [84] All these comprehensive policies structure has provide a good foundation in the development of agriculture biomass waste market. In addition, the Chinese government has adopted a series of incentive measures to share the cost of biomass energy development with the community, or the finance departments at all levels by committing huge sums of money to encourage the participation from enterprises and users. Two types of incentive were provided: (1) front-end incentive for encouraging the biomass energy industry production chain, and market, and (2) back-end incentive to stimulate the sales and use indirect incentive measures to promote the development of the whole industry. [85,86]

One of the major policy challenges faced by PR China government is the difficulty of implementing and enforcing resource efficiency policies at the local level of government. Several policies lack associate regulations that outline the detailed implementation activities. For example, the delay in outline of the practical tasks and measures under the CE Development Plan in 2012 causes the late adoption of CE Promotion Law which was enforced in 2009. Another issue is the execution of the policies by the local level which are not properly evaluated and monitored due to a lack of technical, financial and human resources. This led to poor compliance rates in several sectors and regions of the country. Thus the development of national indicator systems is vital to ensure the effectiveness of policy initiatives and also strengthen the enforcement.[77]

Although PR China has issued a series of regulations and policies for the development of biomass energy, there is a huge gap between the mutual supporting. For example, there is inadequate subsidies policy to promote biodiesel. In addition, there is insufficient investment and financing policies for the biomass energy sector. All these are the reasons that many of

[84] http://www.unep.org/pdf/China_Resource_Efficiency_in_English_2013.pdf
[85] http://www.besustainablemagazine.com/cms2/overview-of-biomass-energy-policy-in-china/
[86] http://irena.org/remap/IRENA_REmap_China_report_2014.pdf

the private capital are unable to invest into the development of biomass energy. Moreover, the low price index of feed in tariff is unable to support the development of fuels industry examples the 140 yuan/ton (≈ USD23) subsidy of straw raw material is insufficient for the development briquette.[87] Although PR China's biomass policy framework has been in the system for a period of time, there are still weakness in the policy and enforcement:

- Insufficient specific policy guidance at the micro level especially local government
- Lack of specific operational approach for the single policy
- Lack of sustainability in the formulation and implementation of industrial incentive policy and market finance and taxation policy
- Lack of effective management rules in the aspects of standard system, market supervision and sales channels.
- Insufficiency of execution mechanism, eg. the strengths of promoting the biomass briquette fuel of the regional executive agencies are inconsistent, resulting in the slow development in some places.

PR China's biomass energy policy system plays an important role in promoting the development of biomass energy. Although there are some problems in the implementation of biomass energy policies, these are inevitable problems in the process of development and can be solved and improved in the development. Future policy is expected to appear in the large-scale biogas engineering; especially the high-quality vehicle gas engineering will get the financial support and tax preferences. [79] The quota system for biomass power generation will be implemented, environmental protection property of the biomass briquette fuel recognized and the support increased. Grain ethanol subsidies will decline further, research and development efforts in cellulose ethanol fuel will be increased and the subsidies on products implemented. And biodiesel will be included into the national oil consumption channels.

[87] http://www.besustainablemagazine.com/cms2/overview-of-biomass-energy-policy-in-china/

5.0 Agriculture and biomass waste utilization and climate change

Rapid increase in volume and types of waste agricultural biomass, as a result of intensive agriculture of population growth and improved living standards, is becoming a burgeoning problem. This leads to environment problems such as rotten waste agricultural biomass emitting methane and leachate, and open burning by the farmers to clear the lands generate CO_2 and other local pollutants. Hence improper management of agricultural waste is contributing towards climate change, water and soil contamination, and local air pollution. Furthermore, this waste is of high value in respect to material and energy recovery.[88]

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 a renewable resource that has a steady and abundant supply, especially those biomass resources that are by-products of agricultural activity. As the debate on food versus fuel intensifies, biomass can provide added income to farmers without compromising the production of main food and even non-food crops.[89]

According to Asian Development Bank (ADB) effective utilization of agriculture and biomass waste contributed to greenhouse gas emissions mitigation[90]:

- Global mitigation potential is 5,500-6,000 megatons of CO_2e / year by 2030
- Carbon sequestration potential of nearly 90%
- Potential to reduce methane (CH_4) emission from rice fields in PR China and India by 26%
- Up to 50% of emissions (1,100-3,000mt CO_2-eq/yr) can be mitigated by 2030 through soil carbon sequestration
- 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

However, 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.[91]

Currently available statistics are insufficient for evaluating the sustainability of using biomass or waste as an energy source[92]. Assessment tool such as life cycle analysis and carbon footprint should be employed as preliminary studies for the implementation of 3R projects in economic use of biomass. The International Resource Panel concludes that both land and water are limiting factors for biofuel production and proposes policies that emphasized system wide increase in resource productivity, including adjusting targets to levels that can be sustainably supplied. An estimated 8 to 34 per cent of total cropland would be required to provide 10 per cent of transport fuel demand with current first generation biofuel technologies. The World Bank has called for food producing countries to relax export controls and divert production away from biofuels to prevent millions more people being driven into poverty.[93]

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[88] http://www.unep.org/ietc/Portals/136/Publications/Waste%20Management/WasteAgriculturalBiomassEST_Compendium.pdf
[89] http://www.springer.com/us/book/9783319138466
[90] http://www.uncrd.or.jp/content/documents/Session2_Agamuthu.pdf
[91] http://www.fao.org/docrep/006/AD576E/ad576e00.pdf
[92] http://www.unescap.org/resources/statistical-yearbook-asia-and-pacific-2014 & Y. Zhang (Eds.): The United Nations Economic and Social Commission for Asia and the Pacific (ESCAP)
[93] http://www.unep.org/dewa/Portals/67/pdf/G2R2_web.pdf.

6.0 The Way Forward: How circular economic utilization of agriculture and biomass waste can make significant contribution in post-2015 development context

Sustainable Development Goals (SDGs) raised the concern of sustainability challenges of biomass production and use.[94] However, the important role of biomass in sustainable development is insufficiently addressed in the current set of Sustainable Development Goals (SDGs). Land-based biomass, derived from plants, is used for food, feed, fuel, and industrial purposes. The competition for land and the sustainability of biomass production are the main concerns mentioned by post-2015 development agenda. The UNEP Assessment of Global Land Use summarizes that crop land expansion due to increased use of biofuels could be between 48 and 80 million ha (Figure 12).

The FAO estimates that 1.3 billion tonnes of food are wasted every year, either through post-harvest losses, including storage, pest management, and 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.[95] Thus, successful management of food wastage 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 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. All these 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 per cent. Currently, FAO is in the midst of establishing the Global Food Loss Index to estimate quantitative losses, using data readily available from a variety of sources.[96] The Global Food Loss Index can be one of the key indicators for 3R of agriculture waste and biomass.

The sustainable production and consumption of biomass is the prerequisite to continuously meeting basic human needs while safeguarding the environment. Therefore, the issue of sustainable biomass plays an important role in achieving key objectives of the Post-2015 development agenda, such as food security, energy security, biodiversity, and/or climate stability. Policy interventions are needed to ensure the development of efficient and sustainable 3R in agriculture biomass 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.

[94] https://sustainabledevelopment.un.org/content/documents/6619132-Goetz-Sustainable%20Biomass%20Production%20in%20the%20Context%20of%20Climate% 20Change%20and%20Rising%20Demand.pdf
[95] http://www.iass-potsdam.de/sites/default/files/files/working_paper_biomass.pdf
[96] http://www.fao.org/fileadmin/user_upload/post-2015/Targets_and_indicators_RBA_joint_proposal.pdf

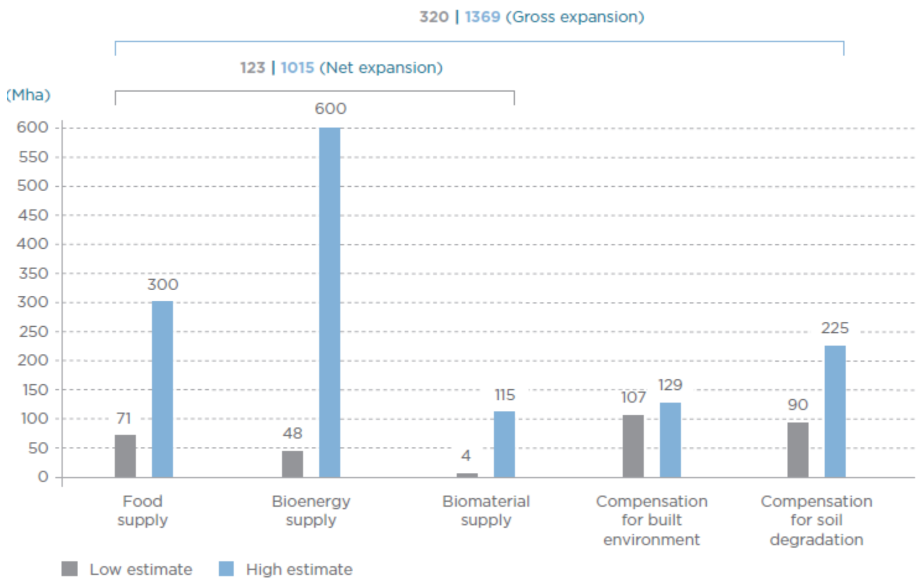

Figure 12: Expansion of global cropland from 2005 to 2050 under business-as usual (BAU) conditions

Development practitioners are therefore less likely to see specific policies aimed at 3R agriculture biomass but will rather have to refine the relevance of bioenergy policy, or even just renewable energy policy, for the 3R agriculture biomass initiatives to be implemented. The lack of policy guidance is even more acute for off-grid and mini-grid (rural) biomass applications, because they tend to lack both the policy framework for waste to energy and that for off-grid or mini-grid electrification. This is certainly the case in the ASEAN countries. The absence of policies, insufficient incentives, or lack of communicate uncertainty with respect to the duration and level of financial support, can act as a barrier to the implementation of 3Rin agriculture biomass. Government and local authorities should formulate and implement policies to promote the use of waste agricultural biomass in macro and micro level instead of focusing on RE. This will lead to the establishment of a green industry, thus creating green jobs which can provide additional income to poor farmers. Economic development due to increased access to energy will contribute to alleviating poverty. Policy system plays an important role in promoting the development of economic utilization biomass and no policy is perfect thus it is crucial for policy maker to conduct frequent efficiency assessment and revised accordingly to adapt to the current situation in individual country.

In the face of growing resource scarcity and climate change, there will be a paradigm shift from current economic development patterns to green economy and sustainable economy for a more sustainable economic development. Agriculture waste has the potential to be the alternative biomass source of energy crop which able to avoid competition of land and resources with food crop. The high agriculture waste generation in Asia Pacific has a huge potential and it has the potential to extend into a biomass market trading region. This paper has identified 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 converting agriculture waste to briquette. The policy maker of these countries especially those who have not realized their country's potential in biomass market should explore any actions and measures (policy, institution, governance, technological intervention) that can be initiated without missing the good business opportunities. The policy maker must understand the importance of government policy intervention and it is one of the key to successful implementation of 3R agriculture biomass. However, these countries also have to define their paths towards sustainable development based on their national circumstances and priorities.

Last, the author would to ask the policy makers:

1) Can your country afford to not move towards a green economy when facing limited resource challenge? Will the global shift from current economic patterns to green economy affects the livelihood of your people?
2) Is the current national policy frameworks and trade policy strategies ready to for green economy?
3) What types of policies framework needed to be developed to take advantage of the rise of new trading opportunities?

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