Review of Sanitation System and Investment Climate for Waste Recycling Technologies in South And Southeast Asia: India, Bangladesh, Nepal, Sri Lanka, Myanmar And Laos

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Abstract

A proper sanitation systems and improved wastewater treatment and recycling are essential for safeguarding environment and enhancing sustainable livelihoods in vast areas of South and Southeast Asian countries, including in Bangladesh, India, Nepal, Sri Lanka, Laos and Myanmar. This paper reviews the technical potentials and investment climate for wider adoption of resources recovery and reuse (RRR) technologies in this region. The review points at poor sanitation in India and Nepal, in contrast to high levels of sanitation in Sri Lanka. However, despite higher levels of fecal sludge and wastewater treatment in Sri Lanka compared to the rest of the region, the levels of waste treatment and recycling are much lower than their potential in all countries of the region. Lack of financial resources, lack of awareness about detrimental impacts of poor sanitation, and poor governance in the system were pointed out as key barriers for wider implementation of waste recycling technologies. Improving regulatory frameworks and governmental support through providing public subsidies can enhance wider implementation of environmentally sustainable waste recycling technologies in the region.

Keywords: resources recycling and reuse (RRR), composting, biogas, nutrient management

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Introduction

Environmental and human health degradation due to poor sanitation and mismanagement of waste are main issues across the developing world (UN-HABITAT, 2010; WWAF, 2017; UNEP, 2017). Population growth and urbanization processes intensify extent of these issues. On the other hand, improving the governance and infrastructure in the waste and wastewater management sector is essential for achieving Sustainable Development Goals (SDGs) related with improved access to sanitation, water, energy, food and better environmental systems (biodiversity, forests, lower air pollution) (UN-WATER, 2016; UN, 2016). Except improving environment and health impacts, recycling waste may enhance also water, energy and nutrients supply (Strande et al. 2014, Bekchanov, 2017). Despite higher costs of recovering nutrients, producing energy and treated effluents from waste streams compared to the traditional sources of water, energy and nutrients supply, growing demands for these resources across the world also are improving the feasibility of the resources recovery and reuse (RRR) options.

Waste and wastewater mismanagement issues are nowhere more evident than in South and South Asia. Lack of proper sanitation facilitates and unsafe disposal of waste and wastewater are common in many parts of this region due to low financial capability and inefficient institutions (Visvanathan and Glawe, 2006). This study thus aims at reviewing the current status of sanitation and wastewater management options and assessing the investment climate for introducing waste recycling technologies to enhance the sustainable livelihoods in the region. South Asian countries considered under the study are India, Sri Lanka, Nepal, Bangladesh, Myanmar and Laos.

Next section briefly presents the location and population in the studied countries. It is followed by the section on the current conditions of fecal sludge and wastewater management. After that currently applied waste recycling technologies to address waste management are presented. Then, investment opportunities for wider implementation of waste treatment and recycling technologies are discussed starting from financial feasibility, demand for products produced through recycling, infrastructure, and regulatory and institutional frameworks for RRR. The last section summarizes and concludes.

Location and population of South and Southeast Asia

In South Asia, India has the biggest territory at the level of about 3.3 million sq. km (Figure 1). An island country – Sri Lanka is the smallest with the territory of 65.5 thousand sq. km. Despite their different sizes population densities are similar in these two countries (338 and 445 people per sq. km respectively; Table 1). Bangladesh is the most densely populated (1,250 people per sq. km) among the studied countries while population density is very low in Laos and Myanmar.

Country	Area (sq. km)
Bangladesh	147,630
India	3,287,259
Laos	236,800
Myanmar	676,590
Nepal	147,180
Sri Lanka	65,610

Figure 1. Map of South Asia

Source: Google maps

Total population in the studied South Asian countries are 1.6 billion which is 21% of global population (Table 1). India with population of over 1.3 million is the most populous country in South Asia and the second most populous in the world (after China). Over 160 million people reside in Bangladesh while Laos despite has only 6.8 million population its larger territory. More than 80% of population lives in rural areas in Nepal and Sri Lanka. In the remaining countries, people residing in rural areas exceed 60%. Taking into account the average global proportion of rural population (45%), the relatively higher proportion of rural population in the studied countries could represent a need for decentralized sanitation facilities and an opportunity to implement resource re-utilization (RRR) technologies in order to decrease environmental and health hazards.

Table 1. Population (2016)

Country	Population (million people)			%		Population density
	Total	**Urban**	**Rural**	**Urban**	**Rural**	**People per sq. km**
Bangladesh	163.0	57.1	105.9	35.0	65.0	1,252
India	1,324.2	438.8	885.4	33.1	66.9	445
Laos	6.8	2.7	4.1	39.7	60.3	29
Myanmar	52.9	18.3	34.6	34.7	65.3	81
Nepal	29.0	5.5	23.5	19.0	81.0	202
Sri Lanka	21.2	3.9	17.3	18.4	81.6	338
Total	**1.597.1**	**526.3**	**1070.8**	**32.9**	**62.1**	

Source: World Development Indicators (World Bank)

Fecal sludge and wastewater management

Densely located population and lack of infrastructure for proper sanitation are behind the major environmental and water pollution problems in South and Southeast Asia. High rates of open defecation and essentially psychological preference for such behavior are key barriers for safe management of waste and implementation of RRR technologies. As shown in Table 2, open defecation rates are enormously high reaching almost 40% in India even after so many efforts to provide cheap toilets and improving the sanitation. High rates of open defecation and low sanitation access rates are also specific to Nepal and Laos. In contrast, open defecation rates are infinitesimal in Bangladesh and Sri Lanka.

Table 2. Sanitation (2015)

Country	Access to sanitation	Open defecation rate
Bangladesh	60.6	0.1
India	39.6	39.8
Laos	70.9	22.1
Myanmar	79.6	4.7
Nepal	45.8	29.8
Sri Lanka	95.1	2.6

Source: World Development Indicators (World Bank)

Fecal sludge and wastewater treatment levels are quite low compared to the sanitation rates and the average treatment levels in Asian countries. Figure 2 illustrates the ranks of the studied countries among Asian countries according to an access to sanitation (availability of sanitary toilets) and the level of waste ware treatment. According to UNEP (2017), sanitation access is quite low in Nepal and India and leveled at less than 30% though low wastewater treatment levels are comparable with Bangladesh. Bangladesh and Laos have similar sanitation access at the level of 50-60% but wastewater treatment almost lacks in Laos. Wastewater treatment levels are also quite low in neighboring Myanmar though sanitation rates are higher than 70% in this country. Sri Lanka performs best among the studied countries reaching high sanitation access comparable to in the developed countries of the region but wastewater treatment levels in urban areas are quite low compared to those in the developed countries.

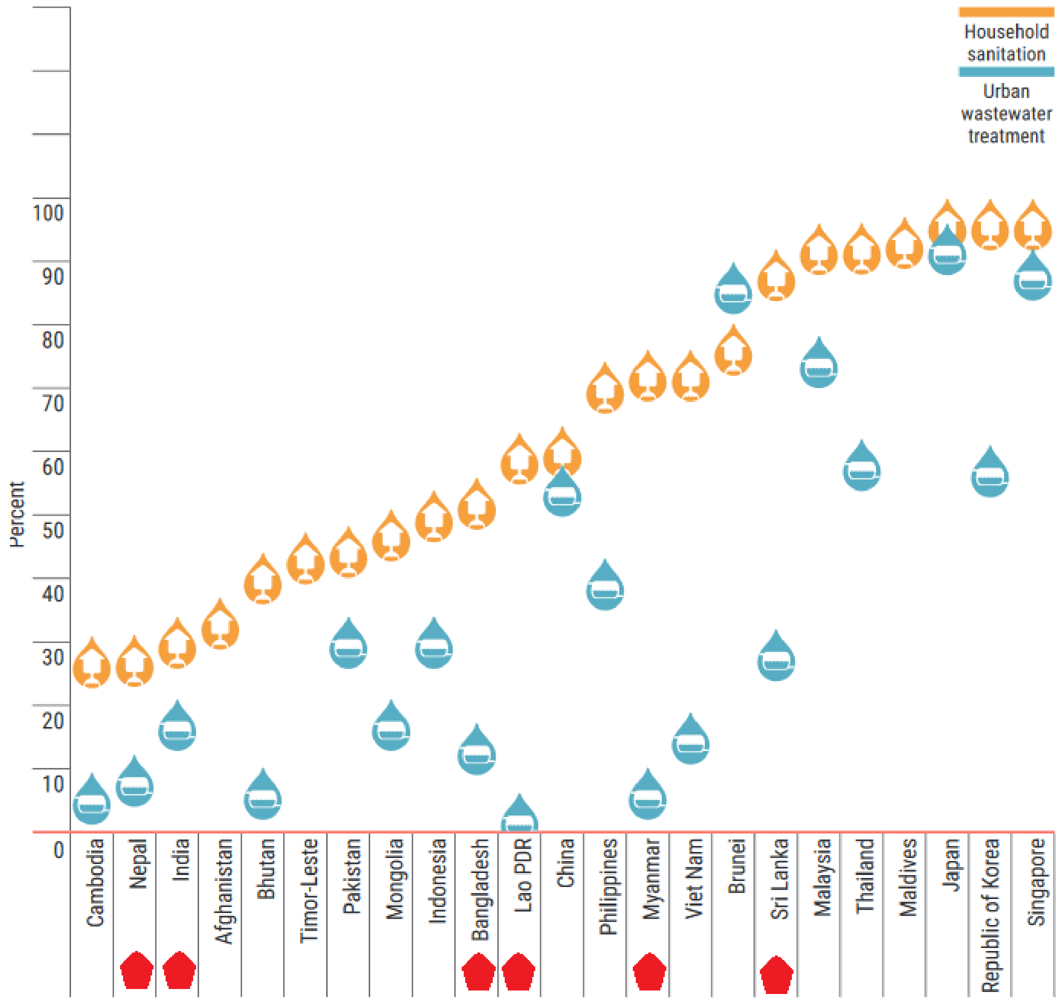

Figure 2. Access to sanitation (sanitary excreta containment) and wastewater treatment levels across Asia

Source: UNEP (2017)

Although open defecation is not a big problem in Dakka, Bangladesh and flush toilets are commonly used for collecting fecal sludge, only 0.3% of total wastewater and fecal sludge generated are treated (Figure 3). Most water from sewerage which serves only 25% of the city population are leaked into water bodies. Large portion of fecal sludge is dumped into open drainage which transports it beyond the local area and discharges into environment without a proper treatment (Opel et al., 2012). Mechanical empting on-site facilities such as pit latrine and septic tanks are rare and manual empting characterized with high disease risks is common practice. In other cities where sewerage system lacks and on-site fecal sludge collection facilities dominate the situation is even worse than the capital city and environmental pollution.

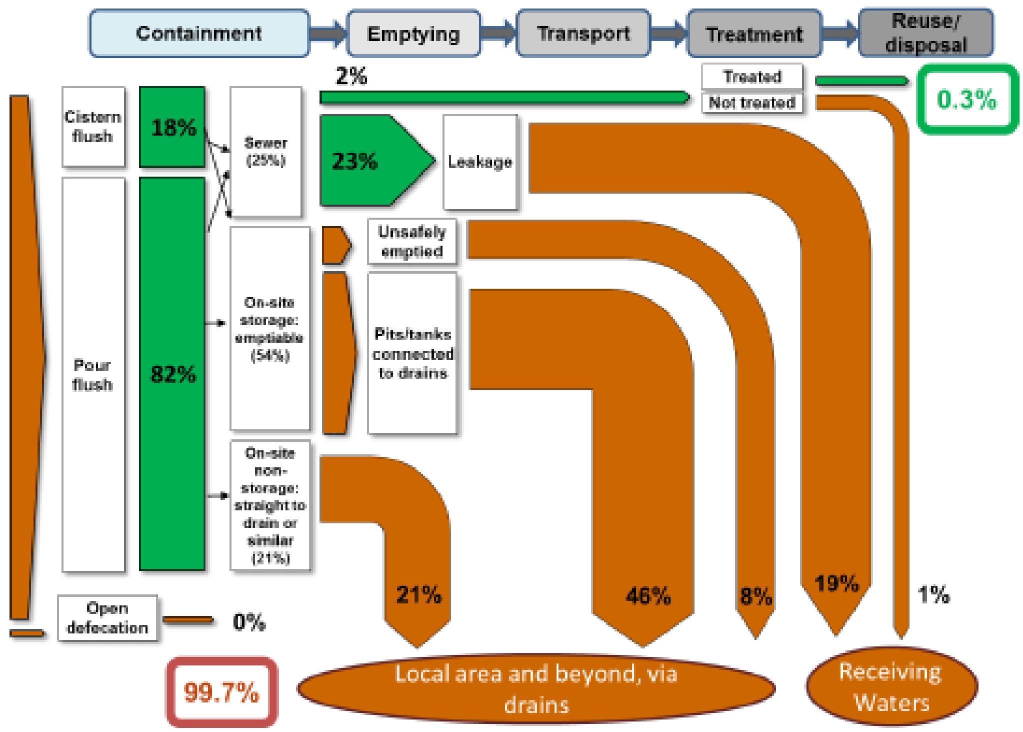

Figure 3. Fecal sludge management in Dakka, Bangladesh

Source: World Bank (2016)

Example of FSM in Tumkur city In India located 70 km away from Bangalore – the capital of the state of Karnataka was shown in Figure 4. Half of the population in the city is provided with sewerage system which transports 90% of wastewater generated to treatment plants. Small portion of wastewater joins to drainage waters due to leakage or failure in the sewerage system. Only 10-20% of the fecal sludge from the on-site facilities are treated while the remaining fecal sludge from is either openly defecated in the surroundings or dumped directly into the drainage system without any pre-treatment. Overall, almost half of the wastewater and fecal sludge generated end up in open fields, drainage system without any prior treatment and thus contributes to heavy environmental pollution and spread of the diseases.

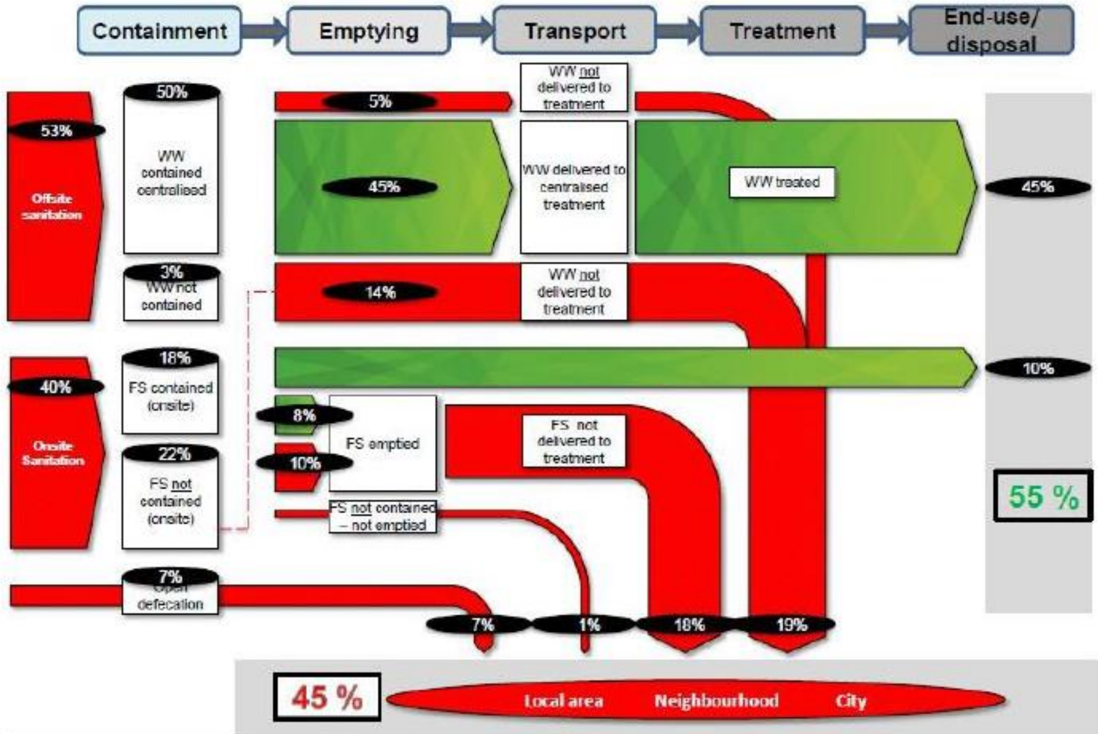

Figure 4. Fecal sludge management in Tumkur, India

Source: Gunawan et al. (2015)

Water supply and sanitation is underdeveloped in urban areas and lacks in rural areas of Nepal. For instance, in the Kathmandu Valley it has been reported that only 40% of households are connected to the sewerage system (ICIMOD et al., 2007). Across the country, only 12% of households in municipal areas have an access to sewerage system (Shrestha, 1999). In municipal areas without connection to sewerage system, septic tanks and pit latrines are in common usage (HPCIDBC, 2011). Effluents from these septic tanks and pit latrines are discharged into drainage system or soak pits where they are gradually absorbed into soil. Although private companies or municipalities are in charge of frequent cleaning of the septic tanks it rarely occurs in time. Consequently, these tanks do not function properly and causes heavy air, water and soil pollution. If 370 million liters per day (MLD) wastewater is generated in Nepal only 5% of this volume can be treated since the overall capacity of wastewater treatment plants (WWTPs) is 37 MLD and only 50% of these plants are operational (Nyachhyon, 2006).

In Colombo, a capital of Sri Lanka, the sewerage network covers only some parts of the city and comprises 320 km of sewers, 18 pumping stations, and two long outfalls into the deep sea (ADB, 2015). Given the lack of pipe-borne sanitation infrastructure in many parts of the country, fecal sludge is collected by special trucks in some areas to deliver them into treatment plant (Figure 5). Wastewater is recycled through passing several ponds in wastewater treatment plants and treated water is safely disposed into a lagoon or sea. In some places like Rathmalana in the South of the Colombo Municipality, a very modern wastewater treatment plant functions using advanced computer technologies for monitoring and managing wastewater treatment process. Treated wastewater is safely released into the sea thus not polluting the coastal area and not damaging fish catchment business. Sediments are dried several days before being delivered to a compost plant for co-composting together with organic waste (food waste, crop residues, etc.) or dumped into landfills. In some cases, dried sediments were supplied to cement production factories for burning (Maheshi et al., 2015). In the areas without adequate access to sanitation services, disposal of wastewater and sewage sludge without proper treatment is a key reason for eutrophication and the spread of diseases in inland water bodies and coastal areas. Increased eutrophication may also damage coral reefs in the coastal zone and negatively effect on fishing industry (Sunday Times, 09 April 2017). Improper management of solid waste such as dumping waste into wetlands or constructing inefficient landfills close to fresh water streams causes organic and chemical contamination of water bodies and leads to the consequent loss of aquatic species and human health degradation (Lagerblad, 2010).

Figure 5. Delivering the fecal sludge to the treatment plant (Sri Lanka)

Source: Photo by Bekchanov M.

In Laos, fecal sludge management is quite undeveloped as only 35% of fecal sludge generated is stored in septic tanks and various poorly maintained latrines are in use for the remaining excreta (Opel and Cheuasongkham, 2015). Although open defecation rate is 4% in urban areas and 70% of population uses some type of toilets, open defecation rates are 40% in rural areas in this country (WHO/UNICEF 2014). Fecal sludge collected in septic tanks are accumulated over 1 to 5 years for further collection. Fecal sludge collection are mostly run by private companies and public service for collecting fecal sludge is quite limited. Since the distance to the official dumping site is too far and the costs for discharging the collected waste into the site are expensive the collected fecal sludge is mostly dumped into waterways and the ditches along the roadside (Opel and Cheuasongkham, 2015). No regulation, monitoring and control exist for the illegal dumping of fecal sludge. At present, some cheap wastewater treatment plants based on planted reed beds are under way of construction which can lessen the environmental burden of the illegal dumping at least in some part of the capital city (The Laotian Times, 2018).

According to the official statistics, Myanmar is well equipped with sanitary means of disposing excreta (Zaw, n.d.). The Minsitry of Health provides subsidies to construct latrines in rural areas (ADB 2013). Thus, improved toilets are used by 80% of population in rural areas and 94% in urban areas (Zaw, n.d.). Majority of population uses pit latrines with slabs for excreta containment. However, only only 3.4% of households are connected to centralized sewerage system and even main urban areas such as Yandong, only key business districts are equipped with the centralized sewerage system and sanitation services are below acceptable levels in the remaining areas. In Yandong city, only 7% of wastewater generated is treated before its release into environment and activated sludge from the plant is used as soil amendment (Premakumara et al., 2017). The remaining waste is mostly discharged into storm water canals or open waterways without proper treatment. These water ways are often blocked due to heavy loading of suspended solids or mismanagement and increase the health risks such as malaria and dengue. Poor governance, lack of data and planning, financial shortcomings are key barriers for constructing a proper urban sanitation facilities in the country.

Status of RRR business sector

Technologies of treating and recycling fecal sludge vary depending on the purpose of the treatment (Table 3). Some municipal areas of South and Southeast Asia are equipped with cheap options of wastewater treatment such as planted or unplanted drying beds. The application of the advanced wastewater treatment technologies are very limited. Resource recovery and reuse technologies are quite underdeveloped in Myanmar and Laos bout composting and biogas plants are more common practices across Sri Lanka, India, Nepal, and Bangladesh. Incineration is also applied yet at limited level because of high operation and investment cost requirements. Studies on cultivating fly larvae and deep row entrenchment were not found. Thus, we mainly focused on composting and biogas generation options across these four South Asia countries in this section.

Table 3. Fecal sludge treatment objectives and technologies

Treatment objective	Treatment technology
Solid-liquid separation	Unplanted drying beds
	Planted drying beds
	Mechanical dewatering technologies
	Settling tanks
Sludge stabilization	Composting
	Anaerobic digestion (biogas)
	Fly larvae (Soldier Fly)
	Incineration
Nutrient management	Vermicomposting
	Deep row entrenchment
Pathogen inactivation	Lime treatment
	Ammonia treatment

Source: Based on Strande et al. (2014)

Composting

Compost is the dark colored matter rich in nutrients and thus useful for improving soil fertility. Most of the farmers in Bangladesh produce compost in their premises based on traditional ways and apply it for vegetables production. However, the application of modern ways of composting including vermicomposting are very limited (Mamun-ur-Rashid, 2013). Large-scale composting plants are rare and mostly run by a few commercialized organizations such as Waste Concern, Annapurna Agro Service, Grameen Shakti and Rural Development Academy (Rashid, 2011). Although most farmers are less aware of the soil productivity enhancement properties of the compost, some farmers in rural areas of Bangladesh prefer using compost for reducing external environmental effects of chemical fertilizer application, improving soil structure, avoiding high expenditures for inorganic fertilizers, and ensuring safe disposal of organic waste. Crop residues, kitchen waste, dry leaves, hay, ashes, and manure are main types of organic waste for composting. Both men and women are widely involved in processing compost in rural areas across Bangladesh.

Overall composting potential from organic waste is about 4.3 million tons as estimated (Chandran, 2012). Windrow composting is main type of composting across the country. Initial plans for composting organic waste were implemented as early as 1970s and thus several semi-mechanical composting plants have been constructed in many states of India at that time. However, most of these plants were also shut down due to lack of spare parts for mechanical machinery which are mainly imported. Even a malicious fault in the machines could prevent the entire process given the unavailability of spare parts for quick fixation of the mechanical problem. Frequent shortcuts in electricity also interrupted the process. Mixed waste with high content of glass, metal and rubber also frequently clogged the pulvetizers. It was not possible or very difficult to continue the composting process in rainy seasons. Demand for the produced compost was also low because of very low quality and contamination with various hazardous material. Given the increased environmental consciousness and thus with the support of the government program, compost plants started to grow since 2008 and were constructed in many cities. Composting plants in Bangalore, Nashik and Pimpri can recycle 100, 300 and 500 tons of organic waste daily. However, contamination of the produced compost with heavy metals is dangerous for soil health and might have consequences in the long term.

Composting organic waste is also limited in Nepal. There have been efforts to establish a composting plant in Kathmandu municipality in Nepal GIZ supported and funded the construction of compost plant with an annual capacity of producing 30 tons of compost in Teku transfer station in Kathmandu (Dangi et al. 2013). However, the project was stopped by the municipal council citing to malodor, lack of market for composts, and the complaints about the low quality and glass hazards of compost. Instead, recently Kathmandu municipality provided 600 households (out of 150,000) with compost bins with the volume of 100 l, for promoting mini-scale composting. Unwillingness of the government to cooperate with NGOs, legislate the initiatives for sustainable environment, and recognize the private sectors prevented the flow of sufficient funds into the establishment of composting plants. It was reported that currently there is a single large-scale composting plant in Bhaktapur region of Kathmandu municipality (ICIMOD et al.

2007). The plant receives about three tons of waste per day. However, the composting in this plant is based on a simple methods and most operations are carried out manually. Other private initiatives to establish composting plants did not have much progress until the recent past since low priority was given for these programs (ICIMOD et al. 2007). At present, some NGO initiatives to raise awareness on recycling waste and not to pollute environment are there through international donor support[1]. Since 2014, Biocomp company also started running a composting plant in Khokana[2]. The composting process is largely mechanized and some positive signs of progress has been recognized. Rather than waste treatment and recycling, some initiations on safe disposal of waste became successful (Dangi et al. 2013). For instance, GIZ supported the construction of Gokarna landfill. JICA similarly financed the establishment of Sisdol landfill.

In many areas of Sri Lanka, composting at household level was supported by sharing composting bins by local governments or NGOs. Centralized composting, especially using windrow composting technology, is also becoming common. Following the Pilisaru Program adopted by the national government in 2008, over 110 compost plants were planned to be established (JICA 2006, Table 4). 94 composting plants out of 119 are under operation at present and 17 are under construction. Though the construction works were finished in the remaining 8 plants these plants did not start producing compost given the problems related to electricity, water and road access. In districts such as Kurunegala, Anuradapura, Polonnaruwa, and Badulla where agriculture is a backbone for rural livelihoods, the targeted rates of waste recycling are substantial. Some plant operations even faced to public protests over malodor and water pollution in some areas. Lack of technical skills to operate the plant, low quality of compost, and underdeveloped marketing system for compost also hinder successful performance of composting plants (Pandyaswargo and Premakumara, 2012).

[1] http://cleanupnepal.org.np/
[2] http://www.biocompnepal.com/

Table 4. Municipal solid waste collection and composting rate across Sri Lanka

Provinces	Districts	Waste collection (tons per day)	Number of compost plants	Targeted waste (tons per day)	Targeted waste (%)
Northern	Jaffna	78.5	3	11	14.0
North-central	Anuradapura	64.7	14	46.5	71.9
	Polonnaruwa	17.5	2	12	68.6
	Total				
Northwestern	Kurunegala	113	16	88	77.9
	Puttalam	87.9	5	30	34.1
	Total	200.9	21	118	58.7
Central	Kandy	209.5	4	17	8.1
	Matale	47.3	4	8	16.9
	Nuwara Eliya	58	2	5	8.6
	Total	314.8	0	30	9.5
Western	Colombo	1,284	2	7.3	0.6
	Kalutara	126.5	7	69	54.6
	Gampaha	372.5	8	40.5	10.9
	Total	1783	17	116.8	6.6
Southern	Hambantota	50	8	30	60
	Matara	92	7	51	55.4
	Galle	107.5	9	13	12.1
	Total	249.5	24	94	37.7
Sabaragamuwa	Kegalle	65.5	6	34	51.9
	Ratnapura	88	2	2	2.3
	Total	153.5	8	36	23.5
Uva	Badulla	75.6	5	52	68.8
	Monaragala	35	2	4	11.4
	Total	110.6	7	56	50.6
Eastern	Ampara	142.5	5	13	9.1
	Batticaloa	136	1	9	6.6
	Total	278.5	6	22	7.9
Sri Lanka	Total	3,424	119	656.8	19.2

Source: Central Environmental Authority.

Biogas generation

Biogas production from organic waste is getting momentum across the world and China and India are the leaders in the implementation of the biogas technology (Halder et al., 2016). In Bangladesh, Bangladesh Agricultural University constructed the first biogas plant in 1972 for research purposes. Several organizations such as Government Engineering Department, the Bangladesh Council of Scientific and Industrial Research, Infrastructure Developing Company Limited (IDCOL) became active in supporting the adoption of small-cale biogas digesters by households. At present, about 80,000 small-scale biogas digesters have been installed already across the country yet over 4 million biodigesters can be built to recycle the entire organic waste (Bahauddin et al., 2012). Thus, over 2.7 billion m^3 biogas which is equivalent to 1.5 tons kerosene can be produced just recycling the livestock manure. IDCOL financed also to construct several biogas based power generation plants. A plant established by Paragon Agro Ltd using the IDCOL funds, for instance, produces 2,400 m^3 biogas from litter and uses it for generating 3,840 kWh electricity daily (IDCOL, 2016).

Promotion of biogas plants started since 1970s in India following the first global energy crisis which made energy access in rural areas very low and economically infeasible (Deo et al., 1991). At present, about 5 million biogas plants have been constructed across the country (Mittal et al., 2018). As estimated, total potential of constructing biogas plants is about 12 million (CSO, 2014). Despite quite large number of biogas plants, the share of biogas in energy consumption of households is low and the dissemination rate of biogas plants is slow. Total amount of biogas generated currently at the level of 2.1 billion m^3 per annum is also quite low compared to its overall potential of 29-48 billion m^3 (Mittal et al., 2018). Recycling municipal organic waste using anaerobic technologies are currently quite low given high investment costs and low profitability of such options (Mittal et al., 2018). Biogas based power generation plants are rare and only 56 plants operate across the country. Most of these plants are located in Maharashtra, Kerala, and Karnataka states (CPCB, 2013).

The first biogas plant in Nepal was introduced by Father B.R. Saubolle in 1955 (Gautam et al. 2009) and additionally 20 years were required to draw the attention of government officials for promoting biogas plants. Starting from 1975, thus the Nepal government offered interest free loans for biogas plant construction. Under the initiation of the Department of Agriculture, Gobar Gas Thata Agricultural Equipment Development Company (GGC) was established in 1977 and 250 biogas plants were built. In 1990, modified Chineese fixed-dom model of generating biogas has been accepted as a suitable model across Nepal. Given the expansion of biogas plant sector, Biogas Support Program (BSP) was established with the support and funding by the Netherland Development Organization (SNV) to develop the biogas sector in 1992. The BSP was realized in four phases and over 200,000 biogas plants were constructed across Nepal till 2010. Biogas plants installed mainly in households for recycling cattle and buffalo dung, and thus have small size (4-10 m^3). Biogas plant implementation took place in majority of districts across Nepal except some few northern districts where biogas generation is not efficient due to cold temperature (Figure 6). Several environmental and health benefits of biogas use are encountered. Earlier agricultural residues and cattle dung cakes were used in inefficient cooking stoves, causing heavy indoor pollution and leading to increased incidents of respiratory system illnesses (Pandey, 1984). Biogas uses reduced smoke exposure in the indoor environments and thus reduced exposure to acute respiratory illnesses. Additionally, child mortality rates and eye ailments were also reduced.

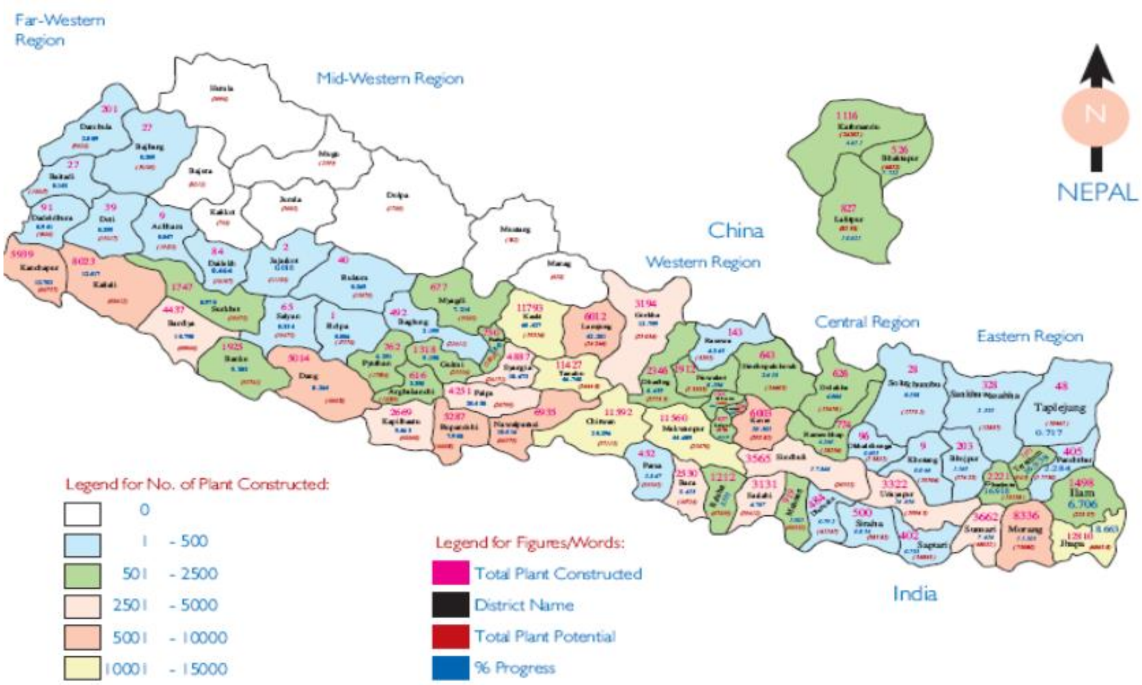

Figure 6. Number of biogas plants constructed across Nepal (in 1992-2007)

Source: SAESUP (2010)

In Sri Lanka, initial experimental projects of implementing aerobic digestion technology primarily aiming at energy recovery have been conducted in Kirulapone and Matale (UNEP 2001, Pandyaswargo and Premakumara 2012). Household biogas plants were also introduced in some regions (De Alwis, 2002). Despite failures due to low financial and technical feasibility in some cases, waste-to-biogas project became successful when implemented in hotels. Treated wastewater and compost through waste recycling was also effectively used gardening in some hotels such as Jetwing. More recently, researchers of Moratuwa demonstrated also waste-generated-biofuel for using in three-wheels (De Alwis, personal communication 30.07.2012). At present several commercial companies such as BIOGAS Ltd and BIOFUEL LANKA Ltd are engaged in installation of waste-to-biogas plants throughout the country. Incineration of waste is less common and can be operating only in few hospitals and industries. Unfortunately, incinerations are not equipped with emission control devices (UNEP, 2001). A wider adoption of incineration technology to treat municipal waste across the country is very limited because of a high share of organic matter, high moisture content and low calorific value of municipal waste. In case of Sri Lanka, the incineration may require supplementary fuel since the calorific value of waste in the country is 2 to 3 times lower than this in developed countries where the incineration treatment of waste is commonly used.

Economy and financial capability

The adoption rates of improved sanitation facilities and RRR technologies are largely determined by financial capability and income levels. Thus, income levels and stability as reflected through GDP per capita, inflation rates and access to credit are discussed in this section.

Given its large territory and population size, India is also the most voluminous in terms of economy earning annually over US$ 8 trillion (Table). However, per capita income is the highest in Sri Lanka compared to the remaining countries of South Asia and reaches US$ 11,400. It is also noticeable that the inflation rate in Sri Lanka leveled at 3.7% is one of the smallest, reflecting perhaps a greater macroeconomic stability after the end of civil war in 2009. Bangladesh and

Nepal are the poorest in terms of income per capita which are leveled at US$ 3,320 and 2,300 respectively.

Table 5. GDP and inflation rates (2016)

Country	GDP (US$ Billion)	GDP per capita (US$)	Inflation rate
Bangladesh	540.9	3,319.4	5.5
India	8,067.7	6,092.6	4.9
Laos	38.8	5,734.5	1.5
Myanmar	280.6	5,305.0	10.8
Nepal	66.6	2,297.7	7.9
Sri Lanka	242.1	11,417.3	3.7
TOTAL	**9,236.7**	**34,166.5**	**-**

Source: World Development Indicators (World Bank)
Note: GDP figures are in international 2011 constant US$. Inflation rates for Myanmar and Nepal are for 2015.

In addition to income levels, interest rates and access to credit is also essential for assessing financial viability of technology upgrading. Table shows the interest rate for 2016 and the 'Easiness of getting credit' (EGC) index for 2018. Both measures are meant to reflect in some way the possibility of financing investment projects in each of the 6 economies studied. As shown, the cases of India and Nepal are the most notorious, as these economies reflect the highest EGC and the lowest lending interest rate, respectively. Difficulty in obtaining credit in Myanmar and high interest rates in Laos are main problems related with financial viability of technological changes.

Table 6. Interest rates and 'Easiness of getting credit' - EGC index (2016)

Country	Interest rate (%)	Easiness of getting credit
Bangladesh	10.4	25
India	9.7	75
Laos	22.6	55
Myanmar	13.0	10
Nepal	8.0	50
Sri Lanka	11.7	40

Source: World Development Indicators and Doing Business Report 2018 (World Bank)
Note: Interest rates are average lending rates as of 2016. 'Easiness of getting credit' index is expressed as the 'Distance to the frontier' (DTF), i.e., a low score represents a more adverse scenario in terms of financing enterprises.

Agricultural production capacity and fertilizer markets

Agriculture plays a pivotal role in the studied countries (Figure 7), implying a substantial demand for fertilizers which can be also met through nutrient recovery from organic waste streams. Agriculture provides over 15% of GDP in India and Bangladesh but more than 25% of GDP are enhanced through agriculture in Nepal and Myanmar. With the share of 8% agriculture has the smallest share in in national GDP of Sri Lanka. Nevertheless, agriculture dominates rural areas ad majority of the population resides in rural areas in these countries. Thus, sustainability of agriculture and adequate supply of irrigation water and soil fertility are essential for food and income security in this region.

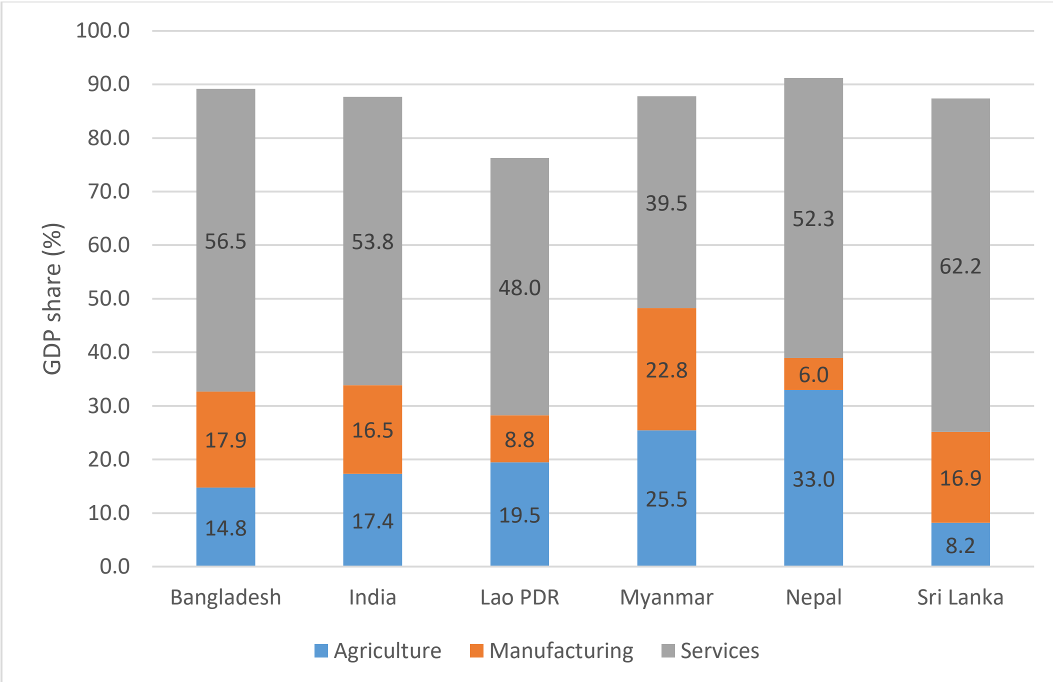

Figure 7. Sectorial structure of the national economies (2016)
Source: World Development Indicators (World Bank)

Agricultural land areas are mostly used for producing cereals such as paddy rice in the studies countries (Table 7). Half of the croplands are irrigated in Bangladesh and only 10% in Laos. Given the high precipitation rates, rainfed agriculture dominates in most of the areas in the region. Forests cover 80% of total land area in Laos but only 10% of Bangladesh. Given the low population density high precipitation and high forest coverage of the territory perhaps expensive centralized fecal sludge recovery technologies are less feasible in Laos and Myanmar except in their central urban regions. Thus, perhaps only safe disposal of fecal sludge with less damage to human and environmental health or deep for entrenchment for enhancing forestry can be an option for these countries. Given the high population density, extensive irrigated areas, adoption of nutrient technologies seems more important to Bangladesh and India but their economic feasibility should be further clarified.

Table 7. Agricultural land uses in South and Southeast Asia (2014)

	Agricultural land (million ha)	Cereals area (million ha)	Irrigated area (% of total cropland)	Forest area (% of total land area)
Bangladesh	9.1	12.1	52.6	11.0
India	179.7	99.0	36.8	23.8
Laos	2.4	1.2	11.5	81.3
Myanmar	12.6	7.7	24.8	44.5
Nepal	4.1	3.5	29.7	25.4
Sri Lanka	2.7	1.0	n.a.	33.0

Source: World Development Indicators (World Bank)

Both nitrogen and phosphorus chemical fertilizers are largely imported in all South Asian countries considered (Table 8). India for instance imports over 4.8 million tons of nitrogen and produces 12.3 million tons domestically (as of 2014). Nepal and Sri Lanka solely depend on the imports of nitrogen fertilizers while substantial proportion of nitrogen use based on imports in Myanmar and Bangladesh. Phosphorus is also solely imported in countries other than India and Bangladesh (as of 2014). Even in Bangladesh, import of phosphorus is 7-8 times higher than its domestic production.

Table 8. Domestic production, exports and imports of chemical fertilizers (tons)

		Nitrogen			Phosphorus		
	Year	**Production quantity in nutrients**	**Exports quantity in nutrients**	**Imports quantity in nutrients**	**Production quantity in nutrients**	**Exports quantity in nutrients**	**Imports quantity in nutrients**
Bangladesh	2005	880,646	179,962	292,643	69,022	0	257,691
Bangladesh	2010	491,520	40,916	716,206	50,140	0	245,946
Bangladesh	2014	394,580	0	881,420	61,640	0	454,480
India	2005	11,218,193	10,127	1,389,864	4,092,561	10,869	1,144,742
India	2010	12,087,720	17,396	4,547,810	4,303,880	5,563	3,698,990
India	2014	12,329,482	19,136	4,809,303	4,097,197	20,553	1,886,750
Laos	2005	0	0	0	0	0	0
Laos	2010	0	0	0	0	0	0
Laos	2014	0	0	0	0	0	0
Myanmar	2005	46,058	0	7,736	0	0	8,051
Myanmar	2010	16,235	0	35,064	0	0	10,476
Myanmar	2014	76,368	0	83,015	0	0	27,145
Nepal	2005	0	0	9,000	0	0	7,000
Nepal	2010	0	0	43,148	0	0	10,130
Nepal	2014	0	0	96,718	0	0	41,940
Sri Lanka	2005	0	0	159,595	11,042	0	22,639
Sri Lanka	2010	0	0	166,096	10,000	0	40,679
Sri Lanka	2014	0	0	227,403	1,000	0	45,403

Source: FAO database, data was not found for Laos

Demand for fertilizer is also increasing substantially in some South Asian countries (Table 8). For instance, phosphorus exports increased from 255 thousand to 454 thousand tons in Bangladesh during the period between 2010 and 2014. Similar rates of both phosphorus and nitrogen exports occurred in Sri Lanka at the same period. In Myanmar and Nepal, demand for fertilizers increased more than five times in the period between 2005 and 2014. Rapidly increasing demand for fertilizers in these countries indicate a large market potentials for the soil amendments and compost recovered from organic waste and wastewater.

Infrastructure, governance and regulatory framework

Access on specific public services such as safe water and electricity is essential for technical feasibility of waste and wastewater management and recycling technologies. Sri Lanka is very well equipped with potable water and electricity provision services (Table 10). Water and electricity is also high in India and Nepal. Electricity access is low in Bangladesh and Myanmar which means potential difficulties in mechanical operations related with waste treatment and recycling. The development of information and communication technologies (ICT) which is essential in marketing the RRR products and improve the relationship between producers and consumers are quite low in Sri Lanka in contrast to India where ICT technologies are quite well developed.

Table 10. Infrastructure (2015)

Country	Access to water	Access to electricity	Information & communication technology index (0-9)
Bangladesh	86.9	62.4	4.5
India	94.1	79.2	6.0
Laos	75.7	78.1	2.5
Myanmar	80.6	52.0	4.5
Nepal	91.6	84.9	4.0
Sri Lanka	95.6	92.2	2.5

Source: World Development Indicators (World Bank)

Quality of public policies are important in order to carry forward entrepreneurship projects in general, and RRR projects in particular. In this sense, it is important to assess the general governance status in the countries in which these projects are meant to be driven. Table shows some indicators that could reflect in some way the quality of public policies and the good governance standing. Regarding corruption, the indicators show that in general all the countries perform poorly (all the indicators are negative). With respect to transparency and general governance quality, the outlook is still weak, although in comparative terms India outperform its peer countries by having relatively higher scores.

Table 11. Governance indicators (2016)

Country	Corruption index	Transparency index (voice and accountability score)	Governance quality (Government effectiveness)
Bangladesh	-0.80	-0.56	-0.69
India	-0.30	0.41	0.10
Laos	-0.93	-1.73	-0.39
Myanmar	-0.65	-0.85	-0.98
Nepal	-0.76	-0.23	-0.81
Sri Lanka	-0.28	-0.11	-0.21

Source: Worldwide Governance Indicators (WGI) - World Bank
Note: Indices range from -2.5 to 2.5, the most negative values reflect the worst condition.

Corruption rates and governance quality also somehow effects the costs of doing business. As shown in Table 12. In terms of the cost and time to start business, the studies countries are around the average for South Asia (83.3), with Sri Lanka as the top performer among the six. The index reflecting the cost of closing business is more heterogeneous considering the regional average (33.0), and reveals greater differences among the studied countries. Finally, the positions of the countries in the Ease of Doing Business ranking reflect in general a weak business environment as none of these economies lie among the top 100 performers across the globe. However, in South Asian region, business climate is more favorable India, Nepal and Sri Lanka than the remaining countries.

Table 12. Business environment

Country	Cost and Time to start business	Cost to close business	Enabling environment [Ease of doing Business rank among 190 countries (1 is best)]
Bangladesh	80.7	27.7	177
India	75.4	40.8	100
Laos	72.6	No data	141
Myanmar	75.4	20.4	171
Nepal	84.0	48.2	105
Sri Lanka	87.7	44.9	111

Source: Doing Business Report 2018 - World Bank
Note: 'Cost and Time to start a business' and 'Cost to close business' indices are expressed as the 'Distance to the frontier' (DTF), i.e., a low score represents a more adverse scenario in terms of starting and closing businesses. In turn, the 'Enabling environment' is an index position, in which 1 represents the top performer.

Given that organic fertilizer from organic waste is attractive RRR option in South Asia because of high share of rural population, dominance of agriculture among economic activities, and high levels of fertilizer imports, the costs and time for registering new fertilizer was also discussed here (Table 13). Costs and time for registering new fertilizer or soil amendment are quite unfavorable in Nepal as it may take almost four years. Though costs are not so much high, time for registration takes almost three years in India and Bangladesh. In Sri Lanka one year can be sufficient to test new fertilizer effectiveness and the costs for registration is on 4% of average per capita income.

Table 13. Easiness of registering new fertilizer

Economy	Fertilizer registration index (0-7)	Quality control of fertilizer index (0-7)	Time to register a new fertilizer product (days)	Cost to register a new fertilizer product (% income per capita)
Bangladesh	4.4	4.5	945	58.8
India	5.0	3.5	804	17.1
Lao PDR	3.4	5.0	No Data	0.5
Myanmar	4.4	3.0	41	7.3
Nepal	3.4	5.0	1125	645.2
Sri Lanka	2.4	3.5	365	3.7

Source: Doing Business Report 2018 - World Bank

Institutional framework for supporting organic waste management

Central government

Institutional framework and clear distribution of roles and responsibilities are essential for proper function of the waste management system. The role of institutions in South Asia regarding waste management could be distinguished in three levels: central government, regional/local governments and NGOs and civil society organizations (ADB 2011). The role of central government institutions consists basically in setting standards and policies and establishing coordination between different government levels. However, the ministries involved are diverse and so they are the roles that they have in the activities of waste management.

In a broad perspective, the Ministry of Environment is the institution in charge of setting the global policy of waste management and the compliance of the subnational governments and other institutions with these regulations. In addition, in some countries the Ministry of

Environment is the ruling organization in charge of agencies in charge of pollution control and environmental regulations.

On the other hand, the Ministry of Agriculture has the role of setting the productive policy of the sector, and in particular to set the standards for soil preparation, and the certification and use of fertilizers/compost. In this sense, this Ministry plays a key role in order to incentivize the use of organic fertilizers through subsidies, information campaigns and regulatory guidelines.

Other important Ministries that could play a role in the waste management are the Ministry of Urban Development and the Ministry of Energy. In the first case, the Ministry of Urban Development deals with the management of waste in urban centers, that could be of crucial importance in order to develop policies enabling the reduce/re-use/recycle (RRR) of organic residues. The role Ministry of Energy, in turn, deals with the setting of incentives/guidelines for the generation of renewable energy, by facilitating the setting up of infrastructure using waste to produce sustainable energy. In addition to set policies, the Ministry could also impose the use of subsidies or other kind of incentives, in order to trigger the use of RRR technologies in the sector.

Finally, the Ministry of Finance and the Ministry of Information have broader roles in terms of facilitating the reduce/re-use/recycle process. The Ministry of Finance is in charge of the budget and tax policy, and in this way, it institutes the general financing conditions under which the RRR process develops. The Ministry of Information is in charge of the ample communicational policy of the government, and could launch dissemination and / or awareness campaigns regarding appropriate waste management.

Regional/local governments

While the role of central government institutions lies on setting the rules for a proper waste management, the regional governments are actually the ones that potentially carry out the waste reduction, re-use, recycling activities at the local level. In this sense, their tasks are much more diverse than the ones of the specialized agencies of central government. Some of the tasks for local governments related with waste management are the following (ADB 2011):

- Ensuring land policies for organic waste management;
- Establishing incentives for the private participation in RRR activities;
- Promoting the use of RRR technologies, by creating community awareness;
- Providing support through local infrastructure (e.g., municipal roads), to enhance the RRR activities;
- Collecting and managing information regarding waste management, in order to improve processes and/or adjust procedures.

Civil Society and NGOs

The role of Civil Society organizations and NGOs are rather framed in the role of local governments, as entities in charge of facilitating and implementing the policies addressed to promote the waste management process. For example, they might help to raise community awareness regarding a proper waste behavior (e.g., separating garbage and correct disposal), managing information campaigns and working together with local governments to incentivize the waste reduction, re-use and recycling process.

Conclusions

Improved sanitation and wastewater management are important for environmental sustainability and health security in vast areas of South and Southeast Asia. As review results indicated open defecation is a major problem in India and Nepal due to lack of proper sanitation facilities and psychological barriers. In Laos and Myanmar, sludge and wastewater collection and treatment was quite underdeveloped. Though, sanitation facilities are available, wastewater treatment are not adequate or sufficient to meet health and environmental safety guidelines in Bangladesh and Sri Lanka. Some level of recycling sludge and organic waste through producing biogas or compost exist in India, Bangladesh, Nepal and Sri Lanka. At the same time most of these countries largely rely on the imports of expensive chemical fertilizers. Energy for cars and cooking are also largely imported. Reducing environmental pollution and decreasing the dependence on the imports of fertilizer and energy resources could be possible through a wider implementation of RRR technologies across these countries. However, inadequate financial resources, high levels of corruption and institutional barriers can be key barriers for a wider adoption of RRR options.

General lack of awareness on environmental sustainability and indifference towards environmental security imped the potential technological changes and maintain the continuity of waste and wastewater related pollution and diseases. Lack of demand for fertilizer or biofuel in urban area may limit the feasibility of RRR technologies in the country. Given its enormous environmental and health benefits, the RRR sector should be enhanced through subsidizing the implementation of composting and anaerobic digesters and developing public-private collaborations. The government should be more supportive of non-governmental organizations and international donors in their efforts for maintaining sustainable environment and livelihoods through increased recycling waste and wastewater. Education and extension programs should be established further for raising the Awareness of population on environmental and health risks and the adequacy of RRR technologies for addressing such issues.

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Appendix I: A critical review of approaches to assess business climate

All internal and external factors for the functioning of the enterprise or economic sector is integrated under the term business climate or business environment. Business environment is an environment where business operates and where government maintains institutions and policies for effective functioning of markets and entrepreneurship ultimately aiming prosperity and economic growth. Thus, in addition to technical, economic and financial feasibility of the project, institutional factors (laws and regulations), market conditions (competitors, tax burden, social acceptability), human resources (skills and capacities), and backward (suppliers) and forward linkages (customers) with other economic agents and market participants, are coined under this term. Business or investment climate has been commonly used to evaluate attractiveness of doing business in a particular country.

General interest in developing a set of indicators which allows for a diagnosis of business environment in a particular country was raised as early as 1970s. Several international research organizations have offered different approaches to evaluate the business climate since then. Ease of Doing Business Index (EDBI) by World Bank, Global Competitiveness Index (GCI) by World Economic Forum, Entrepreneurship Measurement Framework (EMF) by the Organization for Economic Co-operation and Development (OECD), Business Competitiveness Index (BCI) developed by Porter (2004), and Investment Compass Indicator (ICI) by United Nations Conference on Trade and Development (UNCTAD) are among them. The definitions of business environment by multiple organizations are differentiated because of their non-homogenous emphasis on different dimensions of business climate. For instance, more emphasis was put on jobs, economic growth and high return investment opportunities when calculating EDBI (World Bank 2006) but macroeconomic, institutional-legal and infrastructural frameworks are key aspects in calculating ICI (Stern 2002, Christy et al. 2009).

EDBI by World Bank is measured as an average value of several indexes such as easiness of starting business, obtaining construction permits, registering property, access to electricity, access to credit, protection of minor entrepreneurs, procedures of paying taxes, opportunities to overseas trade, enforcement of agreements and easiness of closing business (World Bank 2004). These aspects are assessed in terms of time required, costs, and volume of the procedure. Data was collected from statistical reports, information on laws and regulations, and through surveys of officially registered enterprises on their perceptions of barriers to businesses. Information on regulations are obtained through primary surveys of legal officers. Data behind Doing Business indicator was obtained by surveying formal enterprises only in countable number of the largest cities. Thus, this reflects only a limited geographic coverage within countries and does not consider informal sectors. Thus, although this indicator is good in assessing regulatory framework it can be quite limited to be applied for instance wastewater reuse sector which is largely informal in South Asia. Since most calculations are based on ranking the countries, it may have low practical value when there is only countable number of countries with a similar legal and cultural conditions. Macroeconomic and institutional frameworks are not also considered when using this indicator.

GCI by WEF considers both microeconomic and macroeconomic factors of business climate (WEF, 2014). According to this indicator, competitiveness of the economy which determines its prosperity depends on macroeconomic, institutional, and infrastructural conditions, quality of education, openness of markets, access to technology, investments in innovations, and protection of intellectual property rights. This indicator also considers the stages of development through attributing higher weights to sub-components which are more relevant in particular stage. For instance, for resource-driven economies, GCI is calculated by considering higher weights for well-functioning markets, developed infrastructure, and stable macroeconomic conditions. In innovative-driven economies, however, competitiveness is assessed through prioritizing quality of research, collaboration between universities and industry, protection of intellectual property. Given the differences in considered sub-components and weighting factors country ranks based on GCI and EDB indicators differ from each other (Christy et al., 2009). Despite several advantages of GCI over EDB indicator, it does not consider industry- or sector-specific assessment of the business climate.

BCI by Porter (2004) focuses on business climate at local level and addresses a rigorous assessment of competitiveness at firm- and national levels. Particularly, productivity of the firm is assumed to be largely dependent on factors such as sophistication of production processes, staff training, incentive compensation, level of customer orientation, capacity of innovation, value chain development and branding. Necessary yet insufficient external business climate conditions as considered in this index are access to inputs, human capital, infrastructure, technologies availability, demand conditions, and context for firm strategy and domestic rivalry. Despite advantages of this approach due to a detailed grass-root level assessment, requirements for intensive data collection impedes its application. Lack of reliable data, especially in developing countries, increases the challenge.

EMF by OECD is other measure to measure investment attractiveness of the economy (OECD 2008). Differing from the remaining indicators of measuring business climate that emphasizes on development of entrepreneurship, PFI attempts additionally considers the impact of entrepreneurship on the overall economy. Main subcomponents of PFI indicator are transparency of laws, intellectual property protection, investment promotion, reduced trade and transaction costs, fair competition, effective tax policy, capacity development, affordability of infrastructural services, and quality of public governance. PFI also does not aim to rank the countries based on averaged indexes. Instead this indicator informs investors and policy makers about important areas which needs attention for improving the efficiency of policies and supporting private sector growth (Christy et al., 2009).

ICI by UNCTAD focused more on macroeconomic and infrastructural conditions in assessing business climate. Main subcomponents considered in IC indicator are human capital (literacy rate, science and engineering students), availability of natural resources, market size (GDP, population), infrastructure (ICT, transportation), wage and administration costs, macroeconomic performance (inflation, growth rates, unemployment), governance quality, tax and subsidy incentives, and regulatory framework (property rights, settling disputes, regulations of foreign exchange, labor markets, etc.). While addressing very relevant and essential determinants of business climate IC indicator fails to take into account more detailed value chain components.

Summarizing this section, business climate indexes developed so far reflect the general economic conditions at national level and often miss sector-specific characteristics of business environments. Despite some subcomponents of the business climate indicators discussed above may have important implications also for individual sectors, main limitation of these indicators is that they largely ignore sector- or location specific factors of business climate. Thus sector-specific implications for institutional, legal and infrastructural improvements based on these indexes are very limited. Considering these limitations, revised set of subcomponents for assessing sector-specific business climate in agro-processing industry has been suggested (Christy et al. 2009). For waste and wastewater treatment sector, a similar set of indicators for reflecting business climate would additionally address environmental effects of pollution and environmental safety due to production operations, and geographic-climate conditions that largely effect on the effectiveness of recycling technologies and compost application. Particularly, since environmental benefits from water and wastewater treatment are public goods, beyond market conditions, entrepreneurial performances, economic, policy, institutional and regulatory frameworks, criteria should encapsulate environmental and health effects which are crucial for investment attractiveness of the RRR sector.

Most business climate indexes above mentioned focus on ex-post analysis where the surveyed firms already exist. However, given that waste-to-energy or waste-to-fertilizer companies are mostly new in many developing countries such as the ones in South Asia, ex-ante analysis tools for diagnosing business environment can be helpful for formulating effective decisions on efficient allocation of investments. In addition to general macroeconomic, institutional and infrastructural settings, input availability, output markets, competitors, governmental support, and environmental factors should be taken into account. For instance, business climate indicator for compost supply chain may highlight the reasons for farmer’s preference of compost use rather than chemical fertilizer application, climate and local conditions to produce and apply composts, availability of waste and wastewater for recovering nutrients, and environmental effects of the expansion of recycling.

Ranking the countries based on aggregated indexes constrains revealing details of factors that deteriorate business climate in particular sector or location, particularly when assessing macro-scale business climate. Given economic and cultural values as well as geographical resources vary across the countries more relevant set of indicators without normalization, indexing and ranking procedure can be more valuable for formulating effective transformation reforms. This type of dataset can be also further used directly in system level simulation analysis tools (mathematical optimization models).

Appendix II: Justification of the set of some indicators relevant for assessing the importance and feasibility of RRR business

For a proper assessment of macro-scale business environment in waste and wastewater treatment sector, both upstream and downstream value chains should be taken into account. Upstream value chain participants comprise input suppliers such as waste and wastewater generation units (livestock, fishery sectors, municipalities, households, etc.), producers of chemicals, and suppliers of machinery for treatment companies. Thus availability, quality and affordability of inputs determine the functioning, economic performance and durability of waste and wastewater treatment and recycling companies and projects. Downstream value chain actors include buyers and users of recovered fertilizer, effluents, and energy (biogas or electricity) and competitors in the respective commodity markets (chemical fertilizer, electricity or gas supply companies).

In addition to intersectorial production interlinkages and competing organizations, legal-institutional and macroeconomic frameworks can be shaped by law issuing agencies, municipal councils, and respective ministries for each participating sector such as agriculture, energy, water and environment ministries. General macroeconomic conditions such as openness of the economy, import dependence (for instance, to energy, water or fertilizer), export reliance (for instance, of agricultural commodities), inflation and exchange rates, income level also essential for assessing favorability of business climate for waste and wastewater treatment operations. Last but not least environmental factors, rainfall availability, soil characteristics, pollution levels because of waste and wastewater releases, carbon emission rates also plays important role for the efficient functioning of waste and wastewater treatment companies. Such set of essential indicators to assess a business climate in waste and wastewater recycling system at macro-(sectoral) scale is presented in Table A1:

Table A1. Set of factors for diagnosing a business climate for waste and wastewater recycling sector

Domains	**Indicators**	**Justification to selection**
Geographic	Location and administrative borders (maps)	Defines the market and production system borders
	Temperature	Impacts a choice of recycling or treatment technology and crop choice and yields
	Rainfall	Needed for assessing demand for effluents
	Surface and groundwater availability	Needed for assessing demand for effluents
	Landscape	Impacts on pollution generation and spread rates
Demographics	Population	Determines the levels of pollution and allows for assessing nutrients recovery potential from domestic waste
	Urbanization	Determines the levels and density of pollution
	Social structure (GDP per capita)	Impacts on willingness to adapt advanced sanitation, waste and wastewater treatment technologies
	Religions	Impacts on perceptions of people on recovering commodities from waste

		and wastewater, care of environmental resources
	Nationality	Impacts on perceptions of people on recovering commodities from waste and wastewater
Macroeconomic	GDP growth rates	Stability and sustainability of national economy creates favorable conditions for long-term investments in environmental protections
	GDP structure by sectors	Allows for assessing the role of agriculture and thus demand for soil amendments, and cross-checking waste generation by production sectors
	Employment rates by sectors	Allows for assessing availability of skills
	Exports and their sectoral structure	
	Imports and their sectoral structure	For estimating import reliance on fertilizer and energy consumption
	Inflation	Impacts on rate of returns, business risk and thus investment attractiveness

Input supplies	Availability of waste (manure from livestock sector, fecal sludge from sewerage plants, etc.)	Required for estimating the magnitude of recoverable nutrients
	Wastewater availability (from households and sewerage system)	Required for estimating the magnitude of recoverable nutrients and demand for related treatment technologies
	Waste and wastewater collection and treatment rates	Required to estimate a real levels of nutrients available from waste
	Availability and costs of machinery	Impacts on expansion rates of treatment and recycling plants
	Labor and capital use in sewage and sewerage sector	Indicates willingness to work in the sector
Agriculture (customer)	Crop production and cropland patterns	Determines demand for fertilizer
	Crop prices	Profitability of crops impacts on demand for fertilizer and soil amendments
	Regional diversification of cropland structure	Allows for estimating regionally varying demands for fertilizer
	Livestock production	Important to assess potential of manure production and nutrients availability from waste
Competing sectors or companies	Fertilizer availability and use	Determines fertilizer scarcity or abundance

	Fertilizer prices	Impacts on willingness to pay for compost
	Irrigation water uses	Impacts on demand for effluents use in agriculture
	Costs of alternative water supply augmentation options (desalinization, groundwater pumping, etc.)	Determines competitiveness of wastewater treatment technologies
	Environmental flow requirements	Impacts on demand for filling natural sites with effluents
	Municipal industrial water uses	Impacts on wastewater generation levels and nutrients availability
	Energy supplies and demands	Allows for assessing a demand for recovering energy commodities from waste and wastewater
	Costs of alternative energy supply measures	Impacts on economic feasibility and adoption rates of waste-to-energy technologies
Infrastructure	Access to sewage and sewerage system	Indicates a need for sanitation improvement, allows for assessing potential amounts of waste from domestic sector

	Transportation (Road quality, costs)	Promotes interregional cooperation and integration of regional and sectoral markets
	Access to energy and municipal water	Essential production inputs
	Education facilities	Serves for training the professionals in the field and raises awareness of people
Legal/institutional framework	Main laws related to environmental protection and waste/wastewater management	Serves as an incentive or prevention system
	Main laws in agriculture	Subsidizing fertilizer may reduce demand for organic compost
	Informal social rules (ethical and cultural values)	Affects perception of waste and wastewater recycling and recovered commodities
	Organizational structure of governance organizations	Enforces legislation and ensures responsibility
Environmental effects	CO_2 emissions	Contribution to climate change mitigation
	Water and soil pollution levels	Importance for population and environmental health

	Esthetic and economic value of clean environment	Importance for tourism income

Differing from previous approaches of evaluating doing business indicators, here variables for each domain can be separately analyzed and presented while providing a detailed insight into the system. This set of essential indicators may be also revised (expanded or shortened) depending on the local conditions of the particular country and specific economic sectors involved in integrated management of waste and wastewater generation and recycling. Since waste and wastewater generation locations may differ than the places where compost commodities are highly demanded additional analysis may be required to estimate regionally specific resources availability and demands concurrently considering transportation and transaction costs.