ASIA

Waste Management OUTLOOK

UN environment

Technology for Environment

AIT Asian Institute of Technology

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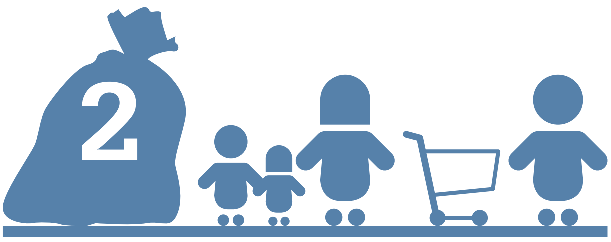
Contents

Introduction **1**

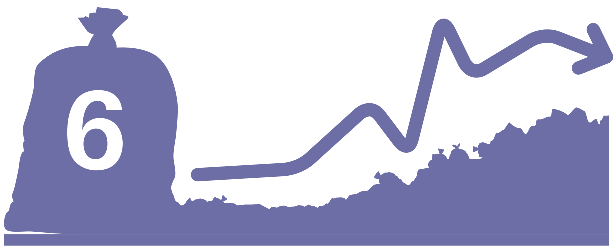


Waste Generation **21**

Waste Management **53**

Waste Economics and Financing 105

Waste Governance 147



Waste and Resource Management Indicators 171

7

List of Boxes, Figures and Tables

List of Boxes

List of Figures

List of Tables

Executive Summary

Asia, inhabited by more than 4.45 billion people in 2016, is the largest waste generating continent. Except Japan and the Republic of Korea, all Asian countries have witnessed an increase in average per capita waste generation over past two decades. A strong correlation between per capita waste generation and gross national income (GNI) is evident at both the country and city level. Decoupling between waste generation and income level is difficult to achieve at least for another decade. It is estimated that Asian cities alone will generate 1.8 billion tonnes in year 2025, compared to 0.28 billion tonnes in 2012.[1]

Availability of reliable waste statistics remains a major challenge in estimating waste generation. Urban waste statistics dominates waste generation in most Asian countries, but makes up a small fraction in terms of volumes when compared to non-urban waste streams (mining waste, agriculture waste, etc.) at the regional level. Composition of municipal solid waste (MSW) varies with the socioeconomic status of the waste generators. High-income countries produce a higher percentage of inorganic waste compared to organic waste. For example, Sri Lanka recorded the highest percentage of organic waste (80%),[2] and China, India, and Japan show higher generation of e-waste as compared to other countries in Asia. Construction and demolition (C&D) waste, a by-product of urban development, contribute to approximately 25–35 per cent of MSW.

Open dumping of waste continues to be the most commonly deployed waste management approach, especially in low- and middle-income countries. Statistics shows that in eastern Asia nearly 55 per cent of MSW was disposed in landfills, 59 per cent in South-East Asia and 74 per cent in South-Central Asia. A large number of these landfills are not scientifically operated and receive incoming waste without any treatment, leading to creation of dumpsites. Out of largest 50 dumpsites in the world, 17 are in Asia.[3] Gaps are serious in waste collection services as well. Except a few exceptions from high-income countries like Japan, the Republic of Korea, and Singapore, collection rates in Asian cities are rather dismal. The current situation demands that strengthening of basic infrastructure—for waste collection, treatment and disposal, including rehabilitation of the dump sites—must receive the topmost priority.

Almost all the countries have enacted waste-related legislation that prohibit the indiscriminate disposal of waste. However, compliance remain poor. Many countries have monitoring and reporting provisions, or both, but very few practice reporting with auditing, inspection, or oversight on a regular basis. Thus, there is need to step up the monitoring and enforcement.

Current infrastructure appears to be suffering from inadequate financial provisions for construction as well as operations. Most Asian countries share responsibilities for waste management between their local and national governments. The better established and more affluent municipalities are most likely to rely on more sustainable funding streams from municipal taxes as compared to smaller municipal bodies.

Support from national and state government is hence needed to establish basic waste management infrastructure. Costs of inaction or unsound waste management can be high. It is estimated that the cost of managing solid waste may range between 10 per cent and 35 per cent of the costs incurred for remediation. To assess the costs on a realistic basis, it is necessary to consider all the multimedia waste streams covering air emissions as well as wastewater apart from the solid wastes.

The informal sector plays an important role in waste management in Asia. Informal waste workers bring cost effectiveness and efficiency to key waste management processes of collection, segregation, and recycling. However, provisions for occupational health and safety and environmental safeguards remain poor. Capacity building is required to impart health and safety know-how, and financial support is required to incentivise

1 Hoornweg and Bhada-Tata (2012).
2 Onogawa (2016).
3 Waste Atlas (2013).

the contribution of informal waste workers. Integration between the formal and informal sector is thus essential. Initiatives like Swach in Pune India are the leading examples.[4]

Positioning the informal sector in integrated solid waste management—with Reduce, Reuse, and Recycle (3Rs)—is the key. It has an enormous potential for creating green jobs and promoting entrepreneurship. Civil society organisations play an important role in integrating informal sector with formal waste management system. In Bangladesh for example, an organic waste composting project helped create 400 jobs for collection activities and 800 jobs for compost processing.[5] The government of India has initiated capacity-building programmes to help develop the skill sets of the informal sector for employment through the Skill Council for Green Jobs.

Many technological interventions and adaptations are required to improve waste collection, segregation, and material recovery. Most cities of low-middle income regions employ manual labour to collect waste with brooms and wheelbarrows. In most cases, waste sorting is done manually. Cities need to invest in collection and sorting equipment and material recovery facilities (MRFs) also called *waste sorting centres*. This AWMO lists many case examples of innovations in waste collection, sorting, and material recovery from Asia. Innovations are needed for the recovery of metals from e-waste and fuel from plastic to reduce consumption of virgin fossil-based resources.

Asia holds the potential to be the largest market for secondary materials. High-volume bulk waste streams such as C&D waste offer high potential for material recovery. China has become the largest industry for secondary plastics. China along with Japan are the biggest market for secondary paper. The private sector must be encouraged through innovative business models and financial incentives to take up waste recycling and treatment. Result-based financing and innovative financial instruments, such as green bonds, may be considered to link sustainable waste management to reduction in greenhouse gas emissions.

A shift from centralised waste management to decentralised strategies is being witnessed owing to the economic, social, and environmental benefits they offer. A zero-waste approach based on industrial symbiosis needs to be considered, following that applied in the eco-towns and biomass towns in Japan.

To move toward a circular economy, products should be designed to minimise the consumption of natural resources and waste generation across the product's life cycle. Dematerialisation, responsible consumption, and producer's responsibility must be promoted and supported by policies. Green products and procurement policies can play a leading role in promotion of waste reduction and resource efficiency improvement programmes. For example, Asia Green Network launched, Japan's Top Runner energy efficiency programme, and India's GreenPro of Confederation of Indian Industry (CII) are some of the leading initiatives that are promoting green product design.

Take back policy is now picking up amongst manufacturers in Asia owing to pressure from regulators and the economics. Reverse vending machines (RVMs) are particularly popular in places that have mandatory recycling laws or require container deposits like China. Information-based instruments have an important role to play to influence consumers on the benefits of the 3Rs. In Asia, the use of information-based instruments is still rather low.

To achieve the true benefits of material circularity, waste management policy and institutions are required to move beyond residue-based management to holistic life cycle-based waste management. Currently, 3R programmes tend to be limited to waste recycling and reuse, with little progress on preventive approaches especially "reduce". Japan and the Republic of Korea are the leading examples where waste reduction and the effective use of secondary materials have been included in the waste management framework for reduction of waste and closed material cycles. These examples should be adopted by other Asian countries. But in this context, the role of the private sector is very important.

It appears that urban local bodies are more familiar and equipped for management of MSW than other important waste streams such as C&D waste, e-waste, and health care waste. End-of-life vehicle waste appears to be of rising concern and needs to be addressed on a priority basis. Other challenges are emerging in the form of absorbent hygiene products (feminine sanitary products, baby and adult incontinence diapers), plastics (like acrylonitrile butadiene styrene used in household and consumer goods) and microplastic

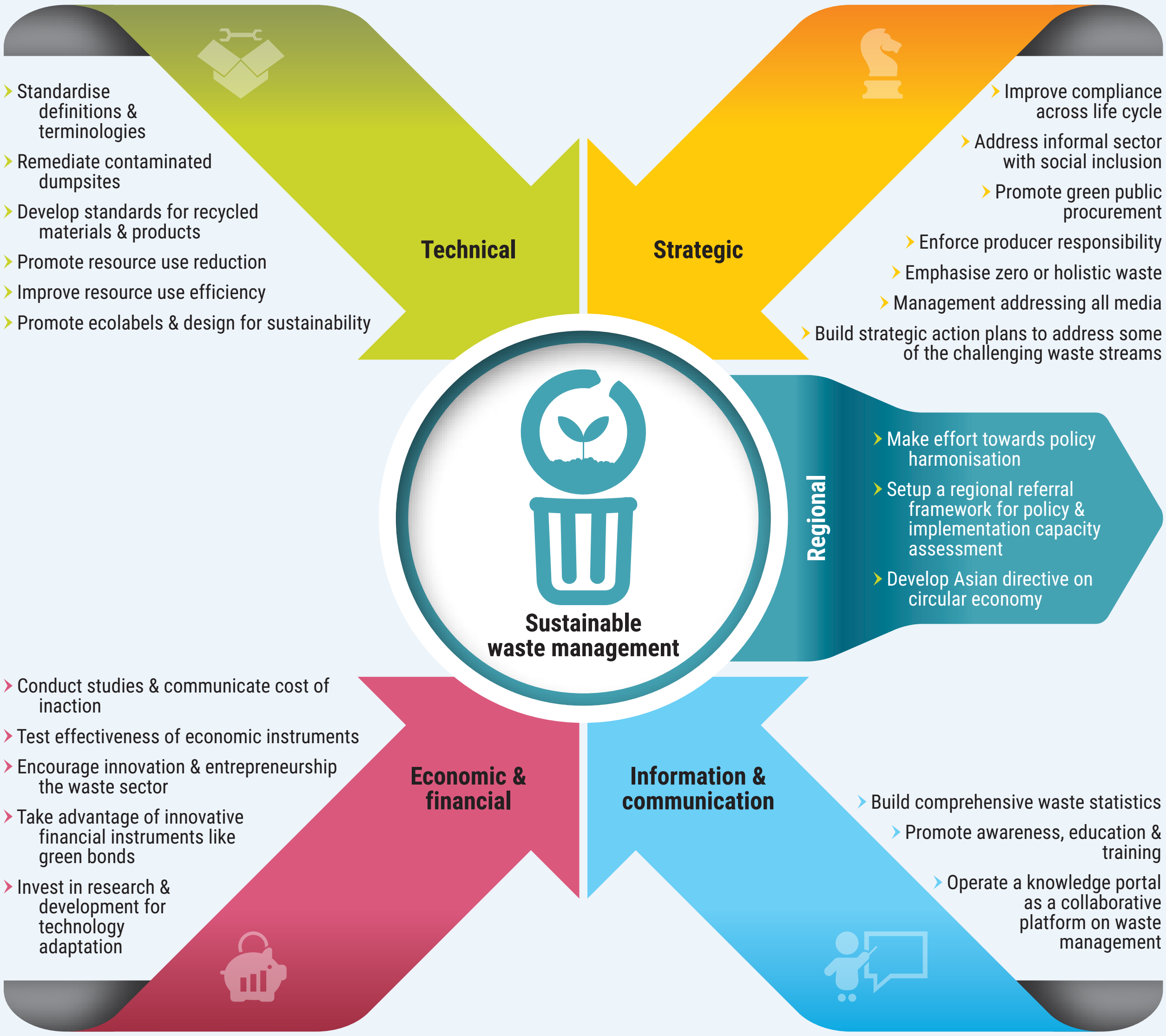
4 *www.swachcoop.com*
5 Sinha and Enayetullah (2010).

(found in basic personal care products, such as facewash and body lotion that are difficult to degrade), waste tires, and discarded solar photovoltaic systems. It is necessary to prepare an inventory of such waste streams, expand the regulatory framework, and build capacities of the enforcing institutions.

In the beginning of the 21st century, the Asia-Pacific region overtook the rest of the world to become the single largest consumer of natural resources. Urbanisation and economic growth has led to a rise in the consumption of lifestyle products, beverages, electronics, and so forth. Considering rising consumption and the state of poor waste management infrastructure, a paradigm shift is needed from traditional waste management to sustainable consumption and production (SCP). To achieve the SCP which is Sustainable Development Goal (SDG) No. 12, there is a need to practice circular economy and mainstream life cycle thinking. Practical implementation of the SCP concept requires capacity building of local bodies and policy makers and involvement of the private sector. Such initiative can be incentivised by accounting for their contribution to local and regional political goals, and key global commitments like the SDGs, Kyoto Protocol, Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, and Agenda 21 at the Earth Summit.

The Outlook provides an overview of the current status, the current thinking on “state of the art” topics, and the future of SWM in Asia over the medium term. Both challenges, as well as opportunities, have been described through case studies. The recommendations are made from technical, strategic, economic, and communication perspectives.

The figure below depicts possible actions that may be used to draw a national or a city level plan towards sustainable waste management.



To ensure that the actions recommended above are implemented in synergy and in an optimal manner, coordination is needed between ministries at the national level. The creation of network approach, connecting cities at the country level as well as across the region will be important, is an endeavor that merits the exchange of knowledge and sharing of best practices. Because waste is transported across the Asian region through the trade flows, a harmonisation between national policies is also essential to address important waste streams such as e-waste. It is hoped that this Outlook helps policy makers and regulators to guide in this direction.

Introduction

1.1 Introduction

The Asia Waste Management Outlook (AWMO) provides an overview of the challenges and opportunities in waste management in the context of Asia. The AWMO is not intended to be a directory of waste-related data or statistics; rather, it is intended to provide a perspective with prescriptions for a variety of stakeholders to encourage early action. It is also intended to provide an overview of the current status, current cutting-edge thinking, and the future of solid waste management in Asia over the medium term. While high-income countries in Asia, such as Japan and the Republic of Korea, provide an aspirational context to other countries in the region, it is worth noting that even after many decades of interventions by multilateral and bilateral donors as well as the private sector, the solid waste management system in Asia still remains in a precarious state. There is a need for a paradigm shift from waste management to resource conservation and recovery, the practice of a circular economy, and the introduction of life-cycle thinking to prevent and minimise waste as a business case for social responsibility. Practitioners in this field should keep in mind the significant financial and institutional commitments required to improve current standards in all phases of waste management. In this regard, AWMO emphasises involvement of multiple stakeholders, the forging of partnerships and regional cooperation.

The AWMO aims to provide the rationale for taking a holistic approach towards waste management and for recognizing waste and resource management as a significant contributor to Asia's sustainable development. It also underscores the importance of addressing climate change mitigation through sustainable waste management practices. Specifically, the AWMO focuses on the following objectives:

- Position waste management as an area requiring urgent action, and call for policy and decision makers to take required actions and provide guidance for the same.

- Promote the concept of circular economy as one of the key takeaways. Similarly, to recommend an integrated approach to waste management as one of our key recommendations (i.e., multi-media and various waste streams).

- Emphasise the relation of waste and resource management to other challenges in Asia, such as sustainable development, water and energy balance, sound chemicals management, climate change, resource scarcity and security, and poverty alleviation. Attempt to establish the links to wider health and environmental policy-related challenges.

- Identify policies and governance strategies for sustainable waste management, while considering the varying levels of economic and human development across the countries of Asia, their priorities, needs and capacities. Also, provide a critical overview of policy instruments that have been deployed, what has worked and what has not and under what circumstances.

- Examine the available approaches to waste management financing and provide guidance on various sustainable financing models for a particular local situation; consider the direct costs and revenues, the costs of inaction, and the indirect benefits of environmentally sound waste management; examine how to raise sufficient revenue to cover the net costs of service provision; and explore investment financing.

- Propose a set of performance indicators on waste management that allow benchmarking exercises, facilitate better analysis of the state of waste management in Asia, and provide a standardised means for monitoring progress.

1.2 Audience

The AWMO is relevant to all countries in Asia, regardless of their current state of development in terms of waste and resource management. That said, it places particular focus on low-income and middle-income countries, which are struggling to address challenges on waste and resource management.

The AWMO is targeted at a relatively high, but non-technical, level to a wide range of professionals and decision makers at both national as well as local government level and other groups of stakeholders, including NGOs, community-based organisations, businesses, the manufacturing sector, the waste industry, financial institutions and research institutions and academia. Chapter 7, in particular, provides a call to action to set out a potential way forward.

1.3 Scope and Coverage

The term “waste” is often broadly used to describe unwanted outputs of human activity in the form of gases, liquids and solids, as well as emissions to the three environmental media, that is, air, water and land. The UN Statistics Division uses the term “residuals” rather than “waste”. ‘The “residuals” are then subdivided into three parts: emissions to air, generation of wastewater, and generation of wastes.[1] The scope of AWMO is focused primarily on solid wastes with emphasis on municipal solid waste (MSW) owing to limited data available on the other waste streams. Important solid waste streams such as construction and demolition (C&D), e-waste and healthcare/biomedical waste are discussed, including emerging waste streams. Owing to the increase in the frequency of natural and climate-related disasters, disaster waste is also addressed in the AWMO.[2]

Although we have not included waste inventories, situation analyses and practical experience on other forms of wastes such as waste water and air emissions, we have emphasised that a multimedia consideration is needed when management of solid wastes is concerned. This is necessary to ensure that the resulting residues and emissions to air and waterbodies are adequately addressed. Environmental management works best if policy and regulatory control, and the agencies in charge of each, address all the media (e.g., wastes and emissions to air, water and land). Unless (solid) waste management is tackled alongside air and water pollution control, the pollution is merely shifted from one receiving medium to another.[3] A holistic consideration is thus necessary across all media towards achieving zero waste.

1 UNSD (2013).
2 Samaria Garrett (2015).
3 UNEP (2015a).

Geographically, the scope of AWMO includes all the nations within Asia. Out of these, 25 countries representative of the diverse sociocultural, economic and technological characteristics of Asia have been selected for the detailed profiling of waste management.

Figure 1.1 shows the geographical scope of AWMO. The AWMO, along with other regional outlooks, is a derivative of the Global Waste Management Outlook (GWMO), published in 2015. The GWMO was the first comprehensive and in-depth assessment of global waste management. The AWMO follows the same goals of providing information about trends and policy analysis, and it offers guidance on the way forward to decision makers for the Asian region.

Figure 1.1 : **Geographical Scope of AWMO**

1.4 Emphasis

The AWMO emphasises the following key concepts, outlined in brief so as to set the context for the rest of the report.

- Life cycle thinking (LCT)
- Sustainable consumption and production (SCP)
- Integrated solid waste management (ISWM) emphasizing the 3Rs and circular economy

These concepts are woven throughout the document to provide an overview of the current scenario of waste management, while at the same time, exploring how these concepts are inherent within solid waste management goals of resource management, environmental protection and safeguarding public health.

1.4.1 Life Cycle Thinking

Life cycle thinking (LCT) goes beyond the traditional focus on production and manufacturing processes to include environmental, social and economic impacts of a product over its entire life cycle. The main goals of LCT are to reduce a product's resource use and emissions to the environment as well as to improve its socio-economic performance throughout its life span.[4]

LCT considers the range of impacts throughout the life of a product by taking the entire life cycle into account — from the extraction of natural resources to material processing, manufacturing, distribution and use, and finally to the reuse, recycling, recovery and disposal of any remaining waste. Life cycle assessments (LCA) quantify these steps by assessing the emissions, resources consumed and pressures on health, environment and safety that can be attributed to a product or services. In addition, LCAs may also include social (e.g., employment), economic (e.g., costs) and sustainability-related considerations.

Figure 1.2 shows the typical approach followed in LCT.

4 For more information, visit the Life Cycle Initiative's web page "What is life cycle thinking? Available from: *http://www.lifecycleinitiative.org/starting-life- cycle-thinking/what-is-life-cycle-thinking/* (accessed 23 January 2017).

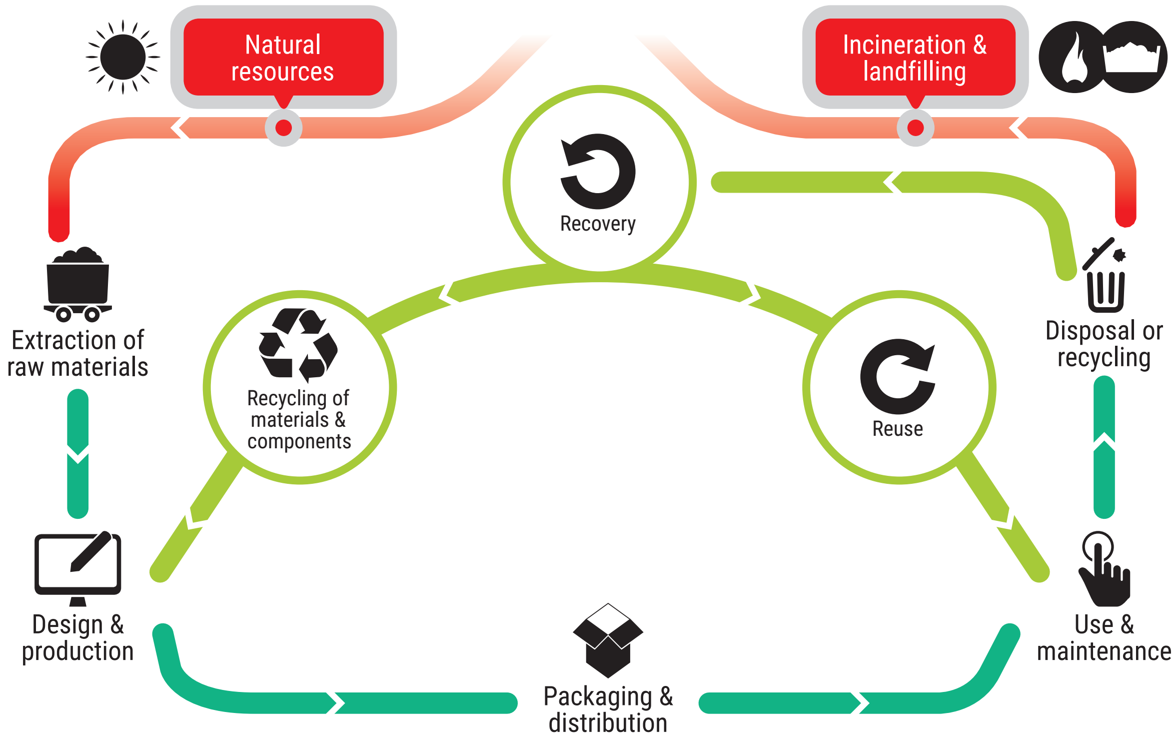


Figure 1.2 : **Approach to Life Cycle Thinking**

Source: Life Cycle Initiative (2007).

Box 1.1 illustrates a few examples of LCT. Few countries and businesses in Asia have integrated LCT in their waste management-related practices and strategies.

Box 1.1 **Examples of Life Cycle Thinking**

Life cycle thinking can be understood and implemented at different scales. At the national level, many countries in Asia have "eco-labels" as a broad approach for addressing the consumption side of the economy. Thailand's Ministry of Industry and the Thailand Business Council for Sustainable Development encourages businesses to improve the environmental quality of their products and services by stimulating consumer demand for such products. A green label scheme was implemented that established product criteria and certified products that have a lower impact on the environment compared to other products serving the same function. Product criteria are based on the impacts a product may have on the environment during its life cycle (referred to as "life cycle consideration"), as well as on how easily businesses can meet this criteria with reasonable process changes or improvements[a].

In the case of businesses, we can see examples of extended producer responsibility being driven by LCT. For example, the electronics manufacturing company, Sony, subscribes to the principle of Individual Producer Responsibility (IPR), the idea that a producer bears responsibility for its products over their entire life cycle. Sony's processes focus on recycling-oriented product design and the collection and recycling of used products. In 2015, Sony recovered resources from approximately 65,000 tonnes of collected end-of-life products from across the globe, a considerable portion coming from Japan and East Asia.

a. UNEP (2004).

Note: For information, visit Sony's product recycling policy and performance web page (updated on September 7, 2016). Available from: *http://www.sony.net/SonyInfo/csr_report/environment/recycle/performance.html#block2* (accessed 23 January 2017).

1.4.2 Sustainable Consumption and Production

1

Consumerism in Asia is increasing at a rapid pace. Urbanisation, rapidly developing economies and increasing spending capacity have led to a desire for improved quality of life in Asia. This has led to higher material consumption of lifestyle products, food and beverages, electronics, etc. Increasing access to the internet, e-commerce and smartphone applications have also resulted in a boom to the consumption patterns in Asia and elsewhere.

In the beginning of the 21st century, the Asia-Pacific region overtook the rest of the world to become the single largest user of natural resources. In 2005, the resources used included biomass, fossil fuels, metals, and industrial and construction minerals, amounting to about 32 billion tonnes or 8.6 tonnes per capita.

Figures 1.3 and 1.4 show consumption trends across the globe and in Asian countries. The countries in the Asia-Pacific region show a steep rise in both consumption and material intensity. The consumption patterns in the region are uneven, and Figure 1.5 shows material use per capita, indicating a diverse situation across the Asia-Pacific region.

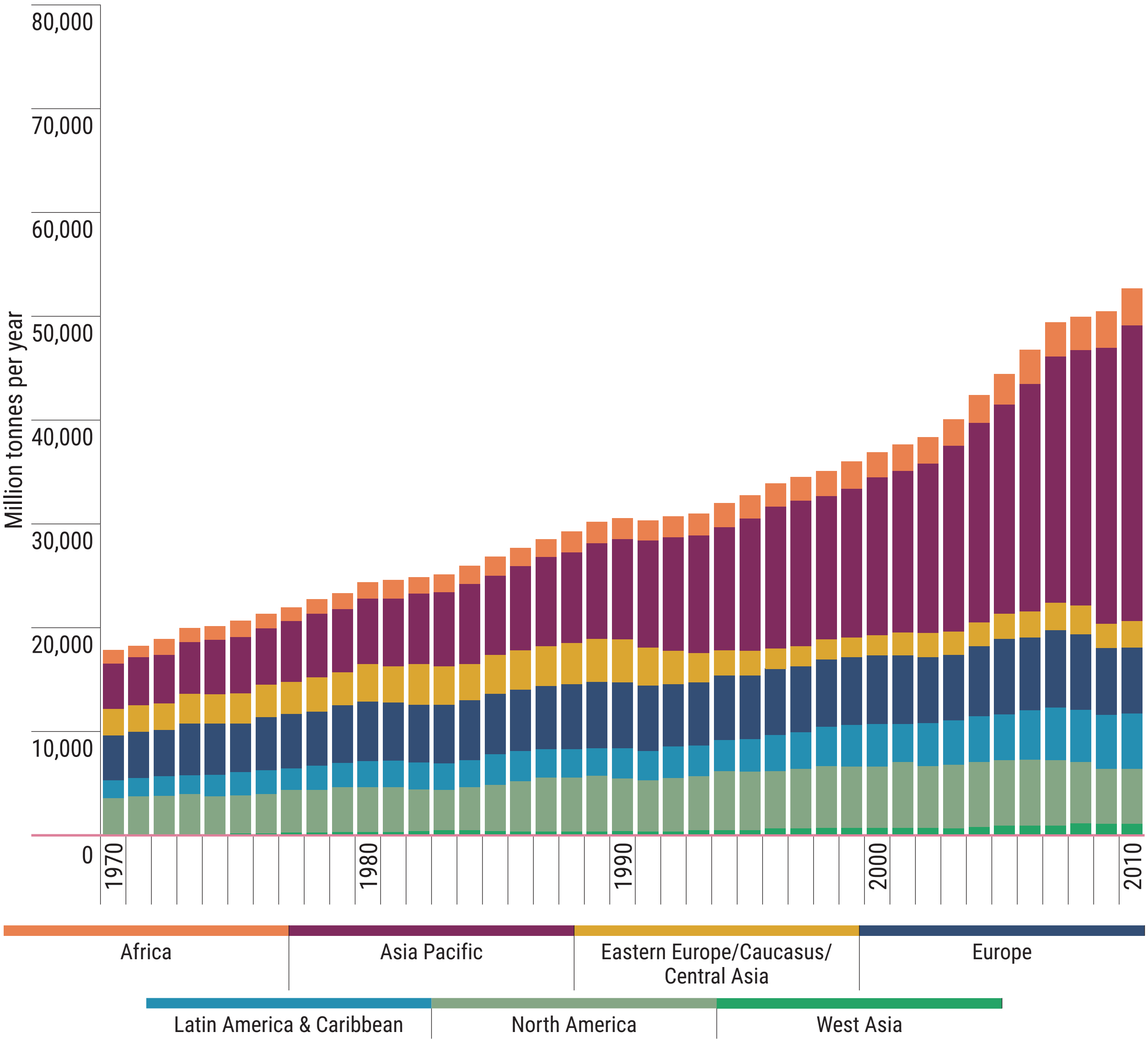


Figure 1.3 : Annual Material Consumption for the Asia-Pacific Region Compared to Other Regions from 1970–2010

Source: UNEP and International Resource Panel (2016).

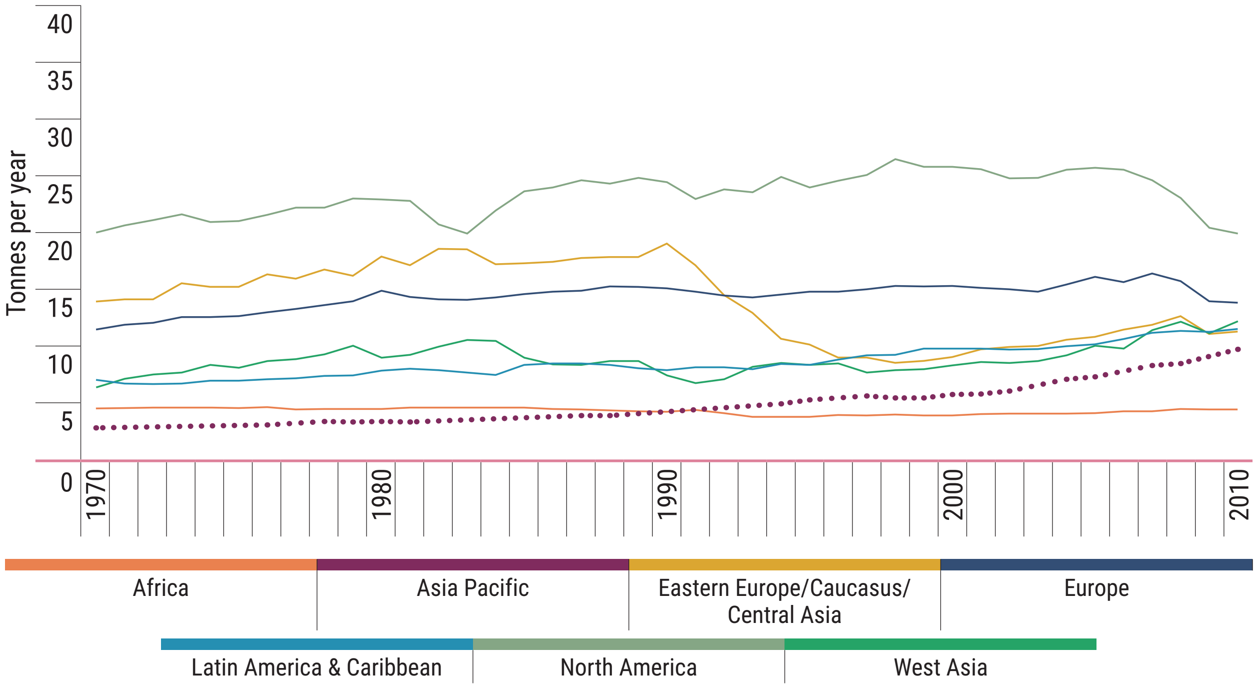


Figure 1.4 : **Per Capita Domestic Material Consumption in Asia-Pacific Compared to Other Regions, 1970–2010**

Source: UNEP and International Resource Panel (2016).

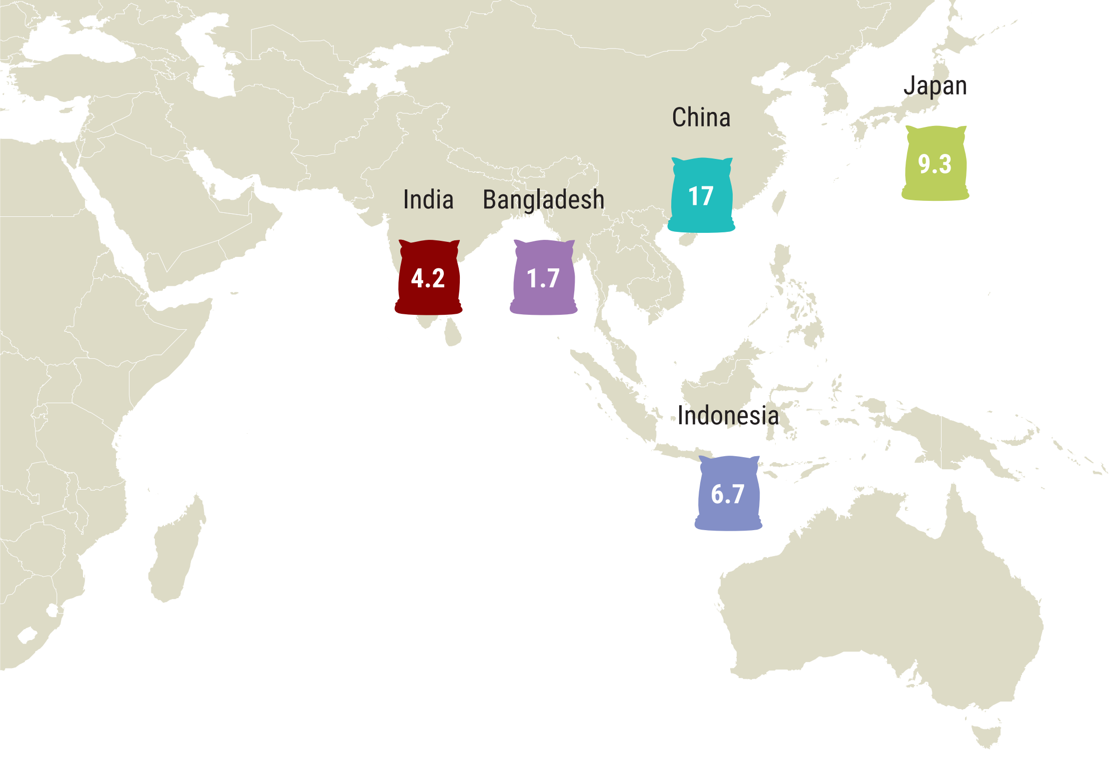


Figure 1.5 : **Per Capita Material Use in Asia-Pacific, 2015 in Metric Tonnes**

Source: UNEP (2015b).

Sustainable consumption and production (SCP) is an umbrella term that combines a number of key issues, such as meeting needs, enhancing quality of life, improving resource efficiency, minimizing waste, taking a life cycle perspective, and taking the equity dimension into account. Integrating these components is the central question of how to provide the same or better services to meet the basic requirements of life and the aspiration for improvement, for both current and future generations, while continually reducing environmental damage and the risk to human health.[5]

Figure 1.6 shows the key elements of SCP. It is clear that these elements play an important role in addressing the concerns of rising resource consumption and high levels of waste generation.

Figure 1.6 : Key Elements of Sustainable Consumption and Production

Source: UNEP (2010).

SCP aims at "doing more and better with less". It requires a systemic approach and cooperation among stakeholders operating in the supply chain from producer to final consumer. It involves engaging consumers by raising awareness on sustainable consumption and lifestyles, providing consumers with adequate information through standards and labels and engaging in sustainable public procurement, among other activities.

In addition to innovative approaches to the management of waste, national sustainable consumption policies and schemes for organisations and individuals can positively impact the waste management cycle by reducing waste across different streams and improving the recyclability of products.

For example, the EU textile industry awards the "Green Cotton Label" to textiles that are produced in an environmentally friendly way without toxic substances. To achieve this certification, the entire life cycle of the product is considered from cradle-to-grave.

Unlike downstream waste management activities, which involve management of generated waste, sustainable consumption necessitates stakeholder interventions at pre-product consumption stages. Stakeholders, including policy makers, product designers, media houses, retailers and consumers, should play a role in

5 UNEP (2001).

promoting sustainable consumption patterns by developing relevant policies, sustainable product design, and responsible advertising for the environment and purchasing practices. LCT is one of the core concepts and drivers of SCP. The status on SCP can be assessed by measuring material flows and resource efficiency.

Box 1.2 provides information on the online database created by Commonwealth Scientific and Industrial Research Organisation (CSIRO) and UN Environment on material flows.

Box 1.2 **Measuring Material Flows and Resource Efficiency: CSIRO and UN Environment Asia-Pacific Material Flows Online Database**

Sound decision making requires good data and analysis. To facilitate reliable resource efficiency-related policies in the Asia region, the CSIRO along with UN Environment developed a database for the Asia-Pacific region to analyse primary material flows and establish indicators of resource efficiency based on these flows.

Material uses and resource efficiency in the region overall focus on ten countries for which data is largely available: Australia, China, India, Indonesia, Japan, Republic of Korea, Lao People's Democratic Republic and Papua New Guinea. Data on the extraction, export and import, per capita material extraction, consumption and trade patterns of material ores, industrial minerals, fossil fuels, construction minerals and biomass are analysed and published.

This data is intended to help governments, policy researchers and stakeholders to plan for green economies by:

- Developing a better understanding of how economic growth patterns influence resource use.
- Evaluating the impacts of policies that have been adopted in the past.
- Developing effective strategies to minimise resource use through targeted sustainable consumption and production policies and actions.

Source: UNEP and CSIRO (2013).

1.4.3 Integrated Solid Waste Management with an Emphasis on the 3Rs

Integrated solid waste management (ISWM) is a comprehensive approach that encompasses the management of all types of waste including municipal, C&D, healthcare/biomedical, e-waste, including their generation, segregation, collection, treatment, reuse, refurbishing, recycling and disposal. Another dimension that is critical in ISWM is resource conservation and resource recovery. To cater to this aspect, the 3Rs become a guiding factor in the concept of ISWM.

3Rs — Reduce, Reuse and Recycle — is a hierarchical approach to waste management that aims to reduce waste volumes and conserves natural resources, landfill space and energy.

ISWM and the 3Rs should be integrated at the relevant stages in a waste management system, as shown in Figure 1.7. Waste generation should be reduced and once generated, waste reuse or recycling should be maximised to divert or reduce waste from being disposed of. Moreover, Box 1.3 illustrates some successful applications of ISWM with 3Rs.

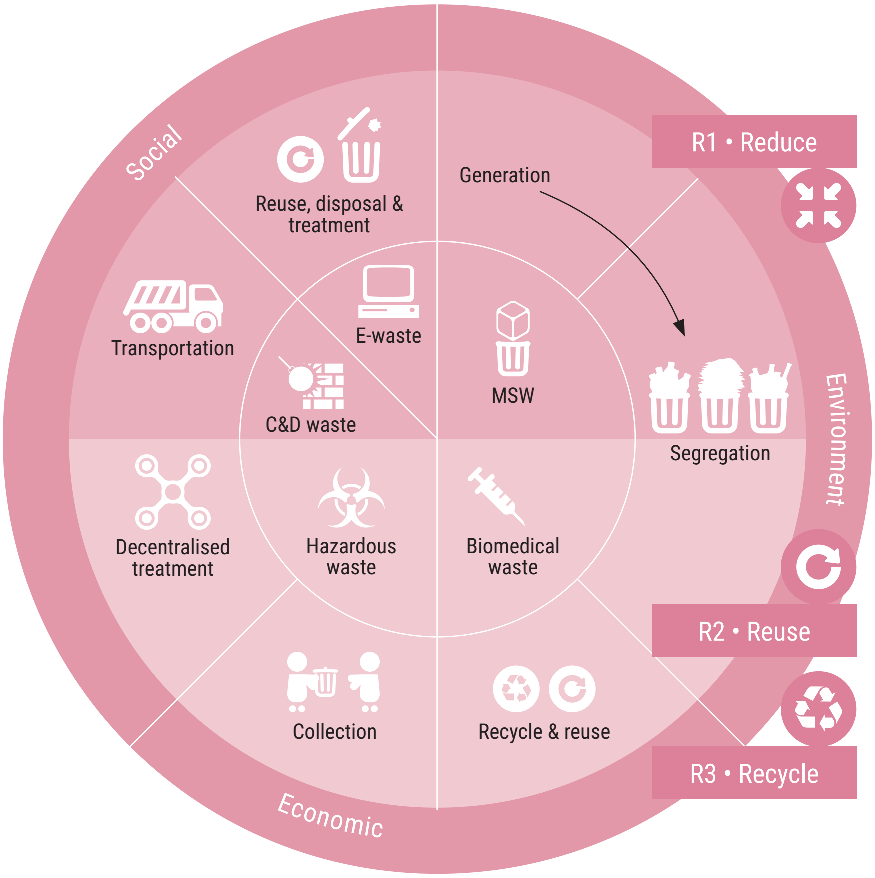


Figure 1.7 : ISWM Integrated with the 3Rs

Source: UNEP (2009).

Box 1.3 Successful Examples of ISWM with the 3Rs

Several examples of successful ISWM implementation exist at the regional level in Asia. In the Pune, India, the municipal corporation piloted a waste collection approach in partnership with not-for-profit organisations whereby they trained 1,500 waste pickers in door-to-door collection to provide services to 125,000 households in exchange for user fees. The pilot was successful as a sustainable mechanism for institutionalizing door-to-door collection and improved working conditions of the waste pickers. The pilot was scaled to cover 60 per cent of the city, involving a cooperative of waste pickers to collect the waste from households, for a user fee, deposit the waste in Pune Municipal Corporation (PMC) bins and then retrieve and sell recyclables and retain the earnings. As of today, the cooperative covers 122 out of 144 wards in Pune. The organic waste stream is processed in decentralised biogas (for commercial wet waste) or composting plants (for residential wet waste) across the city. The electricity generated from the biogas plants is used to power street lights whereas the compost is used in city gardens.

In China, Wuxi New District and UN Environment launched a project on the development and implementation of an integrated waste management plan in March 2008, which aimed to addressing the issue of solid waste generated both from industrial as well as domestic sources. Under the requirement of a national plan to enhance waste management, a 100 per cent collection rate for urban and suburban areas under the jurisdiction of Wuxi New District was envisaged in the future. Thus, in the future, there would be no waste dumping in this district.

Source: India, National Institute of Urban Affairs (2015).

1.4.4 Circular Economy

A circular economy is an economy that balances economic development with environment and resource conservation.[6] It emphasises closed material flows, efficient use of natural resources, coupled with low consumption of energy and low emission of pollutants. It also involves applying a cleaner production approach in companies, eco-industrial park development and integrated resource-based planning for development in industry, agriculture and urban areas.

The principles of a circular economy are:[7]

- **Design out waste**: Products should be designed so that organic fractions can be easily separated and other resources can be recovered using minimal energy and highest quality retention.
- **Build resilience through diversity**: Modularity, versatility and adaptability of products and systems need to be prioritised in an uncertain and fast-evolving world. Diverse systems are more resilient in the face of external shocks than systems built simply for efficiency—throughput maximisation driven to the extreme results in fragility.
- **Rely on energy renewable sources**: Systems should ultimately aim to run on renewable sources.
- **Think in "systems"**: Systems thinking usually refers to non-linear systems (feedback loops) that are designed to evolve with feedback and human-centric requirements.

Although circular economy laws exist across the globe, it is mainly some countries in Europe that have taken a major lead. In 2015, the European Union adopted a new circular economy package that included a requirement to communicate an action plan, list follow-up initiatives and introduce legislative proposals to support the European Union (EU) waste directive. Priority sectors include biomass and bioproducts, plastics, C&D waste, critical raw materials and food waste.

Box 1.4 provides an overview of some of initiatives related to the circular economy in Asia.

Box 1.4 **Overview of Some Circular Economy-related Initiatives in Asia**

In the Asian context, Japan moved towards a highly efficient circular economy primarily as a result of the pioneering Law for the Promotion of Efficient Utilisation of Resources, passed in 2000[a]. China followed suit by adopting the Circular Economy Promotion Law in August 2008 to improve resource utilisation efficiency, protect and improve the environment and realise sustainable development.

The "green growth" model, adopted by the Republic of Korea also underlines the principles of circular economy. It emphasises the need to continue growing economically but under a scenario whereby greenhouse gas (GHG) emissions are reduced to specific levels to mitigate climate change and generate new growth engines such as green technology, green industries and green jobs. The green growth model is distinctively characterised by its high degree of bureaucratic centralisation and strong top-down leadership that elevates green growth as a national priority.

In India, the Indian Resource Panel was set up in October 2015 under the ministry of environment, forest and climate change (MoEFCC) to advise the Government of India and relevant stakeholders on the potential for enhancing resource efficiency and the productive use of secondary raw materials. Some of the key actions identified included developing standards for resource efficiency and secondary resource management, creating a market for waste materials of potential value, developing a green industrial policy, promoting sustainable industrial areas, and green public procurement.

a. Braw (2014).

Note: Life Cycle Thinking (LCT) goes traditional production and manufacturing processes, including the product life cycle's environmental, social and economic impacts. For more information, visit the Life Cycle Initiative's web page "What is life cycle thinking? Available from*: http://www.lifecycleinitiative.org/starting-life- cycle-thinking/what-is-life-cycle-thinking/* (accessed 23 January 2017).

6 UNEP (2010).
7 Ellen Macarthur Foundation (2013).

Recycling facility, Phitsanulok, Thailand

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1.5 Alignment with Globally and Regionally Agreed Goals

In Asia, as with the rest of the world, numerous goals and agreements have been agreed upon through several conventions, which have provided direction to waste management on a global and regional scale. The waste management scenario we see today is a result of these agendas and commonly agreed upon goals. Milestones of key global agreements are shown in the timeline in Figure 1.8.

1.5.1 Sustainable Development Goals

As shown in Figure 1.8, during the past several decades the world has come a long way in addressing complex issues regarding waste management. The latest on the list of waste-related global agreements is 2030 Agenda for Sustainable Development. In 2015, at a United Nations (UN) summit, world leaders adopted a set of goals to end poverty, protect the planet, and ensure prosperity for all as part of a new sustainable development agenda. Each goal has specific targets to be achieved over the next 15 years.

The Sustainable Development Goals (SDGs) build on the success of the Millennium Development Goals (MDGs) and aim to go further in their targets. In 2016, the 17 SDGs of the Agenda 2030 officially came into force.[8]

The SDGs are shown in Box 1.5.

Box 1.5 **The Sustainable Development Goals**

1. No poverty
2. Zero hunger
3. Good health and well-being
4. Quality education
5. Gender equality
6. Clean water and sanitation
7. Affordable and clean energy
8. Decent work and economic growth
9. Industry, innovation and infrastructure
10. Reduced inequalities
11. Sustainable cities and communities
12. Responsible consumption and production
13. Climate action
14. Life below water
15. Life on land
16. Peace, justice and strong institutions
17. Partnership for the goals

The 17 Sustainable Development Goals (SDGs), part of the 2030 Agenda for Sustainable Development, came into force on 1 January 2016. For more information, visit the United Nation's web page, The Sustainable Development Agenda. Available from: *http://www.un.org/sustainabledevelopment/development-agenda/* (accessed 24 January 2017).

8 Ibid.

1970

1972
International Convention on the Prevention of Marine Pollution by the Dumping of Wastes and Other Matter[a]
- Key focus areas in WM: international control and prevention of marine pollution by prohibiting the dumping of hazardous materials (permissible materials enumerated) and banning incineration of industrial wastes at sea (amendment)

1980

1989
Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal[b]
- Key focus areas in WM: reduce hazardous waste generation, promote environmentally sound management of hazardous wastes, restrict trans boundary movements of hazardous waste (subject to exceptions), regulatory system for cases where trans boundary movements are permissible

1990

1992
Agenda 21 at Earth Summit, Rio de Janeiro[c]
- Key focus areas in WM: develop appropriate solid waste disposal technologies on the basis of health risk assessment, mandatory EIA for landfills, integrated management of liquid/solid wastes, promotion of recycling of waste water & solid waste, ensuring that by 2000, 75% of solid waste generated in urban areas are collected and recycled or disposed of in an environmentally safe way, creating and maintaining a cadre of professionals/semi-professionals for solid waste management, etc.

1997
Kyoto Protocol[d]
- Key focus areas in WM: limit or reduce, or both of methane emissions through recovery and use in waste management, formulate/implement national and regional programmes to mitigate climate change and to facilitate adequate adaptation to climate change in sectors including waste management

2000

2000
Millennium Development Goals

2002
Johannesburg Plan of Implementation at Earth Summit[e]
- Key focus areas in WM: waste prevention, waste minimisation, Waste-to-energy (WtE), safe sanitation, Global Programme of Action for the Protection of the Marine Environment from Land-based Activities in SIDS, Sound Management of Chemicals

2005
Mauritius Strategy[f]
- Key focus areas in WM: regional partnerships for waste management, strengthen the control of the trans boundary movement of hazardous wastes, promote sustainable waste management, development of WtE projects suitable for SIDS and international cooperation to reduce the quantity of waste disposed of at sea

2006
Dubai Declaration on International Chemicals Management at International Conference on Chemicals Management in Dubai[g]
- Key focus areas in WM: reduce generation of hazardous waste, environmentally sound management, recycling & recovery of hazardous waste, prevent illegal international traffic in toxic, hazardous, banned chemicals (and products containing them)

2010

2012
The Future We Want at Rio 2012[h]
- Key focus areas in WM: increase resource efficiency and reduce waste in the context of green economy, sustainable management of waste through 3Rs, environmentally sound chemicals and waste management, waste prevention through innovative public private partnerships, promote LCA for WM, increase WtE treatments, waste to resource management

2014
SAMOA Pathway at the Third International Conference on SIDS[i]
- Key focus areas in WM: provide and operate appropriate facilities and infrastructure for waste management systems, expansion of wastewater treatment, recycling and reuse, sustainable consumption and production, environmentally sound management of chemicals and hazardous wastes, control of transboundary movement of hazardous waste

2015
SUSTAINABLE DEVELOPMENT GOALS

Figure 1.8 : Selected Global and Regional Agreements in Waste Management

a. For the text and explanatory information on one of the first global conventions (in force since 1975) to protect the marine environment from human activities, visit the International Maritime Organisation's webpage "Convention on the Prevention of Marine Pollution by Dumping of Waste and Other Matter." Available from: *http://www.imo.org/en/OurWork/Environment/LCLP/Pages/default.aspx* (accessed 22 February 2017).
b. For more information on the Basel Convention, visit the Secretariat of the Basel Convention's web page "Control of Transboundary Movements of Hazardous Wastes and Their Disposal, Overview." Available from: *http://www.basel.int/Portals/4/Basel%20Convention/docs/text/BaselConventionText-e.pdf* (accessed 22 February 2017).
c. UNCSD (1992). *https://sustainabledevelopment.un.org/outcomedocuments/agenda21*
d. *http://unfccc.int/kyoto_protocol/items/2830.php*
e. *http://earthsummit2002.org/*
f. *http://www.unesco.org/csi/B10/mim/mimStrategy_English.pdf*
g. *https://sustainabledevelopment.un.org/content/documents/SAICM_publication_ENG.pdf*
h. *https://sustainabledevelopment.un.org/rio20/futurewewant*
i. *https://sustainabledevelopment.un.org/sids2014/samoapathway*

Almost all the SDGs are directly or indirectly related to waste management. The SDGs most pertinent to waste management, including resource efficiency and sustainable consumption, are detailed in Figure 1.9.

Figure 1.9 : Waste-related SDGs

Note: For more information, refer to the United Nations' waste-related SDGs on its web page "Sustainable Development Goals: 17 Goals to Transform Our World." Available from: *http://www.un.org/sustainabledevelopment/sustainable-development-goals/* (accessed 24 January 2017).

The implementation of global sustainable development agenda requires a foundation, and this is provided by "The Addis Ababa Action Agenda". It builds on the outcomes of two previous Financing for Development conferences, in Monterrey, Mexico, and in Doha, Qatar, and lays steps for the international community to fund UN SDGs.

Domestic resource mobilisation is central to the Addis Ababa Action agenda. Several national governments reaffirmed their commitment to official development assistance, particularly for the least developed countries, and pledged to increase South-South cooperation. Waste Management is also addressed in the Agenda and it calls for reduction in food wastage, efficient resource utilisation and waste reduction, rationalizing inefficient fossil-fuel subsidies that encourage wasteful consumption and combating trafficking of hazardous waste.

1.5.2 Sendai Framework

The Sendai Framework is the successor to the Hyogo Framework for Action 2005–2015: Building the Resilience of Nations and Communities to Disasters. It was adopted at a UN conference in Japan in 2015. The United Nations Office for Disaster Risk Reduction (UNISDR) has been tasked to support the implementation, follow-up and review of the Sendai Framework.

The Sendai Framework is a 15-year, voluntary, non-binding agreement that recognises that the State has the primary role to reduce disaster risk but that the responsibility should be shared with other stakeholders including local governments, the private sector and other stakeholders.

Disaster-related wastes are of great concern today given Asia's vulnerability to disasters such as earthquakes, cyclones, floods and impacts related to climate change (such as sea level rise and the melting of glaciers). The Sendai Framework recognises the need to address these challenges proactively; therefore, its targets include substantially reducing disaster damage to critical infrastructure and disruption of basic services, substantially increasing the number of countries with national and local disaster risk reduction strategies by 2020, and so on.

1

1.5.3 Multilateral Environmental Agreements

Multilateral environmental agreements (MEAs) are international legal instruments between three or more states that have common goals of environmental protection and sustainable development. MEAs are divided into five categories based on the issues they focus on:

- Biodiversity
- Land
- Seas
- Chemicals and hazardous waste
- Atmosphere

Waste is an underlying theme in almost all multilateral environmental agreements. Environmentally sound management of chemicals and hazardous wastes is an important cross-cutting thematic area of MEAs. Some of the waste-related MEAs are:

- Basel Convention on the Transboundary Movements of Hazardous Wastes and their Disposal
- Rotterdam Convention on Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade
- Stockholm Convention on Persistent Organic Pollutants
- Vienna Convention for the Protection of the Ozone Layer
- Montreal Protocol of the Vienna Convention
- International Conference on Chemicals Management
- Strategic Approach to International Chemicals Management (SAICM)
- Minamata Convention on Mercury

It is important that MEAs are reflected in formulating national and local waste management strategies.

1.6 Climate Change and Waste Management

Waste disposal produces emissions of GHGs that contribute to global climate change. At a global scale, the waste management sector makes a relatively minor contribution to GHG emissions, as shown in Figure 1.10. These figures likely underestimate the contribution of the waste sector to GHG emissions from uncollected waste in waterways, which usually decays anaerobically thus generating large amounts of methane, and from waste collection vehicles and open burning, both of which generate significant amounts of black carbon (soot), which is an important short-term contributor to climate change. Moreover, increasing volumes of waste streams in urban areas and across manufacturing sectors will likely lead to the waste sector emerging as a moderate source of global GHG emissions in the future.

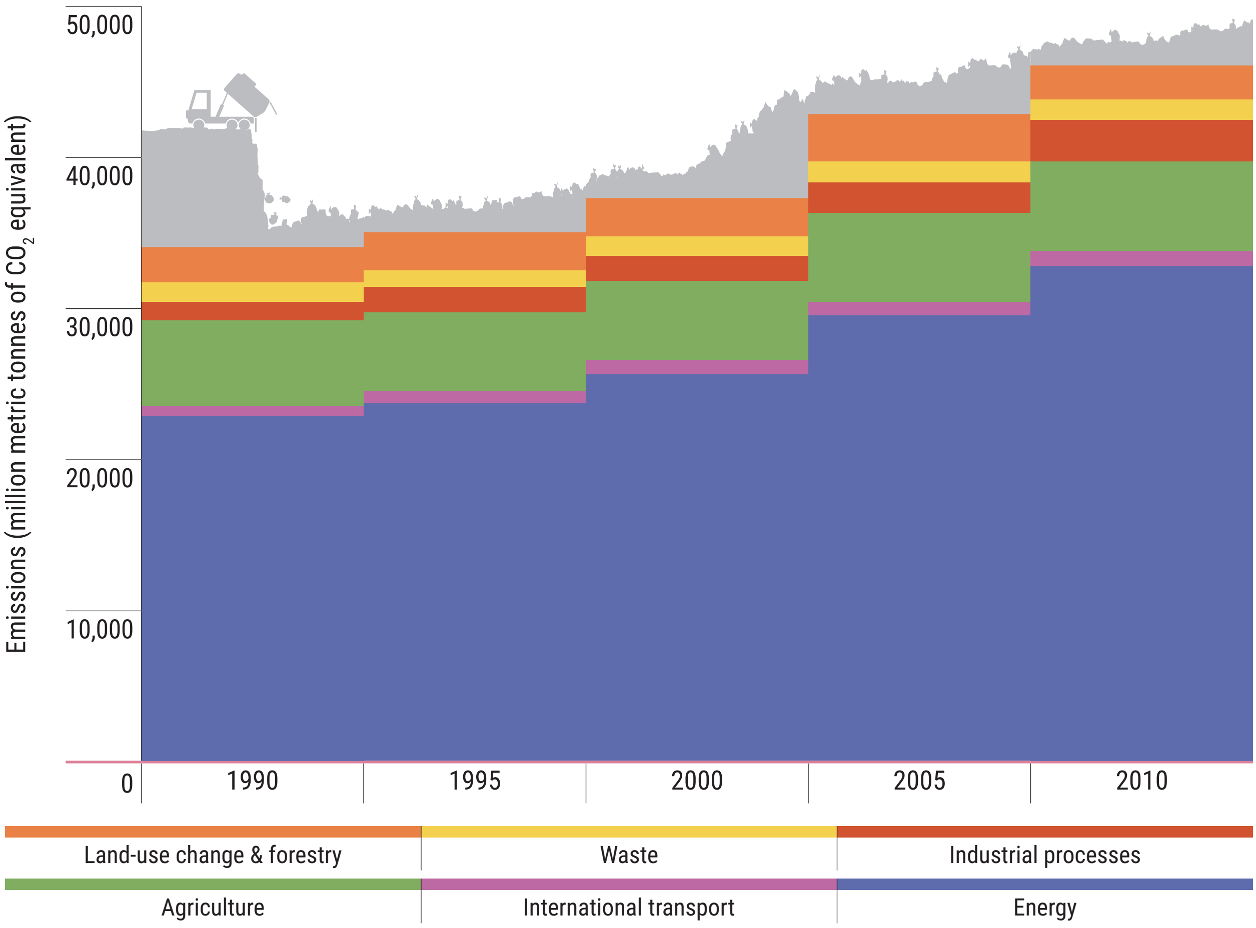

Figure 1.10 : Global GHG Emissions for Different Sectors

Source: US EPA (U.S. Environmental Protection Agency) (2014).

The emissions from the waste sector arise mainly from landfilling organic wastes, which decompose and release methane. In addition, the transportation of waste to landfills also significantly contributes to overall emissions. Therefore, recycling waste—even though it produces some emissions in the process—still offsets overall emissions by reducing the quantities of waste transported to landfills and by avoiding the need for extraction of virgin raw materials and its use in the manufacturing process.

Table 1.1 illustrates how waste recycling helps in achieving overall reduction of GHG emissions.

Waste prevention, reuse and recycling help address global climate change by decreasing the amount of GHG emissions and by reducing the amount of energy required in the extraction, transport, manufacture and disposal of raw materials. There are clear benefits to reducing resource consumption, improving efficiencies and productivity and gaining economic benefits. Climate concerns, thus, need to be factored in sustainable waste and resource management to seize this opportunity.

Table 1.1 Approximate CO_2- Eq Saved When Materials Are Recycled Compared to Virgin Materials

Material	Kg recyclables per 1,000 kg MSW	Kg recovered per 1,000 kg MSW	Kg CO_2-eq. saved per 1,000 kg material	Kg CO_2-eq. saved per 1,000 kg MSW
Paper	200	140	2,500-600	350-85
Aluminum	10	6	10,000	60
Steel	25	15	2,000	30
Glass	50	30	5,000	15
Plastic	80	50	1,000-0	50-0
Total	365	241	20,500-17,600	505-190

Source: ISWA (2009).
(Based on Composition of Northern European MSW)

The United Nations Framework Convention on Climate Change (UNFCCC)[9] requires signatory nations to formulate and implement programmes containing measures to mitigate climate change. These include economy-wide as well as sectoral programmes in energy supply and demand, transport, buildings, industry, agriculture, forestry and waste management. It also requires nations to inventorise as well as adopt measures to reduce wastes and emissions from these sectors.

9 UNFCCC (n.d.). Climate get the big picture. Available from: *http://bigpicture.unfccc.int/* (accessed 24 January 2017).

Key Messages

This chapter describes the objectives of the Asia waste management outlook (AWMO), its scope and coverage as well as its intended emphasis. The future of Asia's waste management must emphasise Sustainable consumption and production (SCP) and promote a paradigm shift from the traditional end-of-pipe solutions to integrated waste management. In addition, key concepts were presented such as life cycle thinking, SCP, Integrated solid waste management (ISWM) emphasizing the 3Rs and the circular economy with some illustrations. The importance of aligning national policies with globally agreed upon goals such as the SDGs is stressed along with an alignment with MEAs and related initiatives. Actors at the city and national levels and in the business sector need to put these concepts into practice to achieve environmental, social and economic benefits.

+ While it is important to emphasise life cycle thinking and to achieve the goal of the circular economy, it is equally necessary to take immediate measures to build basic waste management infrastructure, especially in developing countries in Asia.

+ Strengthening waste collection systems, rehabilitating dump sites and ensuring strict implementation of waste-related regulations needs to be given high priority.

+ To achieve this daunting objective, enabling framework of modern policy and regulations based on economic instruments, awareness raising and training to build institutional capacities is necessary along with increased financial flows with a lead taken by the private sector.

+ We thus present in this AWMO the situation on waste management in Asia, challenges as well as opportunities, frameworks we need to evolve and follow, ending with key recommendations for action.

Waste Generation

2.1 Regional MSW Generation

Asia, inhabited by more than 4.45 billion people in 2016, recorded a huge amount of waste generation, making it the largest waste-producing continent on earth.[1] By 2025, it is estimated that 1.8 billion tonnes will be generated by urban cities alone in Asia.

Income is a highly significant factor in influencing waste generation as it can be used as a proxy for consumer purchasing power: higher income groups have a greater ability to spend, leading to greater consumption of goods and services, thus generating more waste in the bargain.

Figure 2.1 depicts projected MSW generation in 2025 along with the Human Development Indices of selected countries in Asia. Moreover, Box 2.1 lists the general facts about Asia.

Box 2.1 **General Facts About Asia**

- Asia's population is equivalent to 59.78 per cent of total world population.
- Asia ranks number 1 among regions of the world (roughly equivalent to continents) when ordered by population.
- The average population density in Asia is 143 per km^2.
- The total land area is over 31 million km^2.
- Total urban population is 48.1 per cent, equivalent to over 2 billion people (2016).
- The median age in Asia is 30.7 years.

Source: Worldometers (2016).

The World Bank reported that waste management is one of the three main sources of environmental degradation in the region.[1] The World Bank estimated that waste generation from urban cities in Asia ranges from 450,000 to 760,000 tonnes per day. This ever-increasing waste generation trend is expected to last for another decade or so resulting from urban population growth and economic development in Asia.

Table 2.1 shows MSW generation in the Asian region and the waste management treatment and disposal practices that are followed.

In general, waste generation is dependent on the GNP of the nation. It is also significantly influenced by population, particularly urban populations that Asian countries are struggling to manage. The impacts of rapid population growth and urbanisation on waste management, particularly among developing nations are more evident.

1 Hoornweg and Bhada-Tata (2012, pp. 8-12, 82).

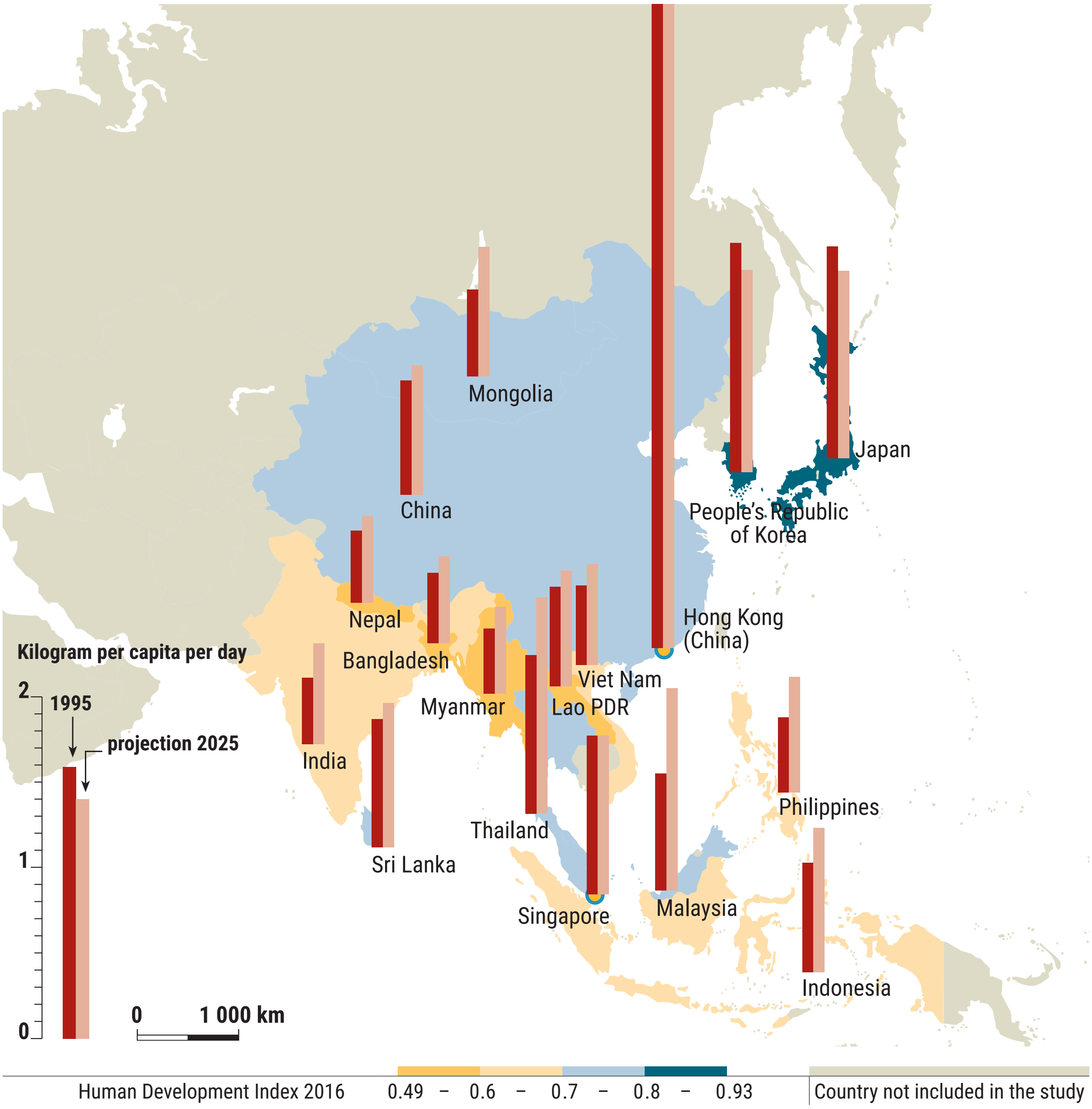

Figure 2.1 : MSW Generation and Projection for Selected Countries in Asia as Linked to Human Development Index

Source: UNDP (2016).

Table 2.1 MSW Generation and Treatment Data in Asia

Region	MSW Generation Rate (tonnes/ cap/yr)[a]	Per centage of MSW disposed at disposal sites	Per centage of MSW incinerated	Per centage of MSW composted	Per centage of other MSW management, unspecified
Eastern Asia	0.37	55%	26%	1%	18%
South-Central Asia	0.21	74%	-	5%	21%
South-East Asia	0.27	59%	9%	5%	27%

a. Kawai and Tasaki (2016).

There is a strong correlation between per capita waste generation and the income level of a country. The higher the per capita GNI (gross national income), the higher the per capita MSW generation. Similarly, at the city-level, it can be seen that high-income cities tend to generate more MSW per capita as compared to those with lower incomes (see Figure 2.2).

Figure 2.3 shows that low-income cities tend to generate less MSW per capita than their wealthier counterparts. Moreover, Figure 2.2 shows data on countries and Figure 2.3 for cities in Asia. Finally, Figure 2.4 shows the variation of MSW generation per capita across the different regions.

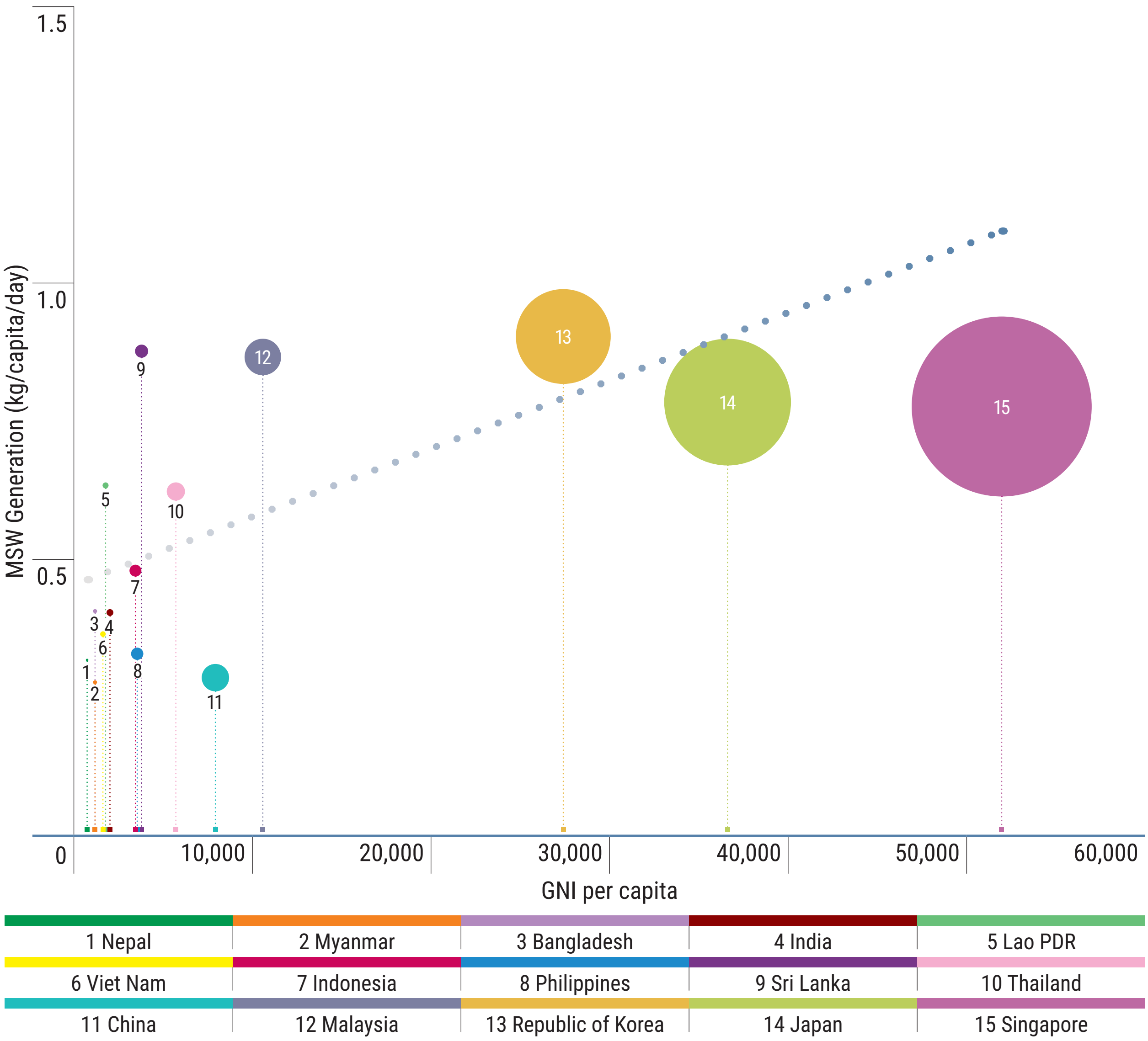

Figure 2.2 : MSW Generation Related to GNI Per Capita in Selected Asian Countries

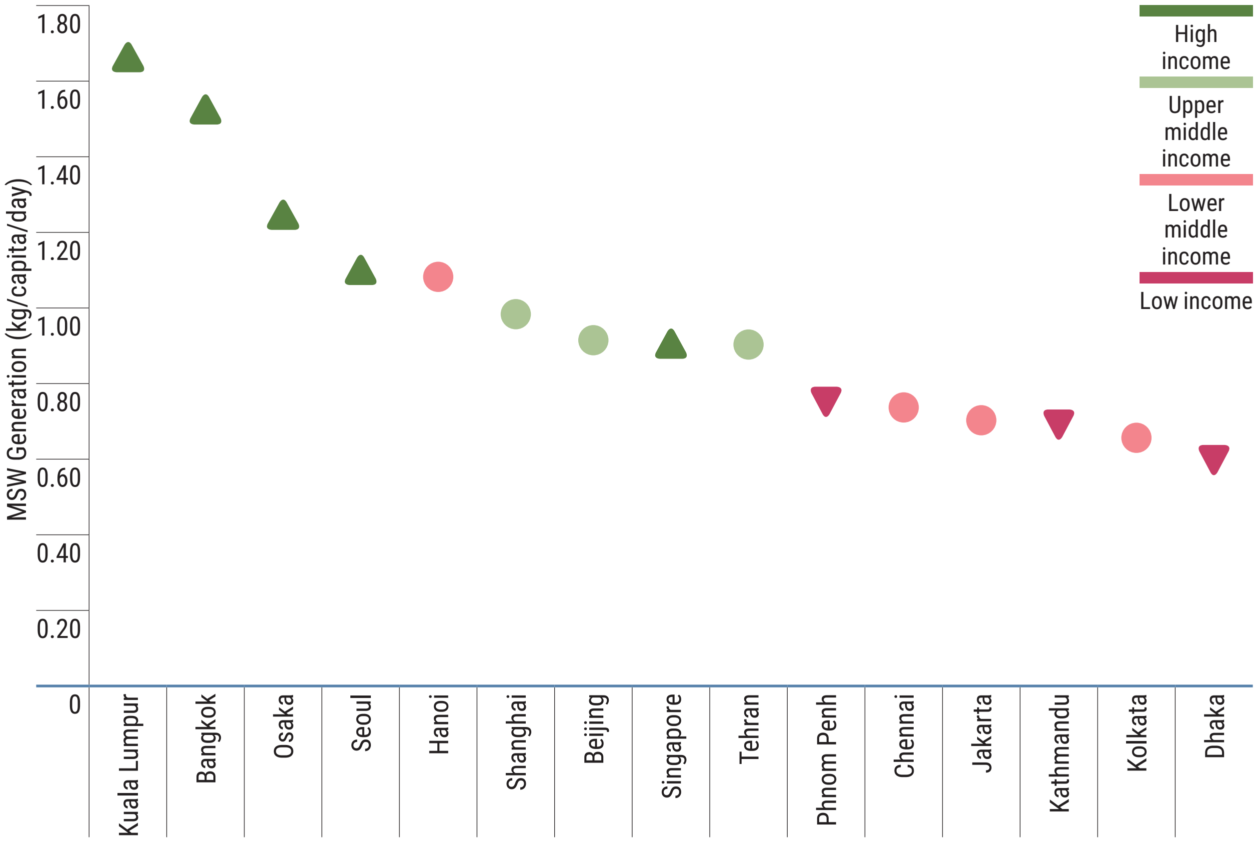

Figure 2.3 : **MSW Generation Per Capita by City Income Level**

Source: Kawai, and Tasaki (2016).

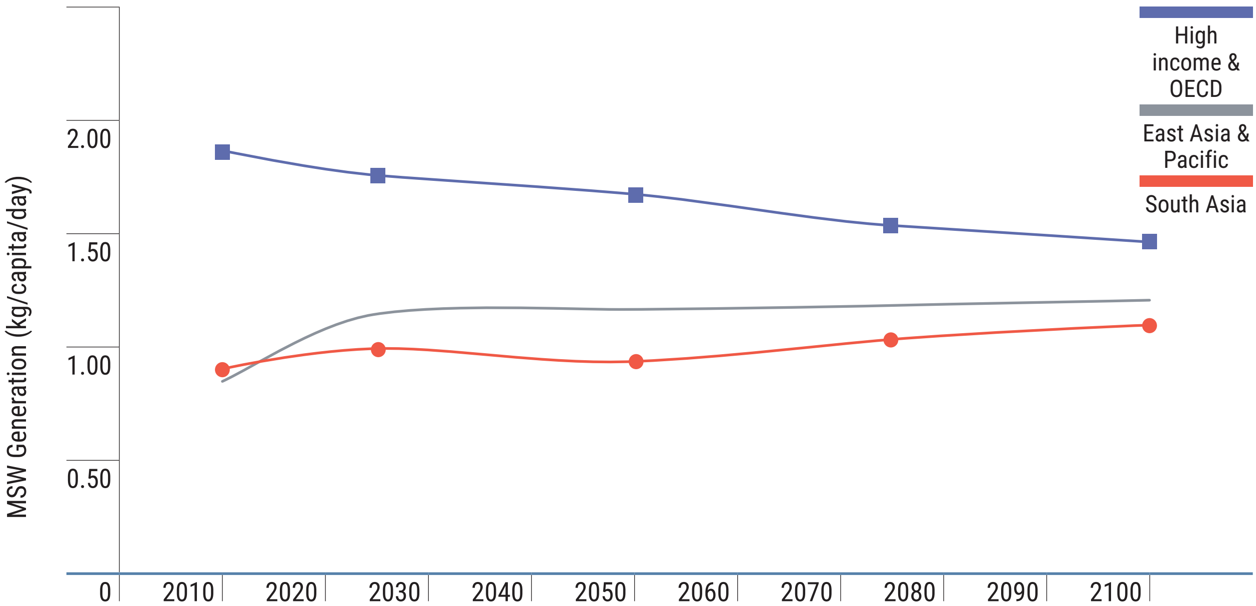

Figure 2.4 : **Forecasted Generation Per Capita Across Different Regions, 2010–2100**

Source: Moss and others (2010).

2.2 National MSW Generation Profiles

It is undeniable that anthropogenic activities dictate waste generation trends in a country: not only does it affect overall waste production, but also waste composition. The combined GNP of a region may not be indicative of actual waste generated by each member country. Variations in waste types are found on a country-by-country basis, as shown in Figures 2.5 and 2.6, which illustrate the types of waste generated in the Asian region.

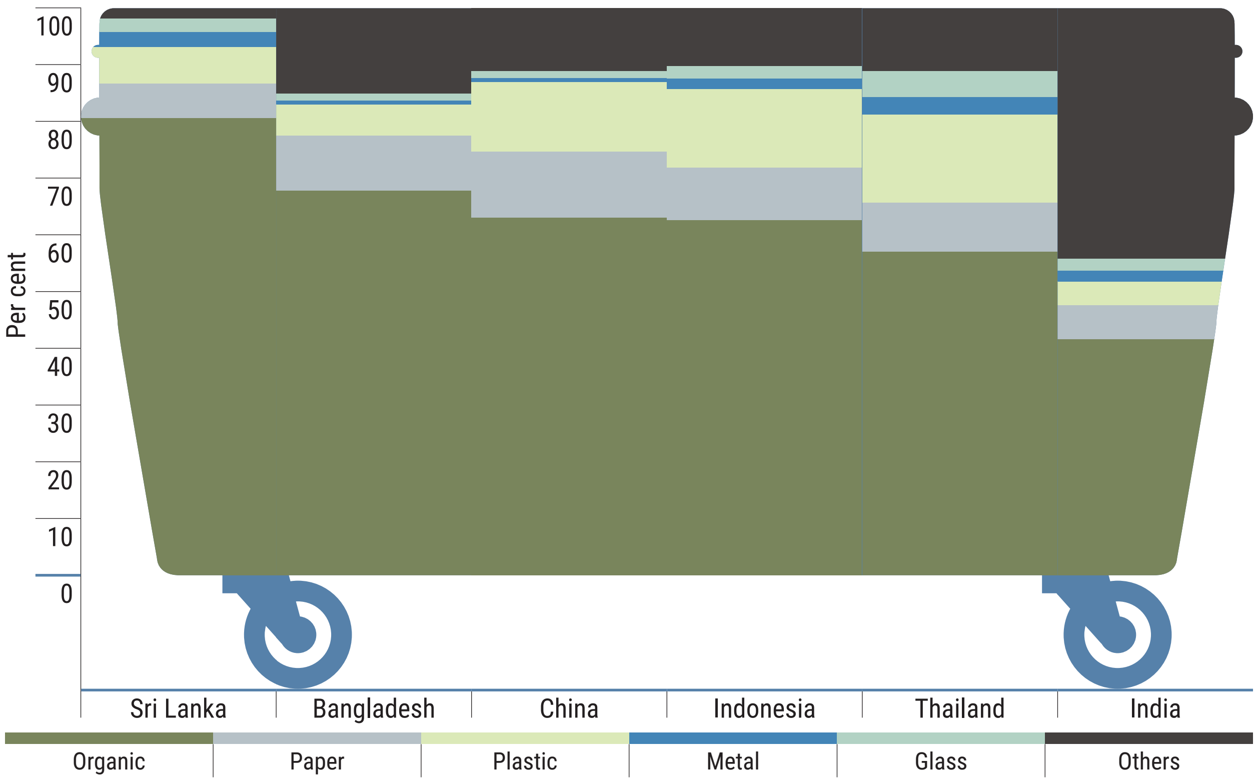

Figure 2.5 : Waste Composition in Various Countries in Asia

Source: Seventh Regional 3R Forum in Asia and the Pacific (Nov 2016).

As Figure 2.6 shows, urban waste generation makes up a small fraction when looking at all types of waste generated within a country. However, two points should be kept in mind: First, solid waste data are incomplete for many countries, and hence, the figures do not accurately represent the total wastes that are generated in a country. Because plastic waste generation has been on the increase, it is worthy to note the contribution of this portion to the total waste generation. Second, the focus of waste policies and programmes are often biased towards MSW, while neglecting other waste types.

The average composition of urban waste from Bangladesh and Singapore are provided in Figure 2.7 and Figure 2.8.

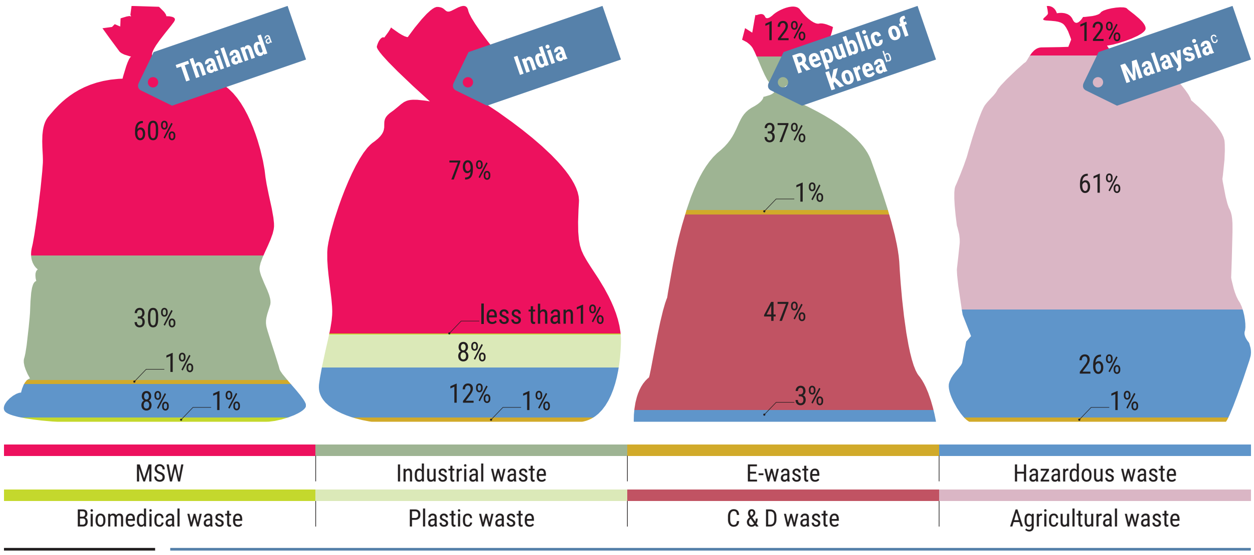

Figure 2.6 : MSW as a Fraction of Total Wastes Generated in Select Asian Countries

a. Pollution Control Department, Thailand (2015).

b. For more information on Korea's Ministry of the Environment waste policy based on the principle of resource circulation, visit the "Policy Direction of Resource Circulation," available from *http://eng.me.go.kr/eng/web/index.do?menuId=364*

c. The data was extracted from the desktop research file conducted by Regional Resource Centre for Asia and the Pacific, Asian Institute of Technology (AIT RRC.AP) (2017) and the files were not available online.

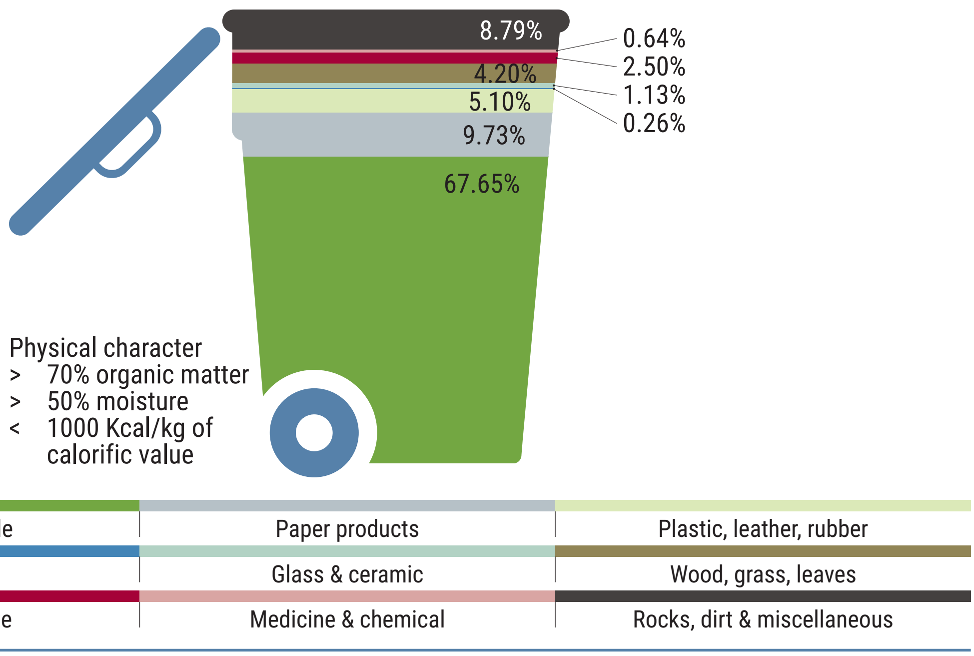

Figure 2.7 : Average Composition of Urban Waste in Bangladesh

Source: UNCRD (2010)

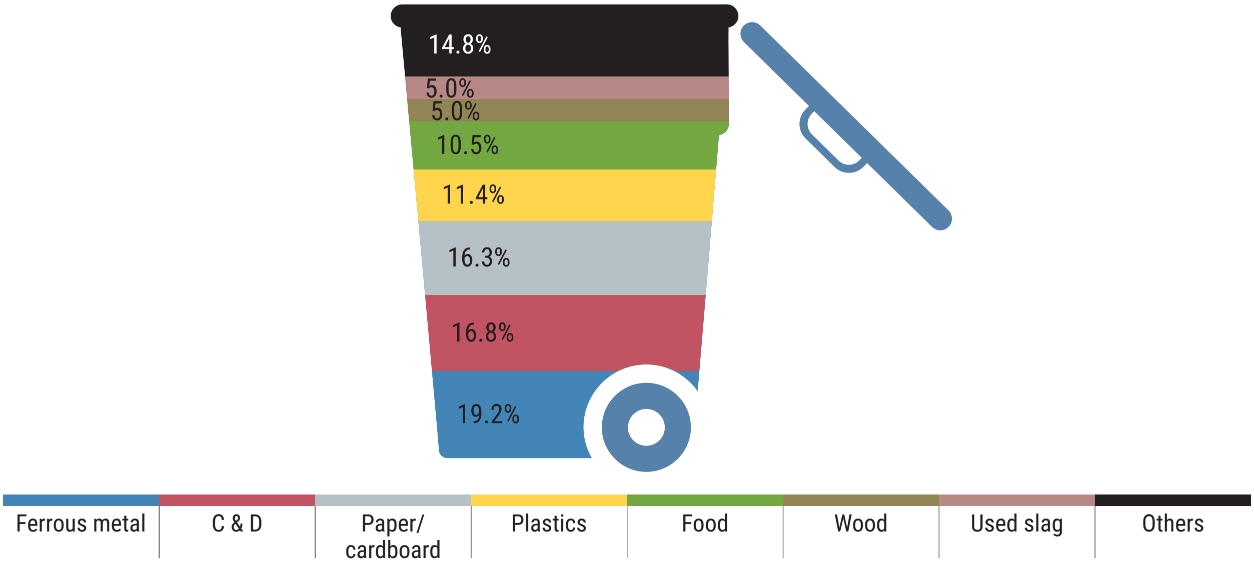

Figure 2.8 : Average Composition of Urban Waste in Singapore

For an infographic on 2014 waste statistics and recycling rate for Singapore, see "Singapore Waste Statistics 2014." Available from: *http://www.zerowastesg.com/2015/03/18/singapore-waste-statistics-2014/*.

Waste characteristics and volume are highly dependent on the socio-economics of a country. The inorganic waste fraction in MSW is generally correlated with GNP. This is reflected by the majority of high-income countries in Asia that produce a higher percentage of inorganic wastes compared to organic waste. The increased consumption of ready-to-eat food and ready-to-use products associated with higher income regions means that there is more packaging material that ends up as waste, contributing to higher inorganic fractions in MSW than in regions where there is less consumption of pre-processed food and disposable products.

Malaysia is a fast-developing country in Asia that waste generation has been at an alarmingly increasing trend. Box 2.2 and Box 2.3 summarise a survey conducted on solid waste generation in Nepal and Malaysia, respectively. Figure 2.9 and Table 2.2 illustrate the household waste composition and the types of wastes generated in Malaysia, respectively.

Box 2.2 Solid Waste Generation in Nepal

A survey conducted in all 58 municipalities of Nepal in 2012 found that the average municipal solid waste generation was 317 grams per capita per day. This is equivalent to 1,435 tonnes per day or 524,000 tonnes per year of MSW. Many of these technically and financially constrained municipalities are still practicing roadside waste pick-up from open piles and open dumping, creating major health risks.

The average household waste generation was 170g/capita/day. It also showed that household waste generation rates varied where households with monthly expenditures of NRs 40,000 (USD 417) and above generate 1.25 kg/household/day on average, which is more than twice as much as the 0.57 kg/household/day generated by households with monthly expenditures of less than NRs5,000 (USD 52).

The per capita household waste generation rate was found to vary from a minimum of 75 g/capita/day (Triyuga) to a maximum of 278 g/capita/day (Inaruwa). Households surveyed in some municipalities, especially in rural areas, were found to use most of the organic waste as cattle feed, resulting in lower rates of waste generation than the average. Higher per capita waste generation was observed in municipalities such as Banepa, Bharatpur, KMC, and Pokhara, because fast urban growth and economic development in these cities have accelerated consumption rates, leading to higher rates of waste generation. However, in a few municipalities that have lower urban growth and economic development, especially in the Terai area, such as Inaruwa, Lahan, Kalaiya, Malangawa, and Rajbiraj, most of the households surveyed were found to generate much more waste than average. A lack of basic knowledge of SWM and poor sanitation in the densely-populated areas of these municipalities might account for the greater amount of waste.

Source: ADB (2013).

Box 2.3 **Municipal Solid Waste Generation in Malaysia**

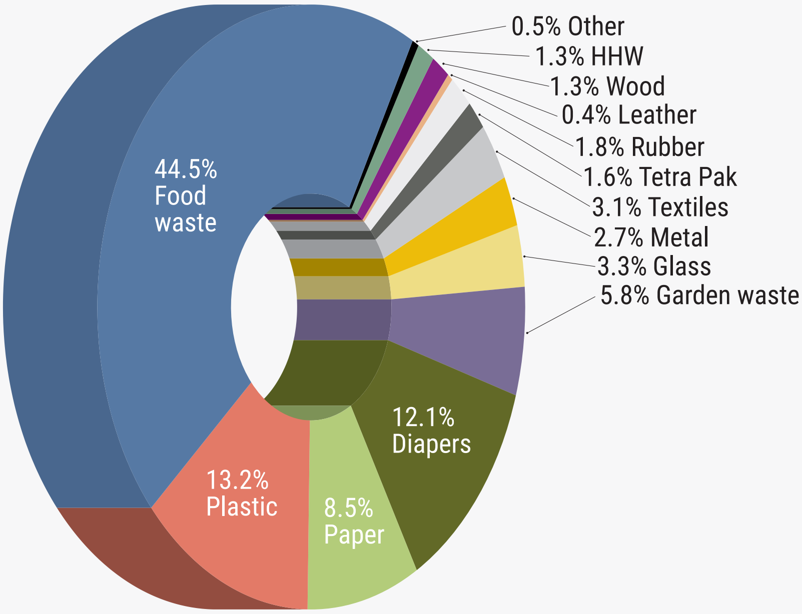

Figure 2.9 : Malaysian Household Waste Composition (As Generated)

Source: KPKT and JPSPN (2013, pp. 68–78).

Note: HHW – Household hazardous waste; Wood – Wood + Peel/Husk

Table 2.2 Waste Components Generated, Discarded, Disposed from Malaysian Households

	Waste Components	As Generated MT/day	As Discarded MT/day	As Disposed MT/day
Organics	Food waste	9,685	8,563	8,492
	Garden waste	1,252	1,240	1,445
	Wood	88	88	92
	Peel/husk	206	217	248
	Mixed paper	310	286	273
	Newsprint/old newspaper	677	475	360
	Cardboard	841	697	567
Plastics	Polyethylene terephthalate (PET)	538	463	374
	High-density polyethylene (HDPE)	774	610	604
	Polyvinyl chloride (PVC)	107	92	90
	Low-density polyethylene (LDPE)	832	782	717
	Polypropylene (PP)	290	263	188
	Polystyrene (PS)	293	293	299
	Other plastics	16	16	33
Glass	Glass bottle	707	528	521
	Sheet glass	12	30	59
Metal	Ferrous metal	383	336	211
	Aluminium	197	160	85
	Other non-ferrous metals	15	15	16

	Waste Components	As Generated MT/day	As Discarded MT/day	As Disposed MT/day
Household hazardous waste	Batteries	23	22	22
	Fluorescent tube	56	48	48
	E-waste	30	52	52
	Aerosol cans	155	140	140
	Paint container	20	20	20
	Polystyrene (PS)	293	293	299
	Other plastics	16	16	33
Other	Tetra pak	343	308	282
	Diapers	2,625	2,625	2,625
	Rubber	309	309	399
	Textiles	661	660	660
	Leather	84	85	99
	Porcelain/ceramic/stones	93	95	289
	Other minor components	5	8	48
	Total	21,627	19,526	19,358

Source: Christine (2015).

Waste separation facility, Bangkok, Thailand

2.3 Waste Streams Other than MSW

2

Composition of the waste stream differs greatly from one area to another. It is also influenced by the urbanisation of the area. Box 2.4 provides the characteristics of urban and non-urban waste. Urban waste dominates the national waste generation in most Asian countries. This is generally owing to the fact that the majority of the countries within this region are currently developing with exception to the developed nations such as Japan, Republic of Korea, and Singapore.

Box 2.4 **Urban and Non-urban Waste**

Urban Waste	Non-urban Waste
Characteristics	**Characteristics**
• Mainly generated in mass volumes owing to concentrated populations; • Generally under the responsibility of the local authorities; • Can be tapped for resource recovery; • Require sufficient budgets to manage the wastes; and • Related to urban activities; and industrialisation.	• Dependent on the types of major activities conducted in a particular region or country; • Influenced by geographical factors; • Falls under the responsibility of the waste generator; • Resource recovery is unlikely; and • Does not depend on the population of the area.
Types and examples	**Types and examples**
• Municipal solid waste • Commercial and institutional waste • Packaging waste • C&D waste • Sludge from wastewater treatment plants • Air emissions from waste processing and disposal facilities • E-waste • Food waste • Waste oil • Waste arising from fossil fuel consumption (air emissions) • Industrial hazardous waste (including household hazardous waste) • End-of-life of vehicles • Healthcare/biomedical waste	• Ship-breaking waste • Fly ash from coal • Mining waste • Disaster waste • Marine and coastal litter (including land-based marine litter) • Agriculture waste

Figure 2.9 shows the "mapping" of some critical waste streams in terms of relative quantities and level of intensity or risks. This mapping has been done based on estimated quantities of waste generated in Asia, likely projections and an understanding of the adverse impacts and risks to humans and ecosystems.

It may be observed that waste streams such as MSW, C&D and agricultural waste dominate in terms of mass. However, they are relatively low intensity/risks as compared to hazardous waste and e-wastes which are high intensity/risk waste streams. Waste streams, such as healthcare waste and marine litter are of concern particularly to humans and marine life despite the relatively less volume generated in comparison. Food and plastic wastes are waste streams of moderate-to-high concern given their relative quantities and associated intensity/risks. While Figure 2.10 is more of a semi-quantitative or qualitative depiction, efforts should be made by each country in Asia to prepare such " waste intensity maps" for a more focused understanding of various types of waste generation.

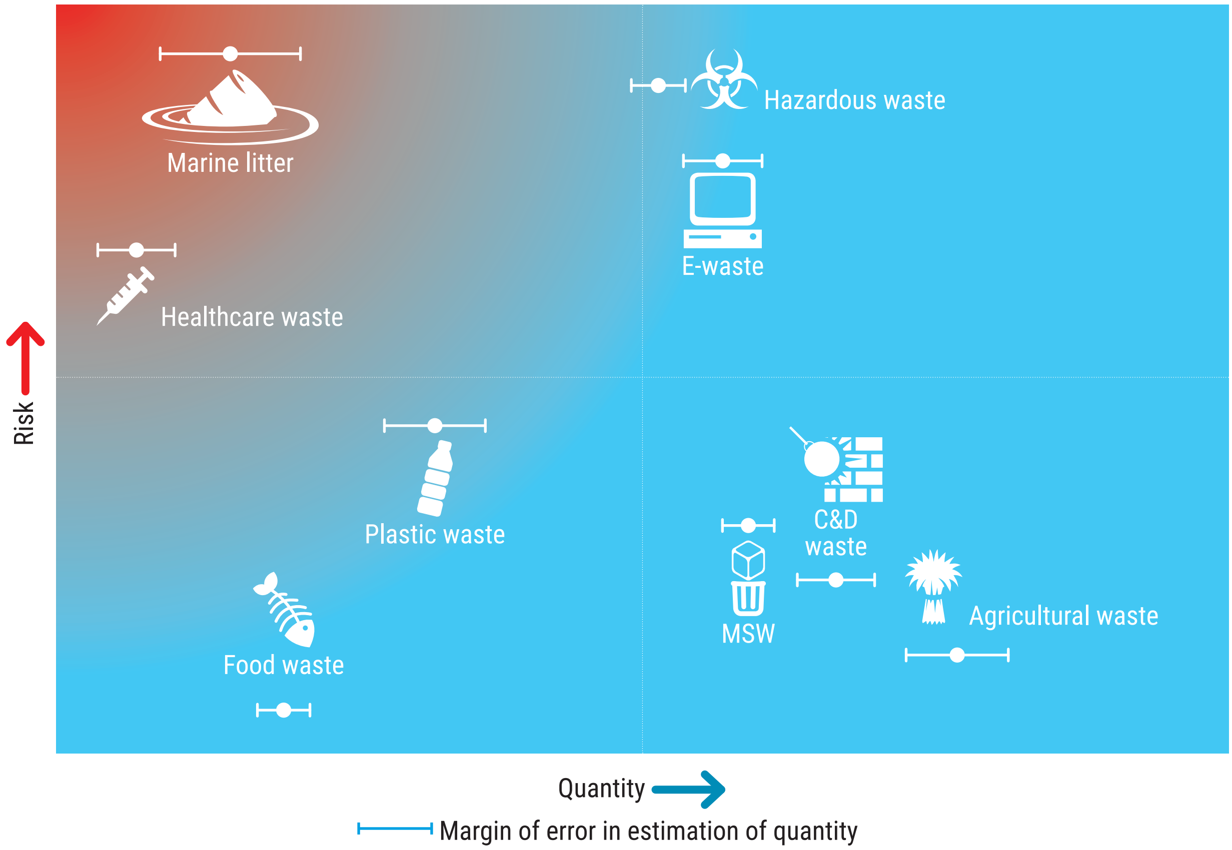

Figure 2.10 : Relative Risks and quantities estimated for key waste streams in Asia

2.3.1 Urban Waste Streams

Urban waste generation primarily consists of waste generated from residential, commercial and institutional entities. It includes food and other organic waste (e.g., from lawns and parks), recyclables (paper, plastic, glass, metals), and inert materials (ash, sand, and construction and demolition waste). These wastes are collectively referred to as MSW *although the working definitions vary across countries*.

Cities also tend to generate other types of solid waste that do not fall under MSW; these include healthcare, industrial, electronic and hazardous wastes. Industrial and hazardous wastes may contribute large volumes to the overall wastes generated in a country; however, they may or may not be associated with urban areas. The level of industrial and hazardous waste generation depends on the overall level of industrialisation and the priority sectors of the economy. For instance, an economy that is based more on providing services would generate less industrial or hazardous waste, or both, than one that is based on manufacturing. These variations are noted even within a country. For instance, Visakhapatnam, India, grew into a large city because of the steel and shipbuilding industries that were located there. Bangalore, on the other hand, gained status as one of the largest cities in India owing to the growth of the IT industry. Andhra Pradesh, the state in which Visakhapatnam is the largest city, generates almost five times more hazardous waste than Karnataka, the capital of which is Bangalore.

2.3.1.1 E-waste

Electronic goods have become a necessity, with a number of them being reasonably affordable to many segments of society. E-waste generation has increased as frequent upgrades in electronic goods have become common, thus making older models obsolete. Hence, estimation of e-waste generation has become increasingly challenging.

Figure 2.11 illustrates the generation of e-waste by various countries in Asia.

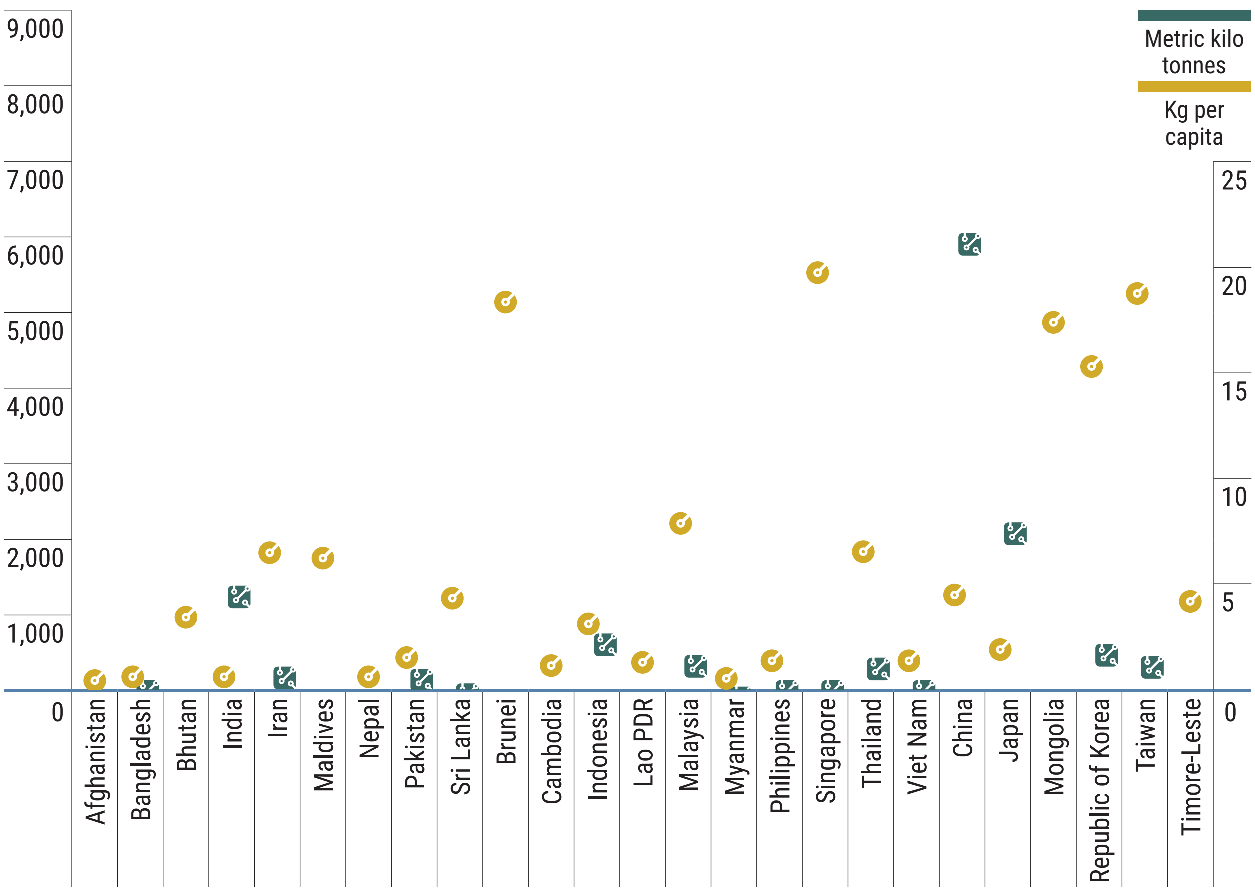

Figure 2.11 : E-waste Generation in Selected Countries in Asia

Source: Baldé and others (2015).

It may be observed that China, India and Japan show higher generation of e-waste as compared to other countries in Asia. This is owing to the fact that these nations are the leaders in electronics products manufacturing.

Figure 2.12 shows the relationship between GNI per-capita and e-waste generation per capita in selected countries in Asia.

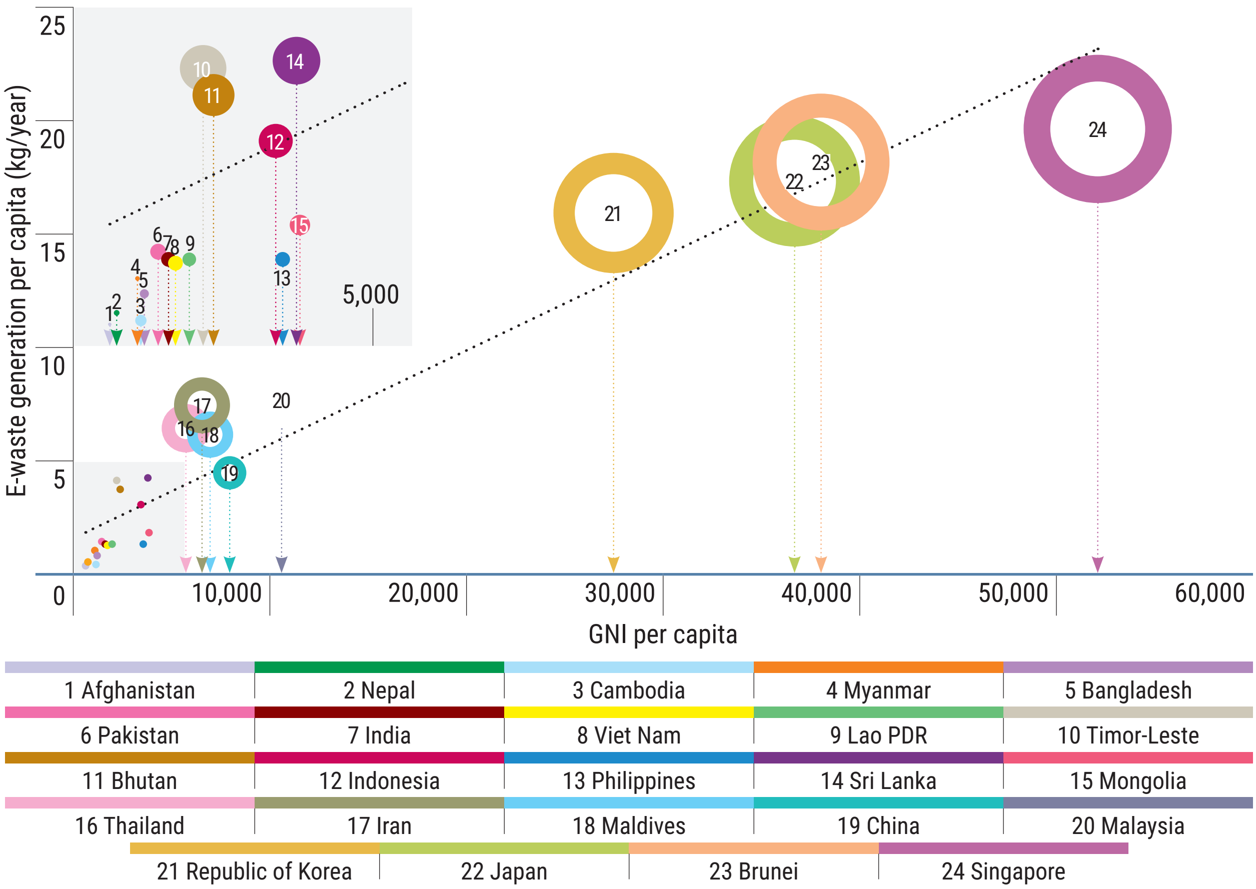

Figure 2.12 : GNI Per Capita versus E-waste Generation Per Capita

Source: Baldé and others (2015). Please see Appendix A for the data of GNI per capita for the selected countries were extracted from the country profiles.

Note: Based on data from selected Asian countries.

2.3.1.2 Hazardous Waste

Hazardous waste is mainly generated from the chemical industry, manufacturing, and oil and gas sector. Industrial waste may be considered as hazardous when they it is toxic, corrosive and flammable or reactive, or both.

Hazardous waste has a huge impact to the environment and the health of humans and is thus of prime concern. Hazardous waste must thus be managed appropriately. Some countries in Asia like Singapore, Hong Kong, Japan, Korea, India, China, Thailand and Malaysia have set up systems to collect, treat and dispose of' hazardous waste.

Box 2.5 discusses the generation of hazardous waste in Malaysia, which contributes to the rapidly growing generation of such waste in Asia.

Hazardous waste can also be generated from homes owing to the disposal of expired medication and used light bulbs. Other commonly found household hazardous wastes include insect repellants, aerosol sprays and home cleaning chemicals. The contamination of MSW by these hazardous waste streams is increasing in urban areas. This trend is concerning because it makes processing of MSW hazardous, and thus, made from MSW, such as compost, potentially unacceptable.

Box 2.5 **Trends in Hazardous Waste Management in Malaysia, 2001–2014, in Tonnes**

Malaysia awarded a 15-year concession to KualitiAlamSdn. Bhd, a Cenviro company with the exclusive right to collect, treat and dispose of' hazardous waste in an integrated waste management centre in Sendayan, Negeri Sembilan, Malaysia, to service the entire company (1999–2015). From 2001 to 2015, the total amount of hazardous waste in Malaysia has grown from 0.5 to 2.5 million tonnes per year.

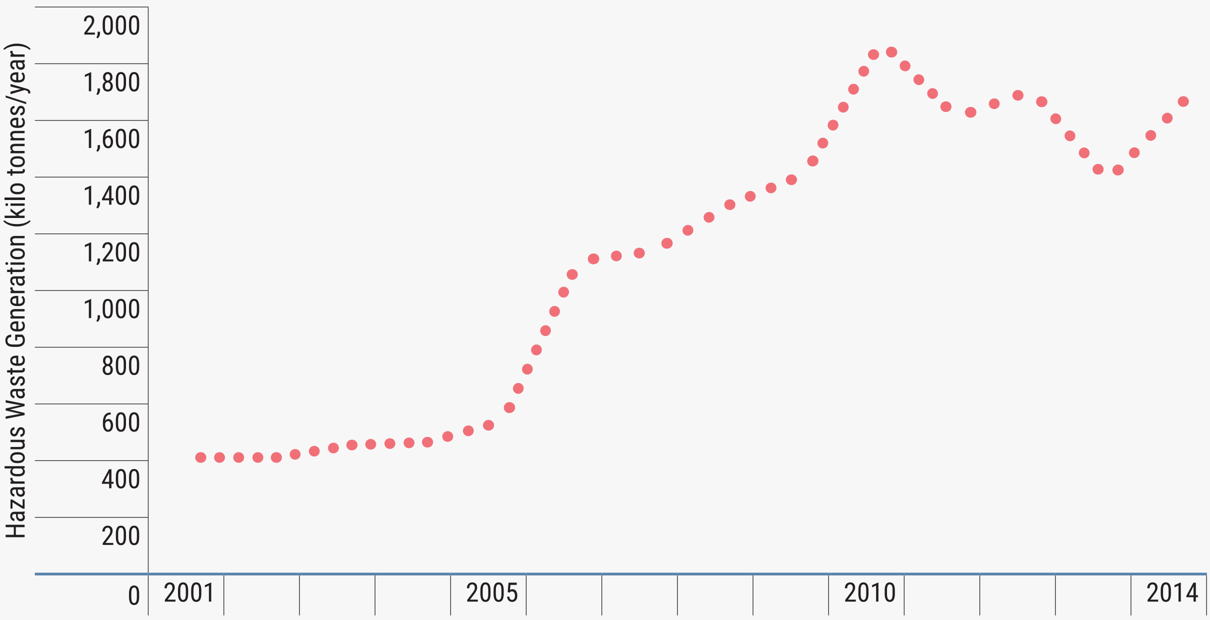

Figure 2.13 : **Rapid Development of Hazardous Waste Generation in Malaysia, 2001–2014**

Table 2.3 **Total Scheduled Waste, 2001–2014**

2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
419,524	414,776	460,506	468,235	545,484	1,099,657	1,133,739	1,301,187	1,705,308	3,087,496	3,281,569	2,854,517	2,965,612	2,541,760

Note: According to DOE Environmental Quality Report

2.3.1.3 Healthcare Waste

Healthcare or biomedical wastes can be found in solid or liquid forms and contain infectious or potentially infectious materials. The definition of healthcare varies considerably across countries in Asia. In general, it contains pathological waste, infectious waste, sharps and radioactive and toxic wastes from healthcare establishments. The most common healthcare wastes generated are used bandages, syringes, scalpels and laboratory wastes. Typically, healthcare waste generation per bed in hospitals is on average about 0.5 kg of hazardous waste per bed per day; while low-income countries generate on average about 0.2 kg.[2]

Figure 2.14 presents statistics on healthcare waste generation in selected countries in Asia.

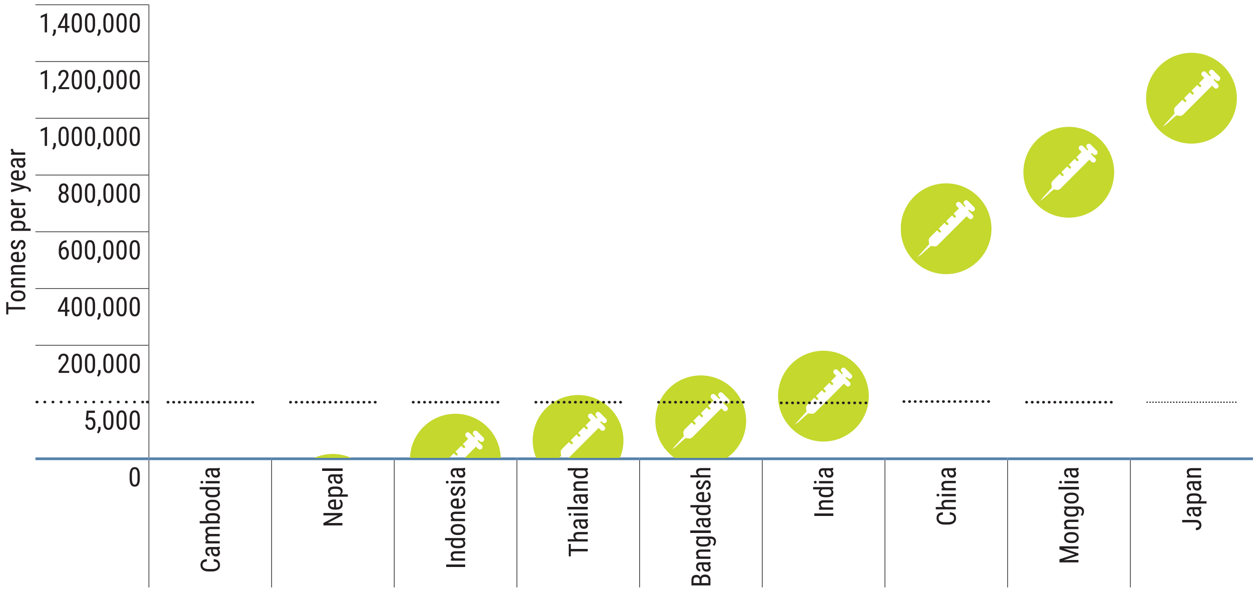

Figure 2.14 : Healthcare Waste Generation for Selected Countries in Asia

Typical composition of biomedical (healthcare) waste from Dongguan in China is shown in Figure 2.15.

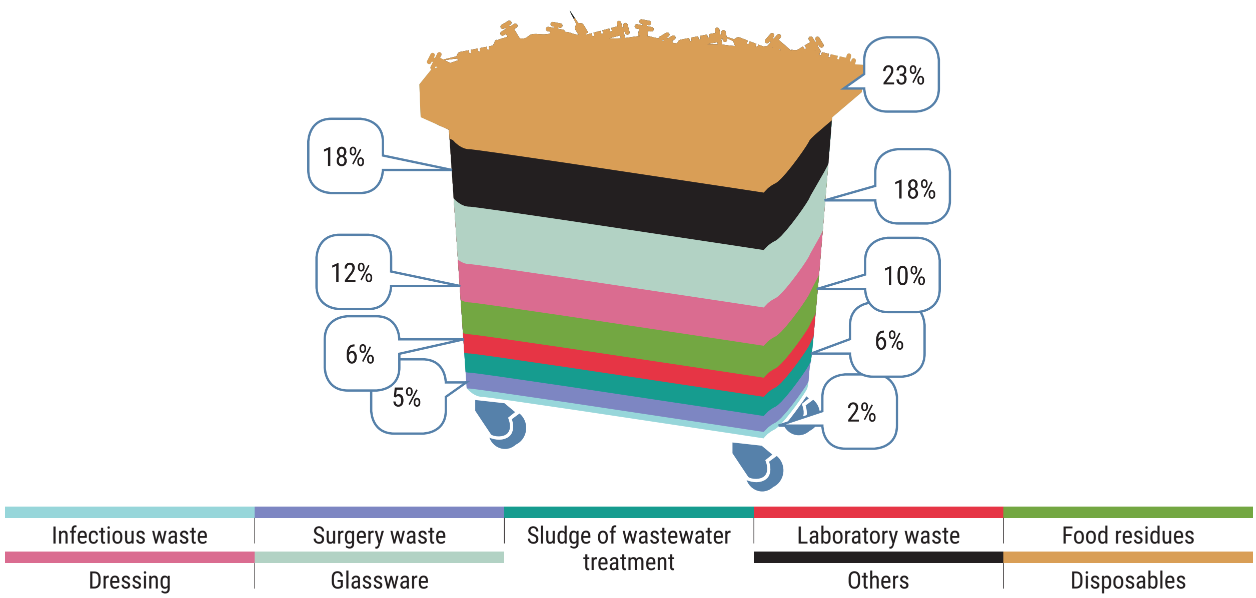

Figure 2.15 : Composition of Healthcare Waste from Dongguan City in China

Source: WHO (2015).

2 WHO (2015).

2.3.1.4 C&D Waste

About 40 per cent of global solid waste generation originates from construction and demolition of buildings. In general, C&D waste is bulky, heavy and poses waste management problems in urban areas in Asia.

Components of C&D waste typically include concrete, asphalt, wood, metals, roofing and gypsum wallboard. Currently, countries in Asia have their own definition of C&D waste in terms of the waste components found in the construction industry.

Figure 2.16 shows C&D waste generation per capita per year for selected Asian countries for 2012.

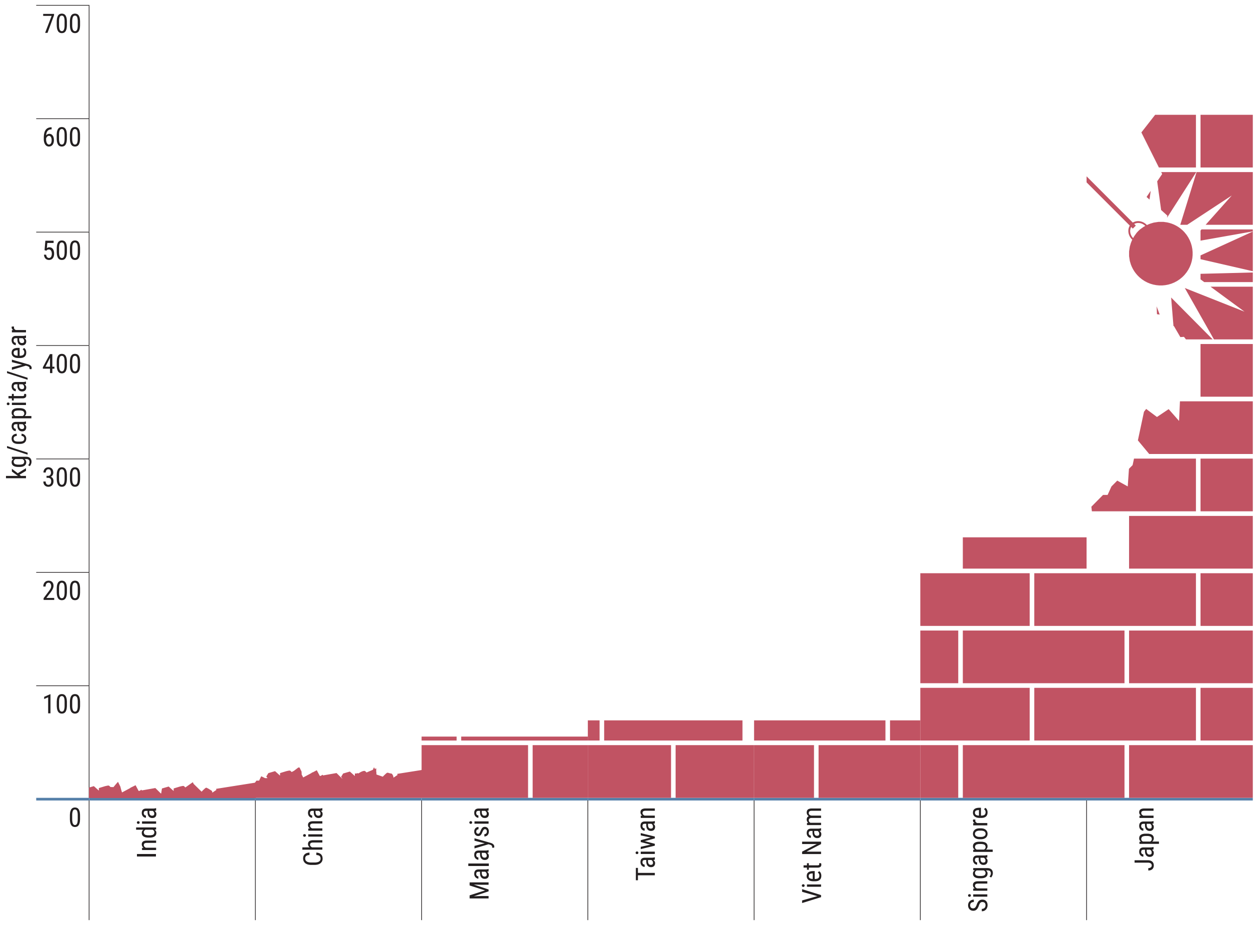

Figure 2.16 : Per Capita C&D Waste Generation for Selected Asian Countries, 2012

Source: Hock (2012)

C&D waste quantities are influenced primarily by the rate of urbanisation, including factors such as development of public infrastructure projects, growth of residential and commercial properties, and foreign direct investments. Typically, it has been observed in many countries that increase in GNI result in the increase of C&D waste.

The ratio of C&D waste to MSW is an interesting indicator when related to GNI per capita. Figure 2.17 shows a depiction across some countries in Asia. It is observed that countries like Japan that have high GNI have relatively high ratios of C&D waste and MSW, while in countries such as China, India and Viet Nam, the contribution of MSW is more significant.

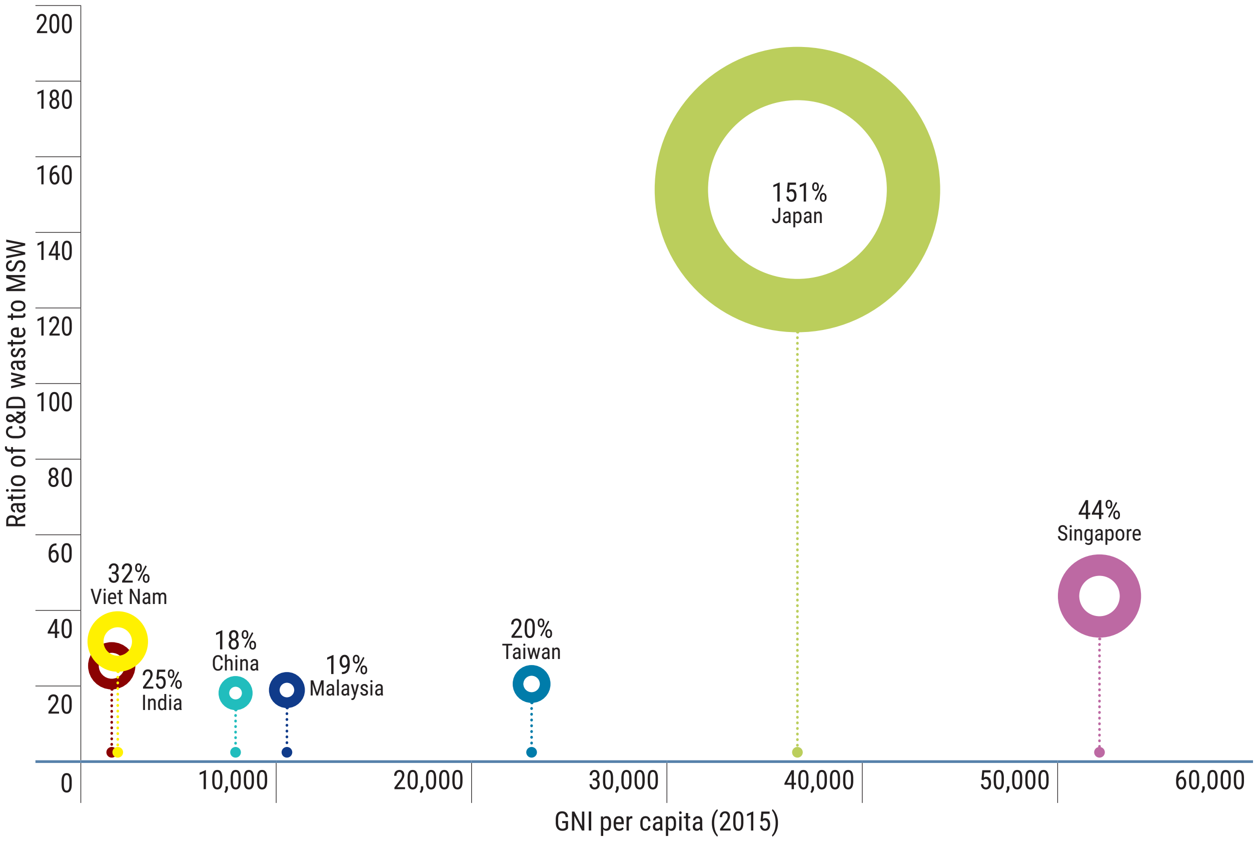

Figure 2.17 : Relationship Between Ratio of C&D Waste to MSW with GNI Per Capita in Selected Asian Countries, 2010 (value derived from World Bank data (2012)

Source: Hock (2012)

2.3.1.5 Packaging Waste

As for other types of urban waste such as packaging waste and food waste, India and China recorded annual generation of 32 and 2.803 million tonnes and 72 and 7.317 million tonnes, respectively. Waste produced from primary packaging (i.e., packaging used to contain products), home delivery and couriers is one of the major sources of packaging waste.

Box 2.6 provides a look at packaging waste generated in China owing to couriering.

Box 2.6 Packaging Waste from Arising from Couriering of Parcels in China

According to the State Post Bureau, the total number of parcels delivered by courier services in China jumped 48 per cent last year. The growth rate for 2014 was even higher at more than 50 percent. Data from the Chinese Institute of Graphic Communication shows there were 20 billion parcels shipped last year by courier services on the mainland. This required the use of 7.5 billion plastic bags, 10 billion cardboard boxes, and 17 billion metres of wrapping tape.

Source: Jack Liu (March 2016).

2.3.1.6 End-of-life Vehicles

End-of-life vehicles (ELV) are one of the emerging waste types owing to the increasing use of vehicles globally. Management of ELV is an issue of rising concern as components are bulky and consist of many small parts, which need to be dismantled and may be considered hazardous in some cases.

Dismantling vehicles generate wastes, such as engine oil and battery acids, and emissions such as air conditioning gas. Parts, such as break shoes, battery terminals, and various electronic parts, also form part of the waste stream if not reconditioned and recycled[3]. In the United States, Japan, China and Korea, ELVs are shredded.

In the ASEAN region, it is estimated that about 2.4 million motor vehicles will be discarded in 2020. Institutional systems for recycling are yet to be developed in a number of these countries, leading to problems such as improper disposal and environmental pollution.

Table 2.4 provides a forecast for ELVs in China.

Table 2.4 Forecast of Vehicles in China, 2015–2017

	Total number of vehicles (million)	Increase in number of vehicles (million)	Total number of ELVs (million)	ELV ratio to total number of vehicles (%)
2015	95.38	14.91	6.44	6.7
2017	112.72	16.91	7.78	6.9
2020	141.03	20.05	9.95	7.1

Source: Sakai and others (2014, p. 4).

In Japan, about 5 million ELVs are generated every year,[4] as a result of the country's 2005 Law on Recycling of End-of-Life Vehicles. In response, Japan established the Law for the Recycling of End-of-Life Vehicles in 2006 to manage ever-increasing ELVs in the country. Effectively, it is expected that 75 to 80 per cent of vehicle parts will be recycled in Japan.[5]

Currently, in Asia, the management of ELVs is essentially left to an informal and unregulated sector. It does, however, interact with the formal sector, especially in the field of scrap metal and other high-value, low-toxicity materials. The materials that stay within the informal sector through their recovery life cycles tend to be of the lowest value and highly toxic due to the lack of interest for these materials in the formal sector. Although the informal sector is often seen as highly efficient in resource recovery, it is also known for its lack of record keeping. Thus, the inventory of ELV waste is difficult to estimate as well as to monitor. Moreover, given the nature of their practices, the informal sector is not always environmentally benign, especially regarding material recovery. The Automotive Recyclers Association 2012 industry report[6] on the global ELV industry reported that more than 100,000 family units are involved in ELV dismantling. A compilation of state-of-the-art technologies on ELV recycling is an interesting read and concludes the importance of ELV recycling in tomorrow's recycling society.[7]

In India, the country's Ministry of Heavy Industry has set up a recycling and dismantling demonstration center.[8] The center seeks to develop recycling processes that employ manual labor to the greatest extent and procedures for dealing with India's two-wheelers, which account for about 80 per cent by number and 40 per cent by weight of the number of vehicles. This ministerial initiative was implemented under

3 Chintan Environmental Research and Action Group and GIZ (2012).
4 *https://www.env.go.jp/en/laws/recycle/11.pdf*
5 For the laws and support systems for promoting waste recycling in Japan, including the Law on Recycling of End-of-Life Vehicles (ELV Recycling Law), visit the Global Environment Centre Foundation's web page, Waste Recycling Technologies and Recycling Promotion Initiatives in Eco-towns in Japan. Available from: *http://nett21.gec.jp/Ecotowns/*.
6 Automotive Recyclers Association (2012).
7 Simic (2013).
8 For more information, visit the Global Automotive Research Centre's web page, "Recycling demo unit." Available from: *http://www.garc.co.in/recycling-demo-unit* (accessed 24 January 2017).

the guidance of the National Automotive Testing and R&D Infrastructure Project (NATRIP) at the Global Automotive Research Centre (GARC).

Since ELVs consist of more than 70 per cent iron, and iron has traditionally been traded as a valuable secondary resource, recycling has been conducted autonomously based on market mechanisms. However, fluctuations in the price of steel scraps and the rise in the treatment cost of automobile shredding residues have at times pulled down ELV prices. Thus, the management of ELV recycling under a legislative framework is becoming increasingly important. Currently, countries, regions and entities with statutes or policies on ELV recycling are the EU, the European Free Trade Association (EFTA), Japan, the Republic of Korea, China and Taiwan.

2.3.1.7 Food Waste

Food wastes include unconsumed food and food scraps and are recorded to be on the rise. Food waste generation is increasing at an alarming rate that reflects wasteful habits among consumers even though food security is a major global challenge.

A report by UN Environment and the World Resources Institute (WRI) indicated that food wastage covered about one-third of worldwide food production, corresponding to a financial loss of USD 1 trillion;[9] food waste also results in the addition of 3.3 billion tonnes of GHG into the atmosphere every year.[10]

According to FAO estimates (2011), Asia contributes to large percentage of net global food wastage; the region's food waste footprint estimates show which commodities from which regions of the world contribute how much to global food wastage.

The results are summarised in Figure 2.18. It can be seen that Asian regions lead globally in the wastage of vegetables, cereals, starchy roots and fruits.

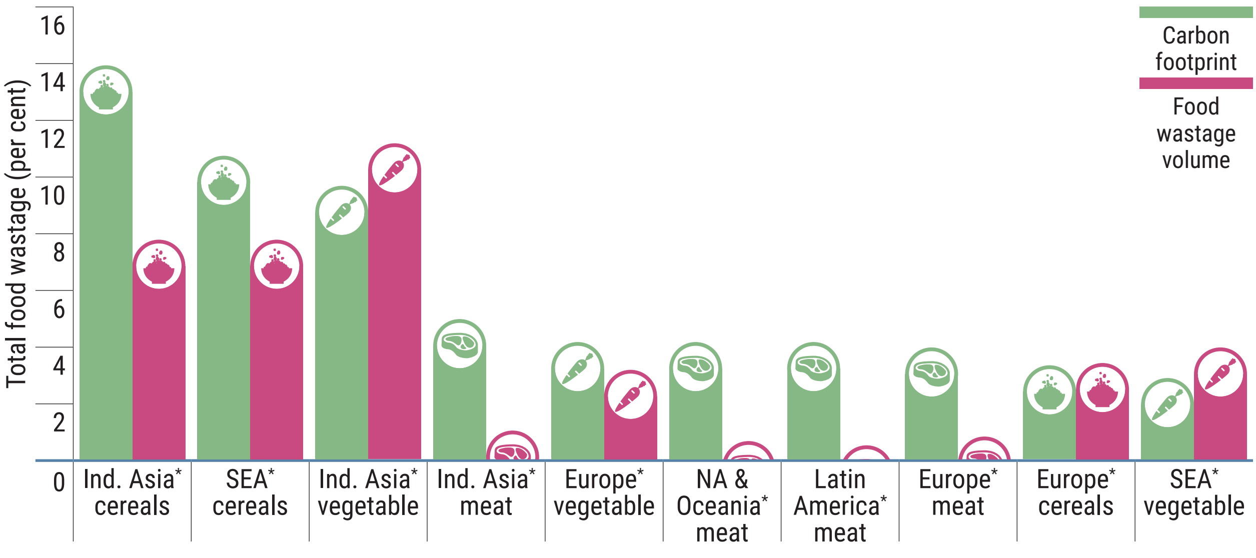

Figure 2.18 : **Top 10 of "Region*Commodity" Pairs for Carbon Footprint + Contribution to Food Wastage Volume**

Source: FAO and Food Wastage Footprint (2013).

9 *http://www.worldfooddayusa.org/food_waste_the_facts*
10 *http://www.theconsumergoodsforum.com/files/Publications/2016_CGF_Food_Waste_Booklet.pdf*

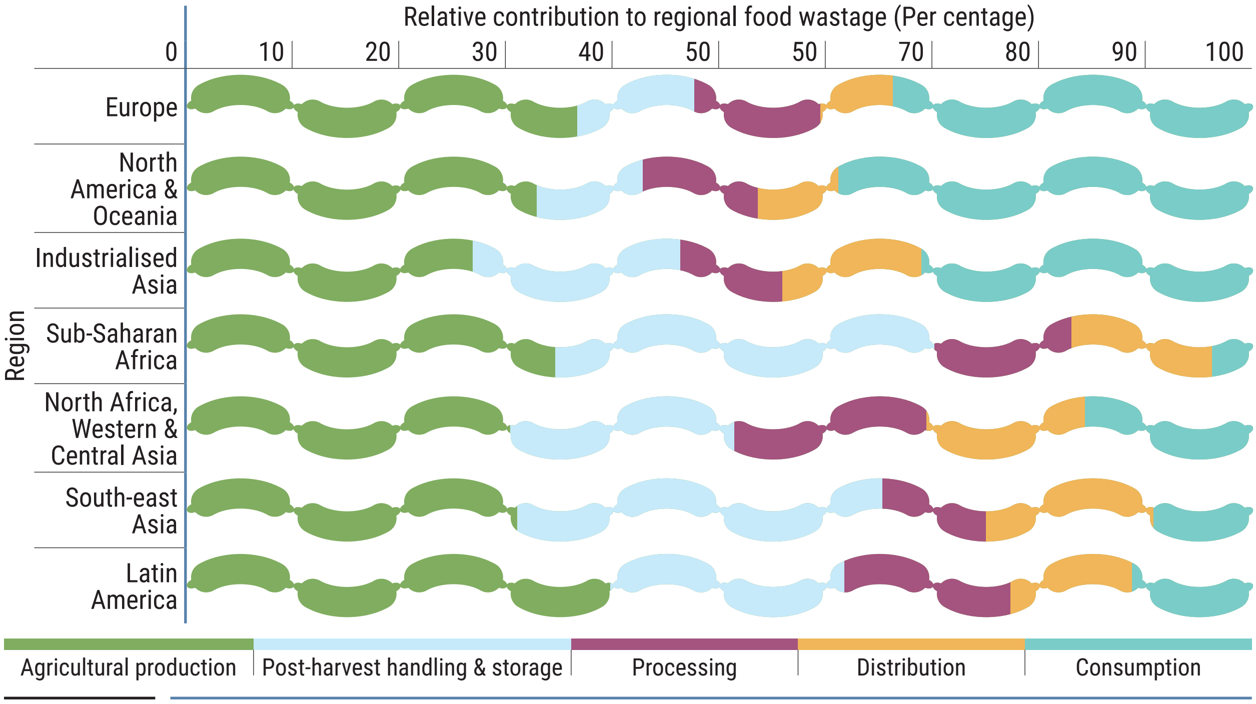

Figure 2.19 : Region-wide Food Wastage Across Different Stages of Food Supply Chain

Source: FAO and Food Wastage Footprint (2013).

It may be observed from Figure 2.19 that in industrialised countries in Asia, most of the wastage happens at the consumption stage,while in South/South-east Asia, maximum wastage happens during post-harvest handling and storage. The general trend is that high-income regions contribute more to food wastage in the consumption stages, while less industrialised and lower income regions suffer large losses during post-harvest handling. However, wastage in the agricultural production stage is high across all regions, irrespective of income level.

In 2013, World Resources Institute (WRI) developed a multi-stakeholder global standard known as the Food Loss and Waste Accounting and Reporting Standard (or FLW Standard) that provides requirements and guidance in quantifying and reporting the weight of food wastage or associated inedible parts , or both, removed from the food supply chain. These standards enable countries, cities, companies, and other entities to develop inventories of how much food waste is generated and where it goes—in order to inform and focus strategies for minimizing food wastage and loss.[11]

2.3.2 Non-Urban Waste Streams

While all countries generate urban wastes with differences in the volume and source contribution, non-urban wastes present a totally different story. The fact that non-urban waste generation is highly influenced by economic activities within an area means that some countries generate specific waste types while other may not. Ship-breaking waste, which is a unique waste type, is only generated in countries with ports and shipyards, while mining wastes are produced in countries that have large mining activities. Given the importance of agro-economies in Asia, agriculture waste forms an important part of non-urban waste streams.

11 Ibid.

2.3.2.1 Agricultural Waste

Agricultural waste is one of the main types of waste generated within the Asian region, particularly in countries with vast agricultural land. These countries include Cambodia, China, India, Indonesia, Malaysia, Pakistan and the Philippines. Agricultural waste (excluding livestock waste) generated by some Asian countries is shown in Figure 2.20.

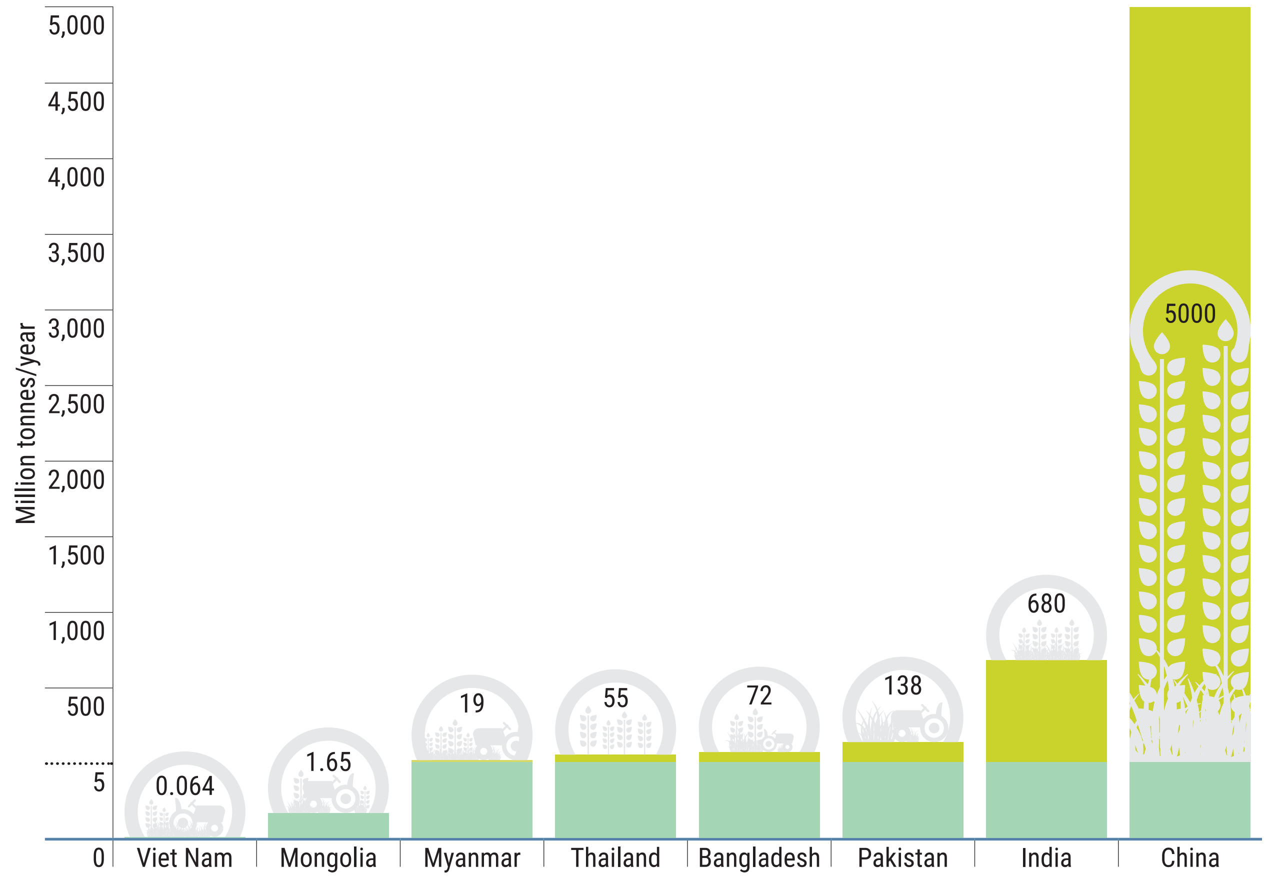

Figure 2.20 : Agricultural Waste Generated by Selected Asian Countries

Source: Huda, Mekhilef and Ahsan (2014); Saeed and others (2015).

Nevertheless, many countries have tapped into this waste stream to enable production of value-added products, including converting the waste to energy.

2.3.2.2 Ship-breaking Waste

At present, the global centres of the ship-breaking and recycling industry are in South Asia, specifically in Bangladesh, India and Pakistan. These three countries account for 70 to 80 per cent of the international recycling market for ocean-going vessels, with China and Turkey making up the remaining market. Only about 5 per cent of global volume is scrapped outside these five countries.

Box 2.7 presents some of the major ship-breaking activities in Asia.

Box 2.7 Major Ship-breaking Activities in Asia

Alang, India

The ship-breaking yard at Alang is located in Gujarat, off the Gulf of Cambay. It was set up in 1983 on a small scale along a 10-km stretch of sandy beach. The tidal, geographical and climatic features make Alang an ideal ship-breaking location. These yards were started in 1983. Some estimates show that Alang has over 160 plots to use for ship-recycling facilities.

Geographically, Alang has a continental shelf that makes it one of the best ship-breaking yards in Asia. At the same time, it is known for the highest tidal level (10 meters) in India, making the intertidal difference convenient for shipbreaking, whereas the high tide makes it possible to accommodate big ships. According to the Gujarat Maritime Board, a total of 415 ships were dismantled at the Alang facility (in 2011-2012), averaging 38.6 million tonnes of light-ton displacement (LDT) against 28.2 million tonnes LDT during 2010–2011. As many as 230 workers have died here in the past decade in fires and other accidents, according to data from the Gujarat Maritime Board.

Gadani, Pakistan

The Pakistani ship-breaking industry is situated mainly in Gadani, Balochistan, about 50 km away from Karachi. It once provided direct employment to about 30,000 people and was the largest ship-breaking operation in the world. From 1969 to 1983, Gadani was in the prime of its life. In the 1980s, it produced a million tonnes of scrap metal each year, thereby fueling the Pakistani steel industry.

The slowdown began in the late 1980s as taxation and import duties grew, and competition from yards in Bangladesh and India increased. The slow down continued until 2001 when the total scrap metal produced at the yard was a mere 160,000 tonnes, down from the millions of the previous decades. In the 2000s, taxation on ship-breaking was reduced 10 per cent from 15 per cent. Growth has been noticeable over the past few years especially, with the 2009–2010 fiscal year being one of the most successful in recent history. A record 107 ships were broken during this period at Gadani, which marked an all-time high for the yard.

Source: *http://www.shipbreakingbd.info/Shipbreaking%20around%20the%20world.html*

The five recycling countries cited above share a common characteristic in having a large appetite for scrap steel. Bangladesh, Pakistan, and to a large extent, India use the steel from recycled ships in steel mills where it is re-rolled and used directly, for example, in urban construction. On the other hand, China and Turkey mostly melt ship scrap. Contribution of recycled steel from shipyards to overall steel production is 50 per cent for Bangladesh, 15 per cent for Pakistan and between 5 to 6 per cent for India, according to the World Bank.[12]

China and India each command around 30% of the world's recycling capacity, while Bangladesh's capacity is around 25%. Pakistan and Turkey each command 9% and 2%, respectively. These capacity figures are based on an analysis by IMO covering the last ten years.

Table 2.5 shows the top-10 ship-breaking nations of the world, as of 2010. It can be observed that the countries of Asia dominate this industry largely.

The low ship recycling activity in Europe is often explained in terms of the inability of Europe to compete with the low labour costs and low compliance costs of South Asia. During 2012, 1309 vessels reported for disposal at total deadweight of about 61million tonnes in South Asia. Ship owners scrapped a total of 1,119 ships over the course of 2013.

The ship breaking industry in South Asia has been under pressure because of alleged abuse of the environment and occupational health hazards. It is a polluting industry that has adverse effects on the ecosystem and human lives, particularly the workers. Enforcement of regulations in the ship breaking industry is weak. Ship breaking activity is associated with dirty jobs, numerous deadly accidents, insecure labor, environmental injustice, and violation of human rights.

12 Sarraf and others (2010).

Thus, the Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships, 2009 (the Hong Kong Convention), was adopted in 2009. The aim of the convention is to ensure that ship breaking activities involved recycling of the materials so that it does not pose any unnecessary risks to human health and safety and to the environment.

Table 2.3 shows the top-10 ship-breaking nations of the world, as of 2010. It can be observed that the countries of Asia dominate this industry largely.

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Table 2.5 Top 10 Ship-breaking Countries of the World, 2010

Country	Scrapped amount, dwt	Accumulated market share, as a percentage	Number of ships scrapped	Rank	Scrapped ships, percentage of total volume				
					Bulk carriers	Dry cargo/ passengers	Offshore	Tankers	Others
India	9,287,775	32.4	451	1	9.7	32.8	5.3	46.2	5.9
Bangladesh	6,839,207	56.3	110	2	15.1	5.5	5.7	71.1	2.5
China	5,769,227	75.5	189	3	46.6	36.3	2.5	12.2	2.4
Pakistan	5,100,606	94.3	111	4	8.1	2.9	6.2	80.6	2.2
Turkey	1,082,446	96,1	226	5	24.3	48.7	0.2	14.1	12.8
United States	217,980	98.8	15	6	0.0	19.9	0.0	80.1	0.0
Romania	16,064	96.9	4	7	0.0	100.0	0.0	0.0	0.0
Denmark	15,802	98.9	25	8	0.0	53.4	22.7	0.0	23.9
Japan	13,664	99.0	1	9	0.0	100	0.0	0.0	0.0
Belgium	8,807	99.0	12	10	0.0	10 0.0	0.0	0.0	0.0
World	28,637,092	100.0	1,324		18.6	22.7	4.7	50.0	4.1

Source: Table 6.7, Top 10 ship-scraping nations, 2010, on the UPSA's webpage, Ship Breaking in Bangladesh. Available from: *https://www.shipbreakingbd.info/Shipbreaking%20around%20the%20world.html.*

2.3.2.3 Fly Ash from Coal

Fly ash is produced from the burning of pulverised coal in thermal power plants. Normally, fly ash from coal is powdery or fine-grained, and is collected in the flue gas chamber as part of a plant's air pollution control equipment.

Figure 2.21 shows the fly ash generation and utilisation in China from 2005 to 2012. The utilisation ratio has remained nearly constant at 66 per cent across this time frame.

13 International maritime organisation (2016).

India generated 184 million tonnes fly ash in 2014, and only 56 per cent of it was utilised. By 2031, this figure is estimated to rise to 900 million tonnes. In Japan, fly ash from coal has been used extensively in the cement industry. In 2014, approximately 29.2 million tonnes of fly ash has been used in the cement industry in Japan.

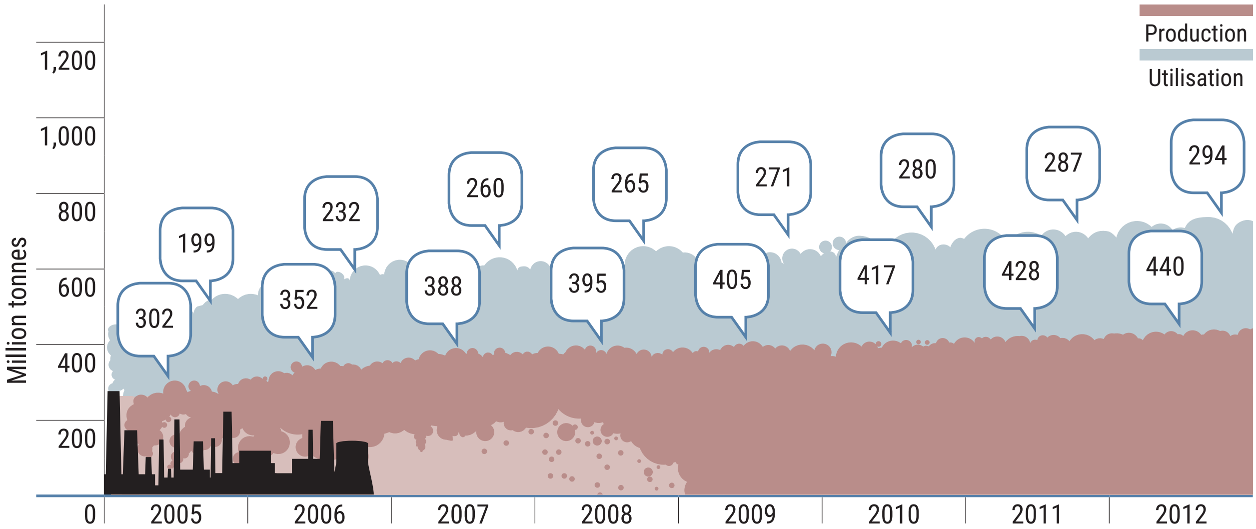

Figure 2.21 : Fly Ash Generation and Utilisation in China, 2005–2012

Source: Asian Coal Ash Association (2014).

2.3.2.4 Mining Waste

Mining wastes include materials left over after the process of separating the valuable mined fraction from the uneconomic fraction of ores. Although it cannot be easily classified, mining waste often includes:

- Overburden: These are often in huge volumes and might be acid-forming
- Tailings and milling wastes: Also generated in large volumes, mostly concentrated in artificial impoundments of impressive size. Tailings can be chemically contaminated and/or acid forming. The amount of tailings can be large, ranging from 90 to 98 per cent for some copper ores to 20 to 50 per cent of the other (less valuable) minerals[14]
- Ash ponds at coal plants
- Hazardous wastes of various forms from engineering and processing operations, which are smaller in volume, but higher in toxicity
- Inert wastes such as tyres, office equipment, derelict vehicles, equipment, and buildings
- Abandoned facilities (often contaminated)
- Rehabilitation residues
- Wastewater from mining operations

Data on mining waste generation is poor across the world and especially in Asia.

14 or more information, see the Wikipedia entry "Tailings. Wikipedia (n.d.). Available from: *https://en.wikipedia.org/wiki/Tailings* (accessed 24 January 2017).

2.3.2.5 Disaster Waste

All natural disasters—whether they are earthquakes, tsunamis, floods, landslides or other natural hazards—result in disaster debris. Increasingly, the management of debris generated by natural disasters is becoming a major expenditure in the immediate aftermath and the longer-term recovery effort.[15] The volume and types of waste generated are greatly different from normal waste, depending on the nature and severity of the disaster. A study on the United States' past disasters showed that the volume of debris generated from a single disaster event is 5 to 15 times greater than waste generated on normal days.[16] Waste generation after the 2004 Indian Ocean tsunami also generated a similar ratio of waste. Massive volumes of debris generated often exceed the capacity of waste managers in the affected area to effectively handle the situation.

Box 2.8 provides the details of the massive quantities of disaster waste generated after the massive earthquake in Japan in March 2011, which led to a huge tsunami causing mass damage across many cities and villages along the Pacific coast of Japan.

Box 2.8 **Disaster Wastes in Japan**

The 2011 disaster in Japan resulted in a total of 25 million tonnes of debris of which 4.2 million tonnes were washed away, leaving 21 million tonnes that required disposal.

To deal with the situation, the national government announced guidelines for disaster waste management and set targets for the final disposal of disaster waste.

Recyclables were sorted out, combustibles were incinerated (several temporary incinerators were constructed in the affected region) and the remaining wastes were disposed in landfills.

Source: Tanaka (2013).

Table 2.6 presents typical debris characteristics of disaster waste.

Table 2.6 **Typical Debris from Different Types of Disasters**

Type of disaster	Typical debris streams								
	Vegetation	Construction & Demolition (C&D)	Personal property/ household items	Hazardous waste	Household hazardous waste (HHW)	White goods	Soil, mud & sand	Vehicles & vessels	Puredecent
Hurricane/typhoon	○	○	○	○	○	○	○	○	○
Tsunami	○	○	○	○	○	○	○	○	○
Tornado	○	○	○	○	○	○		○	○
Flood	○	○	○	○	○	○	○	○	○
Earthquake		○	○		○	○	○		
Wildfire	○		○		○	○	○		
Ice storm	○				○				

Source: *http://www.grida.no/graphicslib/detail/typical-debris-streams-for-different-types-of-disasters_3b32*

15 UNEP (2012).
16 Reinhart and McCreanor (1999, pp. 1–13).

With natural disasters increasing in frequency and severity as climate change impacts worsen, the issue of disaster waste has developed a higher profile and greater sense of urgency.

2.3.2.6 Marine and Coastal Litter

Marine litter or debris is waste created by humans that has been discharged into the coastal or marine environment. It is defined as "any anthropogenic, manufactured, or processed solid material (regardless of size) discarded, disposed of, or abandoned in the environment, including all materials discarded into the sea, on the shore, or brought indirectly to the sea by rivers, sewage, storm water, waves, or winds".[17]

Although there are no certain statistics, it is estimated that worldwide about 6.4 million tonnes of debris reach the ocean each year and that around eight million items enter the sea every day. In the Asia-Pacific region, the information on marine debris is limited.

Plastics are the most prevalent form of debris and consistently comprise 60 to 80 per cent of total debris recorded in marine debris surveys. Microplastics, or minute particles of plastics, have also been known to have significant deleterious impacts on the marine environment. Microplastics are derived from the manufacturing process for direct human use, such as cosmetics, and from industrial processes, and they are also formed from the breakdown of larger plastic debris. Plastics are often mistaken as food by marine animals such as turtles and seabirds. Thus, plastic consumption by these animals will lead to disruption of their biochemical mechanism and death.

Additionally, plastics in the marine environment can act as an attachment point for a wide range of toxins. Significant levels of toxins have been discovered in what were previously thought to be unpolluted deep ocean channels. So the impact of plastics in the marine environment is far-reaching and requires significant intervention. It is generally agreed that both current levels as well as the rates of input are increasing despite measures targeted at controlling the problem. It is estimated that globally as much as 80 per cent of marine debris entering the ocean each year comes from land-based sources, with the remainder arising from shipping and other maritime sources. This percentage varies in different locations and with the effectiveness of debris emission regulations on land and at sea. Derelict fishing gear is a major source of marine debris.

Table 2.7 indicates the frequency and relative percentages of marine debris collected in the APEC Region economies in the 2007 International Coastal Cleanup (ICC) day. In this way, marine debris has significant ecological impacts and contribute to a high level of toxins in the marine environment.

Table 2.7 **Frequency and Relative Percentages of Marine Debris Collected in the APEC Region Economies during the 2007 International Coastal Cleanup**

Marine debris activity sector	Frequency	Per centage or total by number (%)
Shoreline/recreational activities	3,388,742	55.5
Ocean/waterway activities	360,408	5.9
Smoking-related activities	2,179,870	35.7
Dumping activities	132,775	2.2
Medical/personal hygiene	45,463	0.7
Total number of items	6,107,258	100.0

Source: McIlgorm, Campbell and Rule (2008).

17 UNEP (2016).

Marine litter, Thailand.

Figure 2.22 shows how much plastic waste enters the oceans and seas in the form of MSW and wastewater across the globe. It can be seen that the contribution of plastic waste from Asian countries is very large compared to other regions.

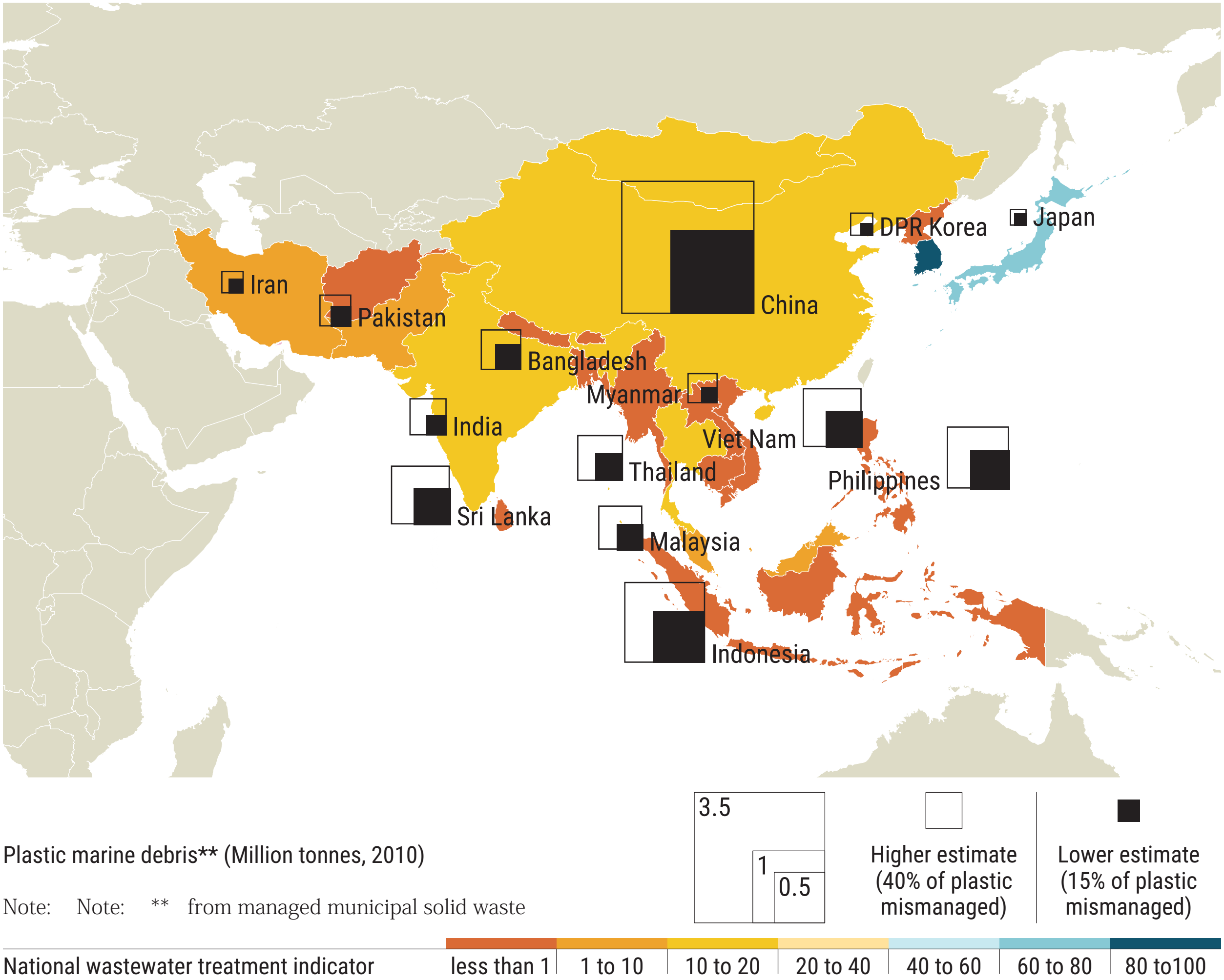

Figure 2.22 : **Plastic Inputs into the Oceans from MSW and Waste Water**

Source: UNEP (2016).

At the macro size, marine litter, particularly plastics, threaten the survival of marine life, while at the micro size, plastics debris, such as micro-plastic enter the marine food chain through the uptake of zooplankton. The threats of micro-plastics can further multiply through biomagnification and bioaccumulation within the food chain.

Figure 2.23 shows the micro-plastic distribution across the oceans in the Asian region.

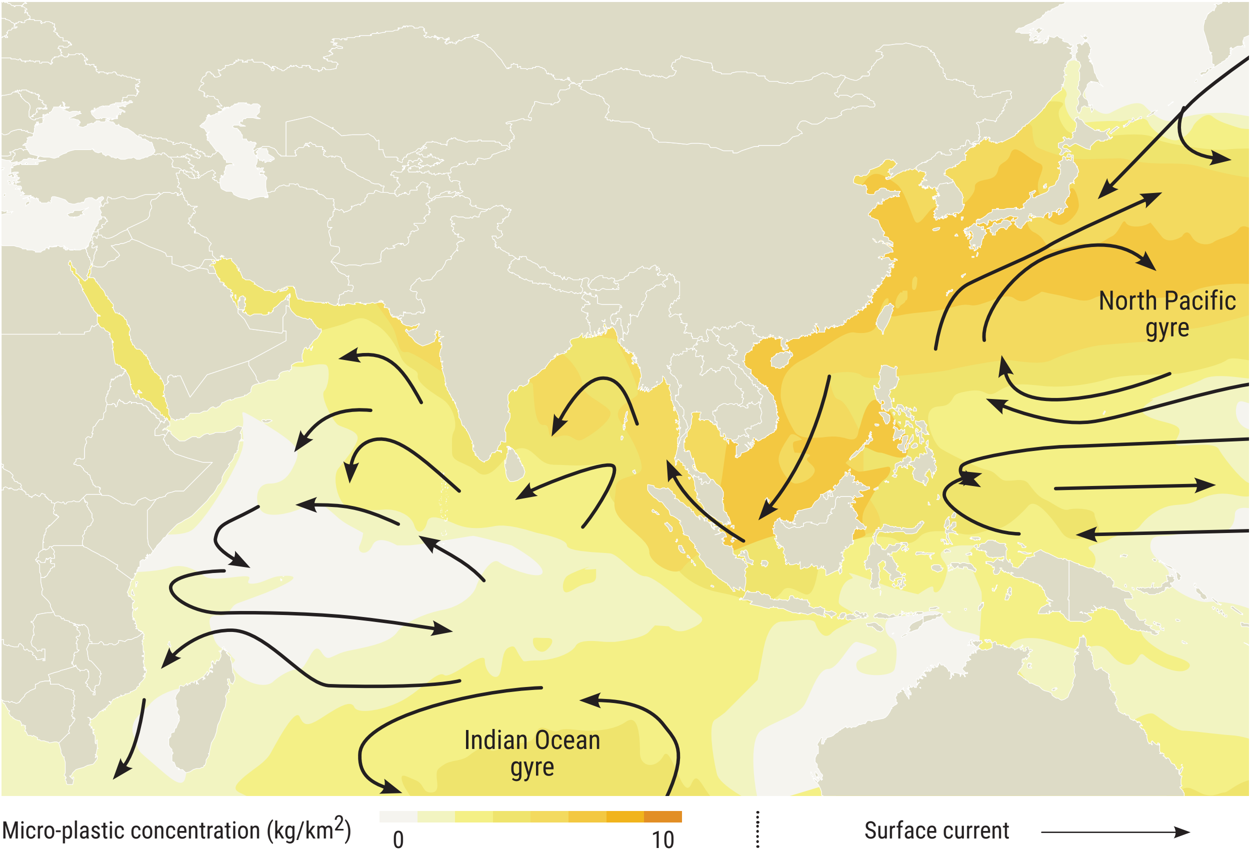

Figure 2.23 : Micro-plastic Distribution Across the Oceans

Source: UNEP and GRID-Arendal (2016).

2.3.3 Emerging Waste Streams

The ever-increasing generation of emerging waste streams is another challenge to sustainable waste management.

In the Asian context, some of the most challenging waste streams to deal with include wastes generated from absorbent hygiene products (AHPs) (feminine sanitary products, infant and adult incontinence diapers), certain types of plastics (ABS plastics and microplastic that are difficult to degrade), waste tires, etc. Besides marine litter, in the Asian context, other most challenging waste streams include wastes generated microplastic especially in the form of marine litter is a major issue of concern.

Waste AHPs often need to be disinfected prior to disposal; since they are made of multiple layers of biodegradable and non-biodegradable materials, appropriate treatment is often challenging. Waste tires contain different combinations of materials, namely metal and rubber, and are difficult to dispose due to their elasticity and bulky character. Acrylonitrile butadiene styrene (ABS) is a thermoplastic polymer very commonly used in household and consumer goods, which at high temperatures can decompose into carcinogenic compounds. Additionally, it also generates large quantities of airborne ultrafine particle concentrations when used for printing. Solar PV waste generation is another issue of concern owing to its toxic content and hazardous nature. It is worth noting that the generation of these emerging wastes is highly dependent on the affluence of the nation.

Wastes that are likely to be generated in the future include nanoparticles, which owing to their minute size, are not visible with the naked eye but may have serious health and environmental risks.

Key Messages

2

- Asia, with a population of 4.4 billion, is the largest waste-producing continent.
- Waste-related data is incomplete, not up to date and unreliable in many countries of Asia.
- At the national levels, social, economic and demographic factors are significant in determining the waste generation, as well as, the volume.
- Population growth increases consumption, and urbanisation will lead to almost the doubling of waste volume in Asia by 2025.
- Waste volumes, especially MSW, are linked to consumption and per capita GNI at the national level, which is more significant for the case of urban areas.
- Municipal solid waste makes up only a small fraction of the waste stream compared to other waste streams like C&D waste.
- Urban waste streams–such as e-waste, C&D waste, food waste, healthcare waste and microplastic–are the key concerns
- ELV waste is a stream of rising concern and needs to be addressed on a priority basis.
- Amongst non-urban streams, agriculture waste, mining waste, fly ash and marine litter dominate in terms of both volumes and environmental impacts.
- There is a significant potential to reduce wastes, reuse and recycle (3Rs) to realise economic gains, achieve higher productivity and resource security, generate employment and reduce risks to humans and ecosystems.
- A focus on reducing waste at source and practicing 3Rs should be the strategy for achieving sustainable waste management in Asia.

Plastic bags in a junk shop, Kathmandu, Nepal

Waste Management

Chapter 3

3.1 Waste Management Hierarchy

In waste management terminology, “Reduce, Reuse and Recycle” or better known as the “3Rs,” has proven to be the most practical strategy towards sustainable waste management. The 3Rs help to reduce costs of waste disposal and harness resources to reduce consumption of virgin materials.

But the preferred strategy is a key element of the waste management hierarchy, which highlights the steps that should be prioritised to bring about maximum overall benefits to public health and the environment. While the typical waste management hierarchy implies the importance of the 3Rs, more advanced waste hierarchies suggest the adoption of the 5Rs—by incorporating “Recover” (for 4R) and “Respect and Rethink” (for 5R). In fact, the EU has directed such a waste management hierarchy on all member countries with the view of reducing or minimizing the disposal to landfill (see Figure 3.1).[1]

But in other regions in including Asia, landfilling (or many times, dumping) of waste is generally practiced with little emphasis on the 3Rs. As a result, the number of dumpsites within the Asian region are high, and because they are unsecured, this has led to significant adverse impacts on the health of the neighbouring communities and the ecosystems.

Figure 3.2 shows a typical waste management hierarchy practiced by many developing countries in Asia.

Although in some countries waste-related legislation states the importance of the 3Rs, the implementation on the ground does not happen for a few reasons: mainly because of poor outreach of governments at the national and local levels, weak institutional capacities at the urban local bodies and less involvement of the private sector.

Nevertheless, countries in Asia such as Japan, the Republic of Korea, and Singapore have implemented a 3R hierarchy and have shown very encouraging results. Demonstration of economic, environmental and social benefits of the 3Rs, judicious use of economic instruments and strict enforcement of regulations have made such successes possible.

The waste management hierarchy adopted by the Government of Japan in ensuring the sustainability of the waste management system involves a holistic strategy. The hierarchy spells out the responsibilities of all stakeholders—namely, waste generators, collectors (local authorities), goods and products manufacturers, retailers and others—thus ensuring that all parties are part of the framework.

The waste management hierarchy adopted in Japan, the Republic of Korea, and Singapore is aimed at allowing the establishment of a sustainable waste management system. Japan has introduced the concept of the “Sound Material Cycle Society,” which aims to achieve zero waste. Japan has been progressively moving towards reaching this target. Singapore also has implemented a programme, “Zero Waste Singapore,” where the government has enforced regulations with innovative strategies of rewards and penalties. Consequently, Singapore managed to achieve 60 per cent recycling in 2015.

As for other countries in Asia, particularly developing economies, implementation of sustainable waste management systems integrating the 3Rs has been a struggle. Yet, few countries have taken the lead. Among countries with the most progressively improving waste management hierarchy is the Philippines.[2]

1 *http://www.zerowasteeurope.eu/2013/04/zero-waste-hierarchy/*
2 Philippines, NSWC (n.d).

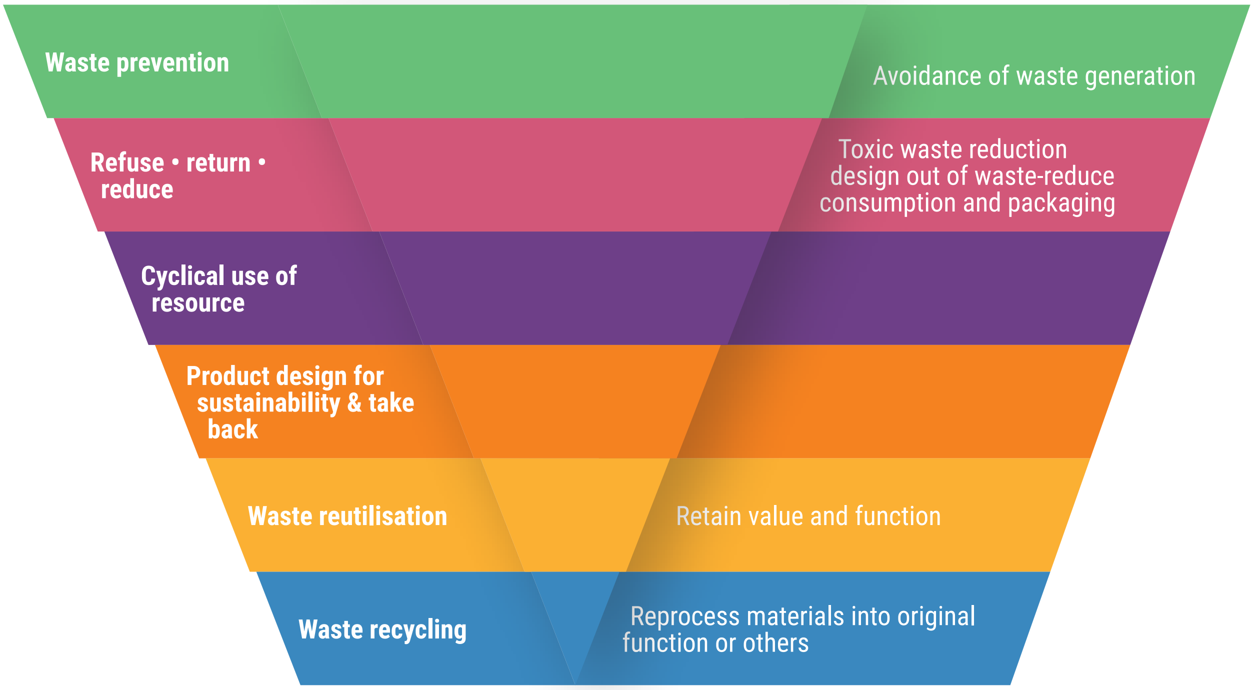

Figure 3.1 : Waste Management Hierarchy for the EU

Source: *http://www.zerowasteeurope.eu/2013/04/zero-waste-hierarchy/*

Clinical Use of Resource (left) => 3R is emphasized (right)
Product design for sustainability & take back (left) => Products are designed to minimise waste and save resources (right)

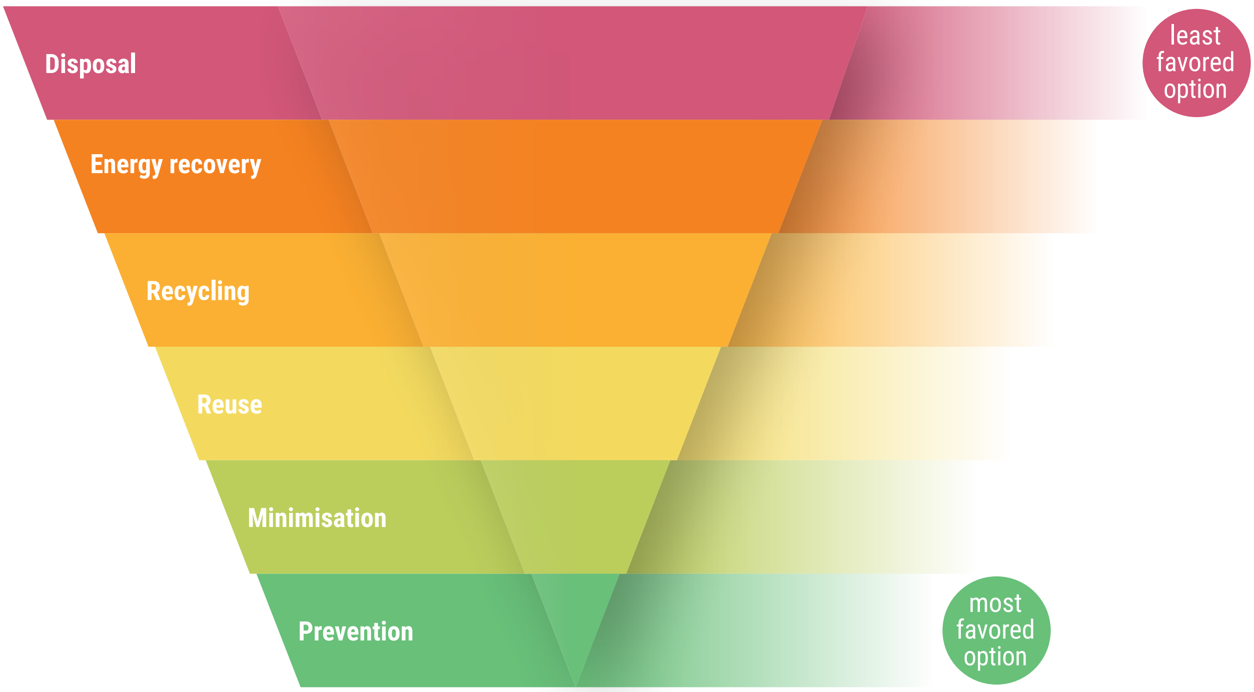

Figure 3.2 : Traditional Waste Management Hierarchy in Developing Countries of Asia

Source: *https://en.wikipedia.org/wiki/Waste_hierarchy*

3

Figure 3.3 illustrates the National Solid Waste Management Framework adopted in the Philippines.

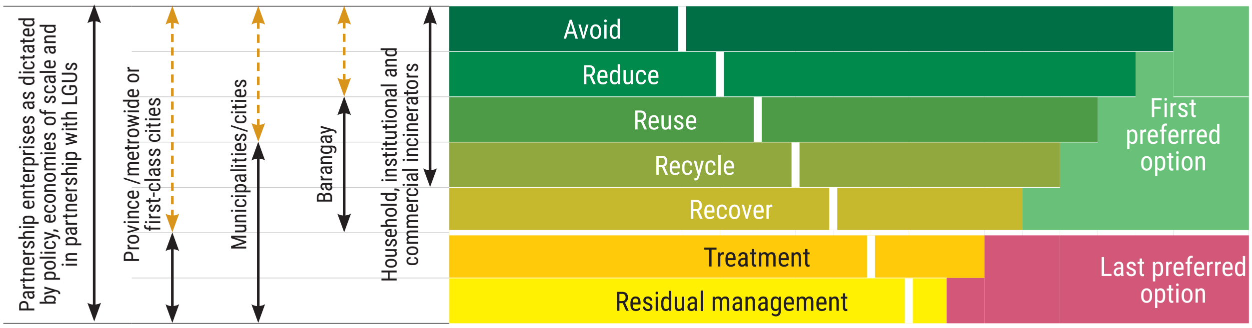

Figure 3.3 : **Waste Management Strategies Proposed in the Philippines**

Source: Philippines, National Solid Waste Management Commission (2016).

It must be noted, however, that while waste reduction must get topmost priority, landfill rehabilitation, particularly of existing dumpsites is equally important. Out of the largest 50 dumpsites in the world, 17 dumpsites are found in Asia (see Figure 3.4)..

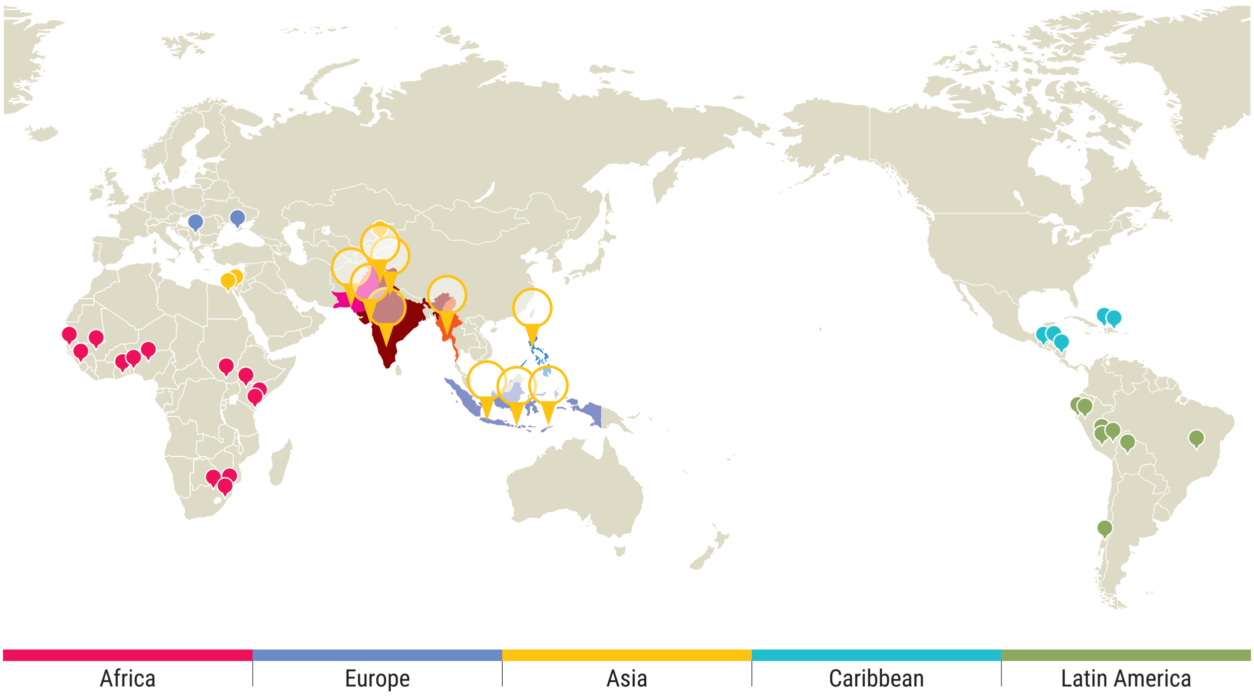

Figure 3.4 : **Fifty Largest Dumpsites of the World**

Source: Refer to the Waste Atlas™. Available from: *http://www.atlas.d-waste.com/* (accessed 24 January 2017).

The rehabilitation of dumpsites requires substantial financial resources. This challenge could be effectively addressed by undertaking landfill mining projects in the framework of public private partnerships (PPP). These projects will lead to the recovery of landfilled materials, the securitisation of the landfill and increased landfill life.

Figure 3.5 presents a "balanced" waste management hierarchy in the context of Asia, particularly regarding developing nations. The following sections in this chapter discuss various components of this hierarchy in detail.

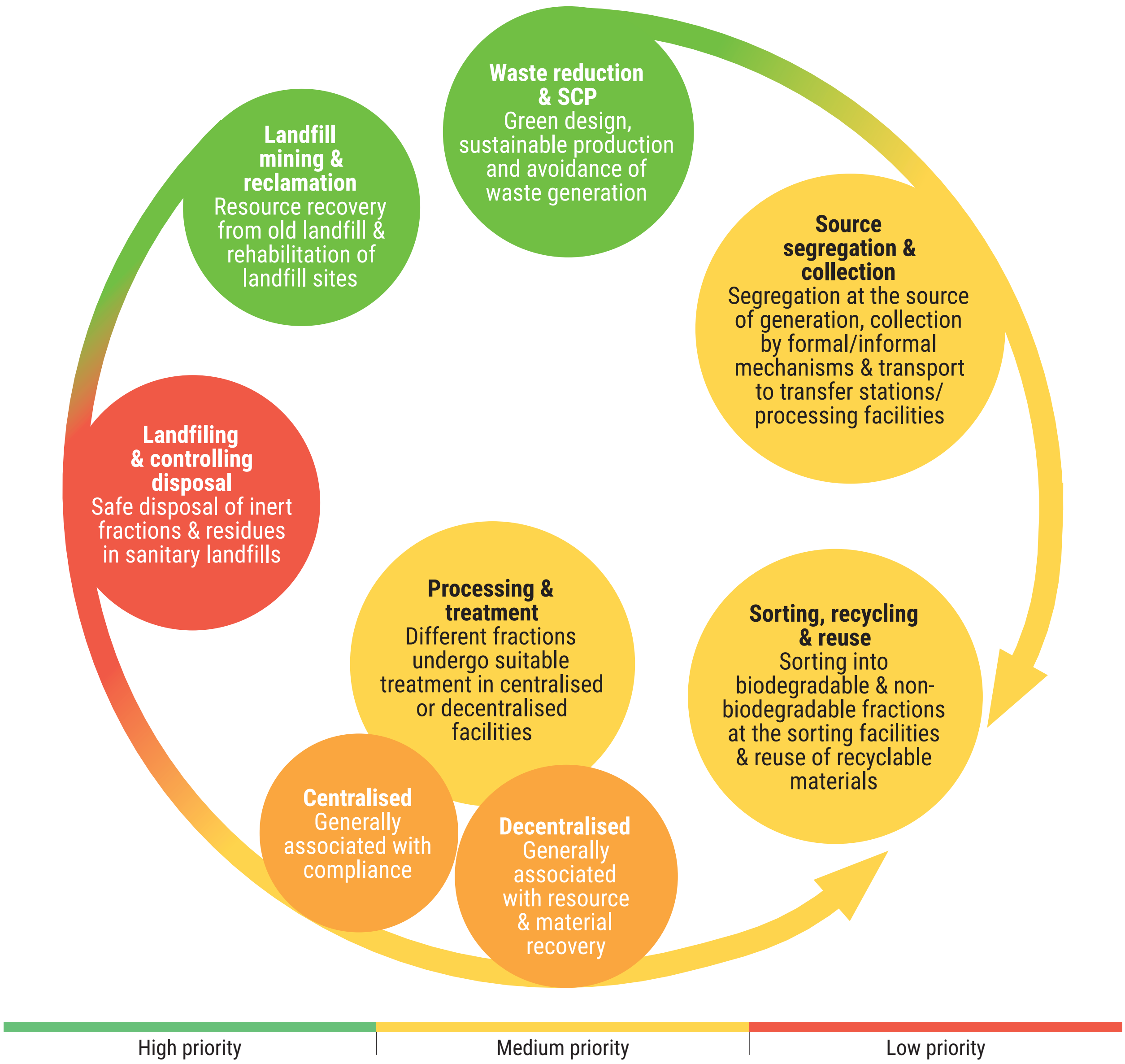

Figure 3.5 : Balanced Waste Management Hierarchy for Developing Nations in Asia, 2000–2015

Source: Prepared by Environmental Management Centre LLP

3.2 Waste Reduction through Sustainable Consumption and Production

Waste reduction should be the first priority towards sustainable waste management. In this section, we discuss three important strategies for waste reduction: green products, green procurement, and product stewardship and take-back mechanisms.

3.2.1 Green Products

Green products play a leading role in waste reduction by increasing resource efficiency and influencing production, markets, prices and available services. In this way, green products help towards sustainable consumption and production patterns.

Box 3.1 shows examples of innovations of sustainable products in Asia, while Box 3.2 highlights the innovations.

Box 3.1 **Examples of innovations on Sustainable Products in Asia**

Product Redesign in Japan

- Manufacturers of PET bottles reduced the amount of resin and, as a result, produced thinner bottles. This reduced the weight of PET bottle waste to be collected and handled by manufacturers.
- Liable under the end-of-life vehicle recycling law, Japanese automobile manufacturers used the 3Rs and a life cycle approach to improve vehicle design for better recyclability and overall environmental performance.
- The Japanese electronics manufacturer, Sony, reduced the weight of electronics such as cameras and home audio equipment.
- Toshiba reduced the number of components in its air conditioner design.
- The sports brand Adidas, together with an environmental initiative called “Parley for the Oceans,” launched shoes produced with plastic debris collected from the oceans.[a]

Source: OECD and Japan, Ministry of Environment, Japan (2014).

a. Howarth (2016).

Such innovations in sustainable product design should be shared and recognised through appropriate platforms, such as online portals, exhibitions and conferences, and so forth. Box 3.2 illustrates such initiatives.[3]

3 Global Product Award (n.d.).

Box 3.2

Illustrations of Initiatives in Innovative Green Product Design and Recognition in Asia

Green Product Award and Green Network
The annual Green Product Award is an international competition introduced in 2014 to recognise and award green products. Some sustainability-related evaluation criteria include the product's environmental effects, packaging and communication of sustainability with consumers. This initiative launched a Green Network—a platform for "green" knowledge exchange for designers, manufacturers and researchers who can learn from each other and develop green products in Asia.

Eco-Product International Fair of the Asian Productivity Organisation (APO)
The Asian Productivity Organisation's Eco-Product International Fair is one of the largest environmental fairs in Asia that showcases the most advanced eco-friendly products, technologies and services.[a] Held since 2004, the fair provides a platform to raise environmental awareness among manufacturers, promotes green product markets and supply chains, and makes eco-products, eco-technologies and eco-services available to the public. The conferences have been held in various Asian countries; these include China, India, Indonesia, Malaysia, the Philippines, Singapore, Thailand and Viet Nam. Representatives from the automotive and transport, construction material, clothing and textile, food and dairy, container, electrical machinery, furniture, IT and office supply, logistics, energy, and educational sectors attend these conferences. The organisation also publishes an eco-products directory every year to document the green products developed in the Asia-Pacific region.

GreenPro of Confederation of Indian Industry (CII), India
The Confederation of Indian Industry (CII) launched the Green Product Certification (GreenPro) system to help organisations assess "how green a product is," with focus on green building materials, industrial products, technologies, consumer products and services. The GreenPro certification system adopts a cradle-to-cradle approach for product evaluation, guiding manufacturers to position their products as green and eco-friendly. GreenPro also encourages manufacturers to implement green measures through the product lifecycle, including product design, raw materials, manufacturing, and product use, recycling and disposal. So far, more than 100 industries in India have obtained GreenPro certification.

"Top Runner" Energy Efficiency Programme, Japan
As an offshoot of Japan's 1979 Conservation Law, the "Top Runner" Energy Efficiency Programme began in 1998 to improve the energy efficiency of 23 product groups covering the residential, commercial, and transport sectors.[b] Energy efficiency standards are based on the most efficient "top running" products in the market. Products are reviewed every two to three years, and new products are added to the list.

Targets for energy efficiency improvements are controlled by the "best in class" product, thereby setting a benchmark or standard for other products in that category. Industry associations are closely involved in the setting of targets, which take one to two years per product.

The programmes standards or benchmark setting process works as follows:
- Products are assessed based on the benchmark set by the "best in class" product
- Compliance with the set energy efficiency standards is awarded through the "Top Runner" label
- Added incentives to maximise energy efficiency comes by penalizing non-compliance through "name and shame." (This method has worked because so far there have not been any manufacturers on the "name and shame" list!)

A manufacturer can receive the "Top Runner" certification based on the weighted average energy efficiency of all products sold, not only on particular products. In other words, consumers must have the option of a range of suitable energy efficient products to select from, provided by the manufacturer.

a. See APO and Eco-products on the Asian Productivity Organisation's website. Available from: *http://www.apo-tokyo.org/wedo/eco* (accessed 24 January 2017).
b. UNESCAP (n.d.).

Green products are often designed to meet the requirements of eco-labels. Many manufacturers get their products certified. Eco-labels can be classified broadly into four categories based on their area of focus, as shown with examples in Table 3.1.

Table 3.1 **Ecolabels and the Focus**

Type of Ecolabel	Example	
Environmental		**China Environmental Label** China Environmental Label was initiated by SEPA in 1993. It provides environmental standards for construction materials, textiles, vehicles, cosmetics, electronics, packaging, and more.
Resource-based		**SCS Recycled Content** SCS Recycled Content Certification recognises products made either in whole or part from recycled waste material in place of virgin raw materials. The percentage of post-consumer or pre-consumer recycled content is reported in compliance with Federal Trade Commission guidelines and ISO standards. The certification process includes company auditing and supply chain verification.
Social inclusion-based		**Fairtrade** Fairtrade is an ethical trade system that puts people first. Fairtrade offers farmers and workers in developing countries a better deal, and the opportunity to improve their lives and invest in their future. Fairtrade International is an association of 25 organisations around the world, including national initiatives and producer networks that represent producers at the highest level of decision-making in the international Fairtrade system.
Carbon-based		**Carbon Footprint of Products** The Carbon Footprint of Products displays the carbon footprint of products on the packaging to provide consumers with information about GHG emissions and the products with the lowest carbon footprint.

Source: Ecolabel Index is the largest global directory of ecolabels, tracking about 465 ecolabels in 199 countries and 25 industry sectors. Available from: *http://www.ecolabelindex.com* (accessed 24 January 2017).

3.2.2 Green Public Procurement

Green procurement refers to purchasing of products and services that minimise environmental impacts. This purchasing method compares price, technology, quality and environmental impact. In recent years, many government have adopted this method to purchase products having lesser or reduced adverse effect on public health and environment. Such green public procurement may contribute significantly to the sustainability of an economy and the environment because it generally has the highest purchasing power of a given country. As such, government can also influence society and companies to adopt similar measures.

Box 3.3 highlights some efforts on green public procurement in Asia.

Box 3.3 Green Public Procurement in Asia

International Green Purchasing Network (IGPN)
The International Green Purchasing Network, headquartered in Japan, has a global mission to spread knowledge of environmentally-friendly products, service development and green purchasing activities. It helps countries develop green procurement policies, purchasing guidelines, tools for product evaluation, product database, and training materials that are used worldwide. The Network holds workshops and international conferences in the Asian region to disseminate green purchasing information and knowledge. Examples of workshop thematic areas include sustainable food systems, green buildings, sustainable transport, and life cycle management.

SWITCH-Asia Programme
The SWITCH-Asia Programme, a grant programme launched by the EU, helps countries in Europe and Asia to switch to SCP practices on a large scale.[a] The Programme has supported the promotion of SCP in Asian developing countries through over 100 projects, comprising 95 grant projects, a network facility, one regional policy support component and five national policy support components in Indonesia, Malaysia, the Philippines, Thailand and Sri Lanka with overall funding of more than EUR 300 million for 2007–2020. The SWITCH-Asia Programme has developed policy instruments for SCP practices for raw material procurement, production, supply chain, retail, usage and end-of-life management of products.

Some projects undertaken by SWITCH-Asia are enhancing sustainability and profitability of the carpet and pashmina industries in the Kathmandu Valley, increasing the uptake of high-efficiency motors and drive systems in the Philippines, supporting a greener and more energy efficient construction industry in Mongolia and upscaling improved cook stove dissemination in Myanmar.

For more information, refer to UNEP's infographics booklet that shows trends of natural resource use and resource efficiency in the Asia Pacific region as well as evolution over the past 40 years. Available from: *http://www.switch-asia.eu/publications/resource-use-in-the-asia-pacific-a-booklet-of-infographics/*

3.2.3 Product Stewardship and Take-back Mechanisms

EPR, which has been proven to effectively manage waste, is one of the most favoured programmes among manufacturers. It enables products stewardship so that manufacturers can be more responsible of their products' life cycle while empowering manufacturers to contribute more significantly towards environmental protection. The most common method to manage waste products is the take-back programme.

In Thailand, Hewlett-Packard has established a recovery facility of its products where the HP Planet Partners has recycled more than 1.5 million tonnes of mainly computers and IT goods through product return and a recycling campaign. The used products are resold and recycled in 74 countries worldwide. The programme resulted in significant reductions of GHG emissions by 26 percent from the emissions recorded in 2010, and the company hopes to reduce it further to 40% by 2020. Box 3.4 provides two examples of product stewardship from Asia.

Box 3.4 **Product Stewardship in Asia**

Hewlett Packard

Hewlett Packard (HP) is one of the leading global companies to show its commitment towards sustainability by adopting eco-friendly initiatives to reduce waste from its own operations.[a] HP has worked towards reducing waste from the user side as well through product design and by adopting an EPR strategy to take responsibility of managing its products at the end of a product's life. HP's take-back and recycling programme has successfully salvaged over 1.8 million tonnes of computer hardware and HP supplies over the past 25 years. In 2015, 41,100 tonnes of electronic hardware were recovered for reuse, while 114,100 tonnes of hardware and supplies were recovered for recycling from 73 countries and territories worldwide. The programme's outreach is widely seen all over Asia.

Moreover, an 87.2 per cent landfill diversion rate was achieved globally in 2015. HP began closed-loop recycling with toner cartridges made from plastic recycled from the company's Planet Partners programme in 2000. Since its inception, more than 197 million HP LaserJet and inkjet printer cartridges have been returned and recycled worldwide, comprising nearly 300 million pounds. In 2005, HP started using recovered PET from its ink cartridges as a source for new cartridges. It has since extended the programme to include other cartridges and polypropylene. Through 2015, HP manufactured more than 3 billion ink and toner cartridges, using more than 177 million pounds of recycled content material. More than 80 per cent of HP's ink cartridges now contain 45–70 per cent recycled content, and a 100 per cent of HP toner cartridges now contain 10–33 per cent recycled content (Figure 3.6).

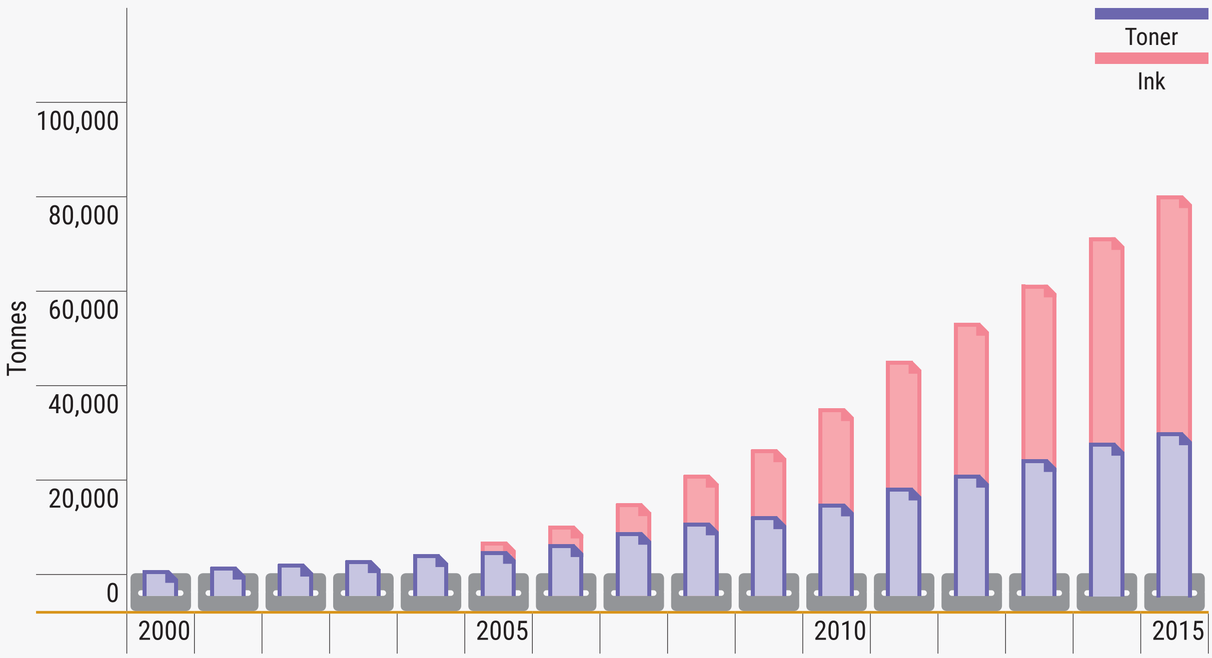

Figure 3.6 : **Recycled Plastic Used in HP Toner and Ink Cartridges, Cumulative in Tonnes**[b]

Source: HP (n.d.).

a. For more information on HP's commitment to waste management, visit the HP web page "Product return & recycling" Available from: *http://www8.hp.com/us/en/hp-information/environment/product-recycling. html* (accessed 24 January 2017).

b. HP (2015).

Fuji Xerox

Fuji Xerox Company has taken several steps to demonstrate its commitment to environmental responsibility and sustainability over the years. In Asia-Pacific, the company has four purpose-built remanufacturing, reuse and recycling facilities—in Australia, China, Japan and Thailand. These facilities achieve over 99 per cent resource recovery from its products at the end of their life.[c] In 2008–2009, Fuji Xerox disposed 4,052 tons of end-of-life equipment from Australian customers, of which 1,412 tonnes were shipped to its Thailand recycling centre for processing in accordance with its Basel permit (Figure 3.7).

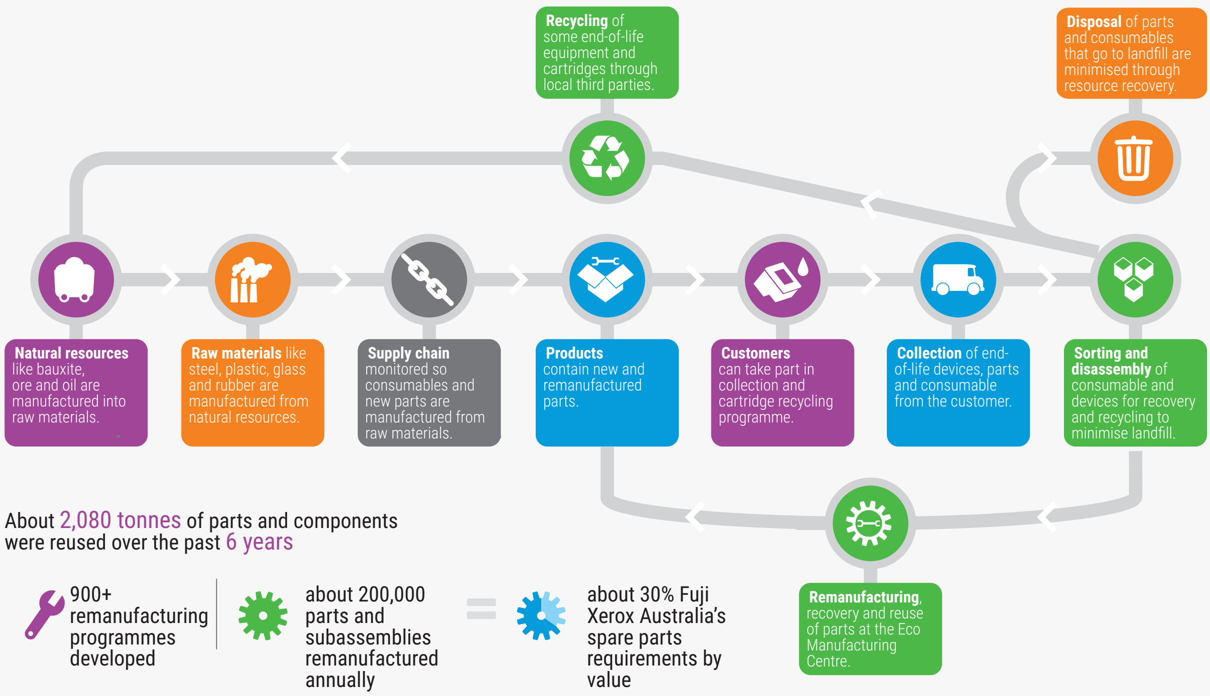

Figure 3.7 : Fuji Xerox's Product Stewardship Process

Source: *http://www.fxasustainability.com.au/stewardship_approach.php*

Fuji Xerox takes back products, parts, and toner cartridges and then sends them for remanufacturing and recycling either at the company's Sydney-based Eco Manufacturing Centre (for remanufacturing) or to domestic third-party recyclers, depending on the type of product recycled. The centre is a total waste management hub for returned parts, cartridges and packaging for resource recovery, and it successfully remanufactures about 250,000 parts and subassemblies annually.

Eco-manufacturing now supplies 65 per cent (by value) of spare parts and consumables for Australian customers. The company's rationale for taking products back at the end-of-life is not based solely on responsible waste management; remanufacturing and reusing parts allows Fuji Xerox to reduce new resource inputs through the import of spares and parts and to lower the carbon footprint of new products. Customers also benefit from lower prices and the elimination of the need to dispose materials themselves. Fuji Xerox also aims to incorporate environmental initiatives in its design and product development by eliminating the need to use hazardous materials like lead-based solder.

c. For more information, see Fuji Xerox's fact sheet "Fuji Xerox and Environmental Sustainability." Available from: *http://www.fxasustainability.com.au/reso urces/0321344_FXA%20Sustainability%20Media%20Factsheet_v2.pdf* (accessed 24 January 2017).

3.3 Source Segregation, Collection and Transportation

Segregation of waste at the source is critical to achieve waste reuse, recycling and recovery. It also helps to reduce collection and transportation costs. This section discusses the benefits of source segregation and certain contemporary practices of waste collection and transportation in Asia.

3.3.1 Source Segregation

It is generally not mandatory for the waste generators to separate different types of wastes. Segregation is achieved not just by enforcement but also by raising community awareness, NGO and community-based organisations (CBO) leadership and schemes of recognition, rewards and penalties.

Several countries in Asia have introduced the "carrot and stick" concept to promote source segregation. Some strategies include economic incentives and disincentives such as fees, taxes and concessions. The success of these strategies is, however, city- or case-specific and cannot be generalised.

In Indonesia, waste segregation occurs at two levels: in the first stage, collectors, including the informal sector, segregate recyclable materials at source. In the second, waste sorting is carried out at collection centres by municipalities. The first level of segregation takes place mainly owing to economic drivers; this activity provides informal workers or the urban poor with income from selling recyclable materials.

In the Uttara Model Town in Bangladesh, source separation is achieved through an effective 3R programme that enables the retrieval of recyclables from 51 tonnes of waste generated daily.[4] Each year, the programme has succeeded in diverting an average 2,780 tonnes of waste: 930 tonnes of plastic waste, 1,300 tonnes of paper waste, and 540 tonnes of textiles and other recyclable materials. As a result, the Uttara Model Town has managed to save about USD 120,000 per year in its waste disposal.

Attitudinal issues are one of the most significant barriers to waste segregation at source. Malaysia introduced voluntary waste segregation in 2015.[5] Over the span of a year of implementation, only 51 per cent of the public responding to a survey knew about the importance of waste segregation. Only 47 per cent did some segregation, while 53 per cent of respondents excused themselves from segregating waste owing to limited space, time constraints and the distance of the recycling facility. A mandatory enforcement of source segregation in 2017 might see a different scenario. In certain Asian countries, such as Viet Nam, the public routinely segregates plastics, papers and metals to sell to waste collectors.

4 UNCRD (2010).
5 Malik, Abdulla and Manaf 2015).

Waste transfer station facility, Bangkok, Thailand

3.3.2 Waste Collection and Transportation

Waste collection is another factor influencing the efficiency of a waste management system. A proper waste collection system ensures that waste is not heaped or indiscriminately disposed, causing health concerns as well as an eyesore.

Collection services depend on the type of waste generated. In most cities, municipal solid waste (MSW) collection is the responsibility of local governments, while industrial waste is collected and transported either by licensed waste haulers (e.g., Malaysia) or by the waste generators themselves (e.g., India).

Waste collection is usually under the jurisdiction of private waste operators awarded contracts to manage waste within a certain area. Waste collection may be solely managed by the main company that handles the waste or municipality, or it could be contracted to smaller enterprises with responsibility for a smaller areas or wards.

Collection rates vary across countries, regions and even across cities within the same country. These rates are often driven by a given jurisdiction's income level. In low-income countries, it is not uncommon to find collection rates below 50 per cent, and in a lower middle-income country such as India, data for 105 cities show that collection rates vary between 40 to 100 per cent. In contrast, high-income countries consistently reach close to 100 per cent (e.g., Singapore and Korea).

In Viet Nam, the collection rate in urban areas ranges between 83 to 85 per cent.[6] The collection rate in its larger cities is normally higher than that in the smaller cities. The rate of household solid waste collection in urban areas reached an average of 83–84 per cent with the core districts in Hanoi City achieving 98 per cent, according to the National Environment Report 2011; however, the rate is 60 to 70 per cent in its suburbs. In Ho Chi Minh City, the collection rate is 90 to 97 per cent.[7] In this city, waste collection is under the responsibility of Ho Chi Minh Environmental Company (CITENCO), 22 district service companies and the Cong Nong Cooperative. In other cities like Hue, Da Nang and Hai Phong, collection rates are about 90 per cent.

Figure 3.8 shows the collection efficiency for several municipalities across the world.

6 Thoa, Yen and Hai (2013).
7 Country Chapter, Viet Nam (2013).

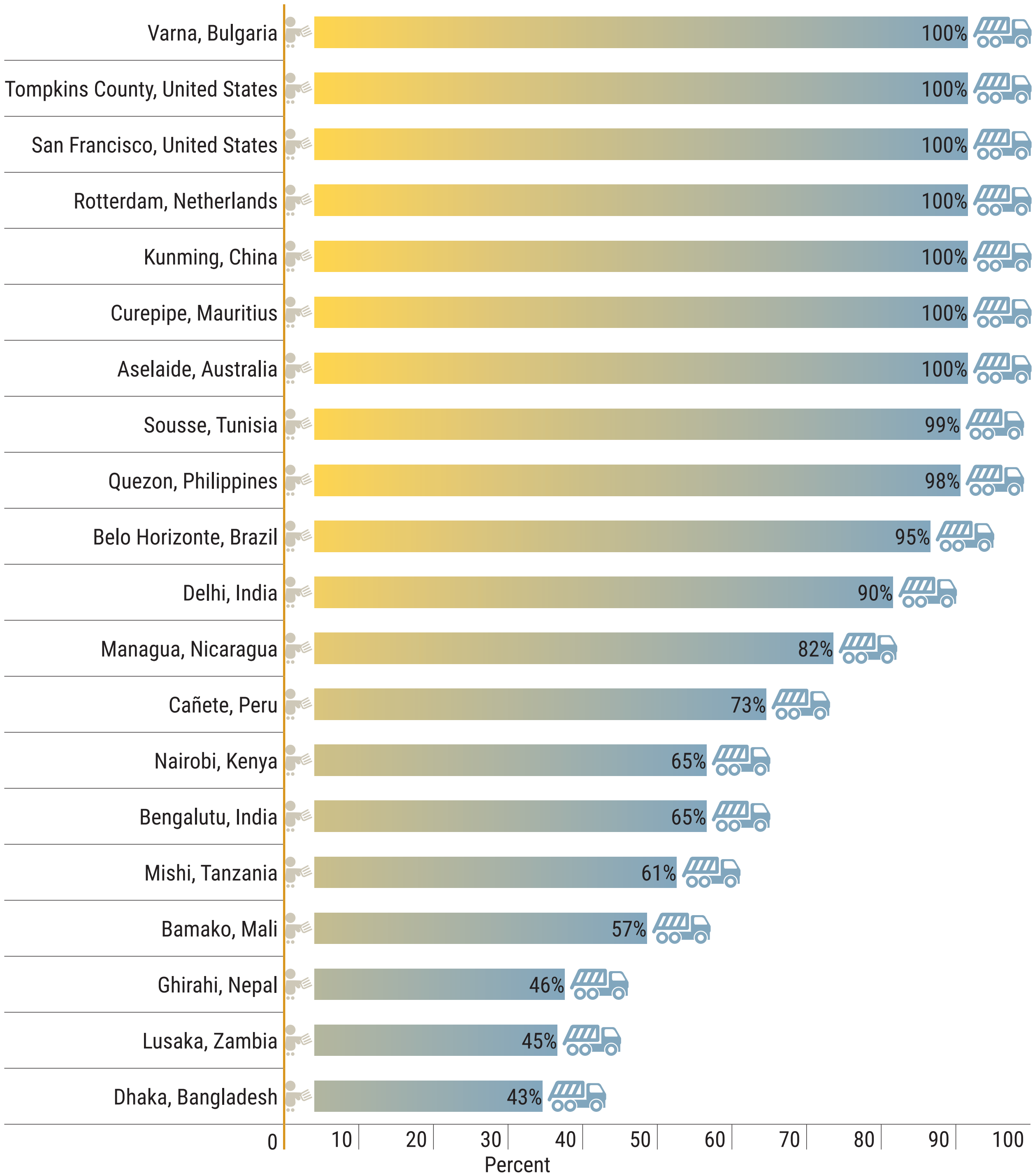

Figure 3.8 : **Collection Efficiencies for Several Municipalities**

Source: Kawai and Tasaki (2016).

Figure 3.9 shows the extent of collection by communities and municipalities in Japan along with their recycling rates in 2012.

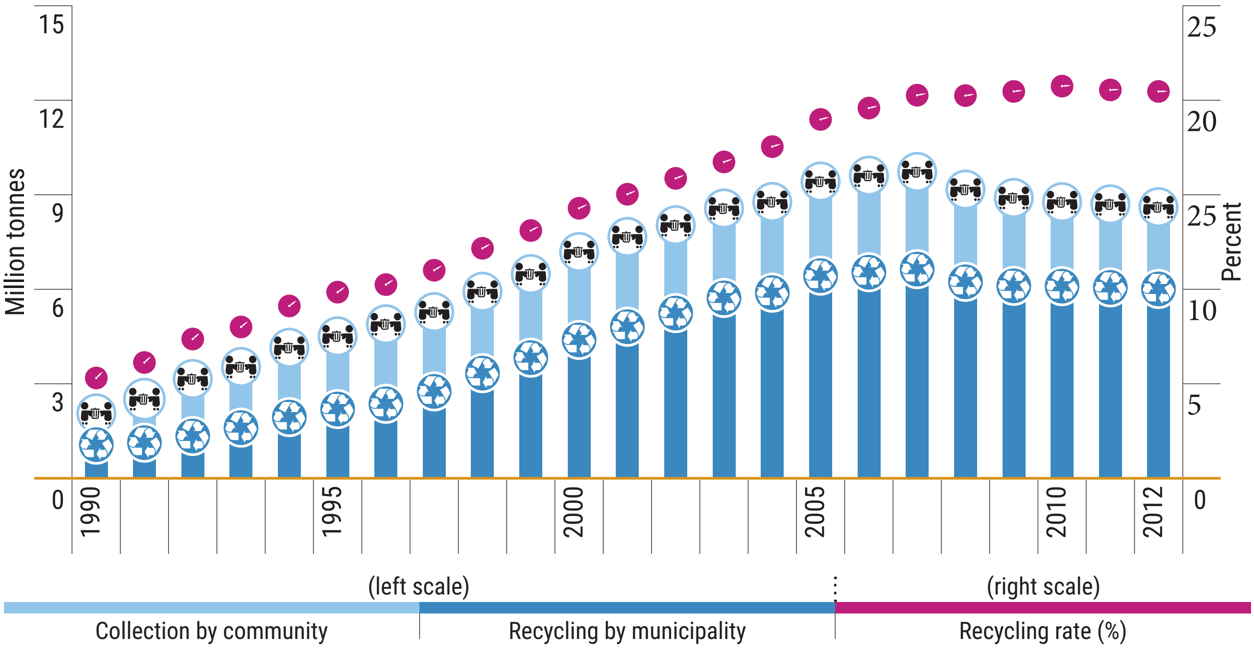

Figure 3.9 : Accumulated Waste Collected by Community and Municipality in Japan, 1990–2012

Source: Yonetani (n.d.).

Box 3.5 highlights manual waste collection in low- and middle-income countries in Asia, whereas Box 3.6 discusses advanced waste collection systems in developed Asian countries.

Box 3.5 Manual Waste Collection in Low and Middle-income Countries in Asia

Most cities in low- and middle-income regions employ manual labour to collect waste, often with brooms and wheelbarrows. For instance, the Dhaka municipality employs over 7,000 workers only for street cleaning and waste collection from lakes. This number does not include workers who collect waste from community bins, roads, open spaces and so on. Street sweeping can be a large part of the waste collection cost. The cost breakdown of street sweeping is typically as below:

- Labour: 50–70 per cent
- Capital costs for sweeping equipment: 20–30 per cent
- Maintenance and consumables: 10–20 per cent[a,b]

a. The Asian Productivity Organisation (2007).
b. Cointreau (2005).

Box 3.6 **Modern Waste Collection Systems in Singapore**

Pneumatic Waste Collection in Singapore

Pneumatic waste collection or Automated Refuse/Waste Collection Systems (ARCS/AWCS) is considered to be leading-edge, state-of-the-art technology. In this system, waste is transported underground through a pipe system directly to a waste collection centre. Waste is deposited into containers or hatches that may have separate intakes for different kinds of waste. The waste is then pulled into the pipeline through air pressure differentials.

Such systems can be particularly useful in high-density urban residential areas or in hospitals. In fact, an
ARCS has been implemented at Singapore's renowned Changi Airport, mainly to address security concerns during waste transportation. Waste collection vehicles would frequently pass underneath the main terminal, which was found unacceptable and highly risky after the New York 9/11 incident. Because the ARCS system is operated and monitored remotely, no waste collection personnel are required to be at the airport site. Waste is collected at a central collection point 1 km away from the airport. The ARCS system, totalling 2 km of pipeline, took three years to complete, operates 24 hours a day, and is estimated to collect over 4,800 tons of waste per year.[a]

Smart Bins in Singapore and the Republic of Korea

Singapore's National Environment Agency (NEA), in collaboration with Mobiquest, is installing sensors on over 10,000 refuse bins across the city that will signal when the bins are full. The sensors send out notifications through the regular cell phone network to a central server. This enables the efficient collection of refuse and minimises overflow and littering around bins. Over time, this data can also be used to develop flexible, cost-effective waste pickup routes. For instance, refuse bins in parks and restaurant areas may fill up quickly and require more frequent collection over the weekends than on weekdays.[b]

In 2014, Seoul, Republic of Korea installed 85 smart bins developed by Korean Ecube Labs to enable smart waste collection. These "smart" waste bins have solar-powered compactors, which work automatically based on how full the bin is and send information via cellular data networks. If the bins are nearing capacity, the waste operators are alerted and can dispatch vehicles for collection to the areas where the bins are located. This has enabled about an 83 per cent reduction for waste collection—a 66 per cent reduction in collection frequency and a 46 per cent increase in recycling.

a. STREAM (2005).
b. Gaia Discovery (2015).

Note: For case studies on smart city waste management, please refer to the Ecube Labs website. Available from: *http://ecubelabs.com/case-studies/* (accessed 24 January 2017).

For MSW collection in large cities, where the distances to disposal sites and travel times are substantial, transfer stations are used for temporary storage to improve transportation logistics as well as costs. A transfer station is essentially a building or a yard for temporary waste storage. Smaller waste collection vehicles catering to neighbourhoods deposit their waste; the waste is then loaded onto larger vehicles for transport to an end-point, such as a treatment facility (e.g., waste recycling or waste-to-energy facility) or a disposal site (i.e., landfill).

Transfer stations are sometimes co-located with waste sorting centres (also referred to as "material recovery facilities"). Some sorting centres may use mechanical biological treatment (MBT) systems to convert the organic waste fractions to useful products through anaerobic digestion. These systems are also sometimes used to remove recyclables from the waste stream before treatment or disposal.

3.3.2.1 Formal Sector

The involvement of the formal sector in waste collection in Asia is undeniably crucial. This is mainly because the commitment to provide solid waste management services is maintained at a specific level, regardless of influencing factors such as economic development and social factors. As a result, most countries in Asia are highly dependent on the formal sector services in ensuring the effectiveness of waste management services. The main advantages of this dependency on the formal sector include the level of satisfaction achieved and the continuous efforts in promoting sustainable waste management.

An example of a government's appointment of commercial institutions and industry in managing waste collection is the formalisation of waste collection in Viet Nam.[8] Waste management in Viet Nam, for example, has been awarded to URENCO, while in Malaysia, waste collection and disposal are handled by three concessionaires—namely, Alam Flora Pvt Ltd., Southern Waste Management Pvt Ltd. and E-Idaman Pvt Ltd. URENCO is also formally responsible for the collection, transportation and disposal of MSW generated in Viet Nam. As a result, the collection rate has significantly improved in the country since the company has been awarded the contract.

More than 97 per cent of municipalities in Japan have their own waste sorting facilities. Almost all of these facilities (99 %) have waste treatment facilities such as incinerators and provide waste collection services and other types of intermediate treatment for recycling.[9]

3.3.2.2 Informal Sector

The informal sector plays an important role in improving the efficiency of a country's waste management. Despite advantages to increased waste recycling (i.e., cost reduction and employment generation), health risks posed to industry workers are very high. Often, materials are burned to separate plastics and precious metals, thus posing a major health hazard to the waste pickers. There is a need to recognise their contributions and address these concerns by supporting waste pickers; some approaches include offering training and providing safety equipment. The formation of cooperatives with local government support has shown to be an effective strategy.

3.3.2.3 Integration between the Formal and Informal Sectors

Both the informal and formal sectors are equally important in improving the waste management system of a country; thus, integration between the two sectors is necessary to reduce conflicts and take advantage of the synergy in providing the waste management-related services.

In Dhaka city, Bangladesh, 120,000 urban poor from the informal sector are involved in the recycling trade.[10] In 2005, the informal sector recycled 15 per cent of the total waste generated (mainly inorganic), amounting to 475 tonnes per day.[11] This was achieved by encouraging government policies targeted towards the informal sector. The effort also facilitates local authorities and industries to provide infrastructure facilities, arrange required financial mechanisms to implement this strategy and provide a key role for the informal sector. In India, for example, the government has initiated capacity-building programmes to help develop the skill sets of informal sector workers.

Although in developing nations the integration between the formal and informal sector is essential to enable the implementation of sustainable, holistic waste management systems, in developed nations, the situation is different owing to the almost non-existence of the informal sector. The effective waste management system in Japan, for example, does not provide any opportunities for the informal sector to emerge. As a result, only the formal sector plays a role in the waste management system.

In other Asian countries, urban local bodies have signed MoUs with cooperatives and informal waste pickers to improve the efficiency of waste management services. This brings about a huge advantage because it creates more job opportunities, increases the resource recovery rate, and provides economic benefits for waste pickers.

8 Country Chapter, Viet Nam (2013).
9 Government of Japan, Ministry of Environment (2008).
10 UNCRD (2010).
11 Ibid.

In Nepal, the majority of cycle hawkers and small scrap shops are registered with the Nepal Recycle Producer Association (NEREPA), an association of buyers of recyclable materials in the Kathmandu Valley.[12] The step in formalizing the informal sector is to ensure that the level of commitment of the participating members can be maintained regardless of market influence.

Box 3.7 provides an example of informal and formal integration in Pune, India.

Box 3.7 **Integrating Waste Pickers and Waste Sorting Centres in Pune, India**

A waste sorting centre in Pune, India, serves as a model for recycling for other cities in India. The sorting centre was built after feedback was provided from the neighbouring community while also taking into consideration the needs of waste pickers. The building was designed with separate entry and exit points and allowed small trucks and collection vehicles to drive in, thus easing loading and unloading requirements, while also mitigating odour and noise issues and scavenging by stray dogs. Dedicated space has been provided for waste pickers to work and rest, along with large windows, high ceilings, and bathrooms. Ample room has been provided to scrap dealers to load recyclable materials.

Source: The Times of India City (2016).

Partnership between municipalities and communities is another example of integration of formal and informal sectors. In Matale, Sri Lanka, three neighbourhood-based plants have been installed with a combined capacity of nine tonnes of organic waste and three tonnes of recyclables a day, thus treating a major portion of waste generated by the town and creating employment for 20 urban poor.[13] This compares with a typical sorting centre that recycles about 1 ton of waste per day. In parallel, community development officers of the Municipal Public Health Department were responsible for raising community awareness through intensive face-to-face communication with households, resulting in a source segregation rate of 60 per cent. The leadership and strong commitment by the mayor and the municipality played an important role in the initiative's success.

3.3.3 Waste Transportation

Wastes that are collected and may be stored temporarily in transfer stations are transported for treatment and disposal. Route optimisation and waste vehicle tracking are two ways to improve and maintain efficiency in waste collection, effectively take corrective action and enable proper planning. Each of these is discussed in this section.

3.3.3.1 Route Optimisation

One key element of waste collection is route planning (i.e., deciding which routes waste collection vehicles follow, types of waste to be collected on priority and the frequency of collection for different types of waste. Compostable waste, for instance, may be collected daily, while recyclables may be collected less frequently, (e.g., once every three days). Planning also involves deciding what types of vehicles to use in certain areas (e.g., in areas with narrow streets, only handcarts and mechanised three-wheelers may be used). Another important issue is how to schedule vehicle movement to maximise efficiency and minimise time on the road, reduce fuel consumption, minimise idling of vehicles, avoid peak traffic hours and so on. Furthermore,

12 3R Knowledge Hub (2014).
13 UNESCAP (2016).

as cities expand, new areas require waste collection services, and new routes are constantly being added. Optimal planning, monitoring and tracking are, thus, key to reducing costs and improving efficiency. In developing country cities, waste collection makes up the bulk of total expenditure on SWM services.

Unfortunately, waste collection has historically been planned on an ad hoc basis: new routes are added based on necessity and availability of vehicles without factoring in a "systems perspective" over the long run. Today, technological innovations enable the city planner or solid waste engineer to optimise collection using sophisticated software and digital tools to include collection systems (e.g., door-to-door, community bins), fleet selection (size of trucks, other vehicles), and routing. In fact, route optimisation studies for part of Chennai, India, estimated that the distance travelled could be reduced by almost 10 per cent, resulting in significant annual cost savings.

Tyre waste reused as bins, Bali, Indonesia.

© Nang Sian Thawn, RRC.AP

Box 3.8 provides further details on these route optimisation studies.

Box 3.8 **Studies on Route Optimisation in Chennai, India**

Chennai has a population of 7.1 million spread over a large land area. In 2011, the city expanded its boundary from 175 to 426 km^2, further stressing the already suboptimum levels solid waste management services. The city generates an estimated 4,840 tonnes of waste per day. MSW is deposited in bins across the city, which is then collected by workers daily. However, owing to various factors such as lack of manpower and planning, the city collects and disposes of only 60 per cent of the total waste generated. The waste collected from the bins is taken to 12 transfer stations spread across the city and from there to two main dumping grounds.

A GIS-based study was conducted to minimise routes from collection sites to transfer station and further to the dumpsites, considering that would in turn reduce costs, time, and wear and tear on vehicles. The study involved an area of about 35 km^2, covering 13 waste collection routes and 1 transfer station. The waste generated in this area is 187.4 tonnes per day, and the related costs were INR 128/tonne, corresponding to 136,321 USD per year (8.76 million Indian Rupees/year).

The results showed that with the help of proper GIS planning, routes in the study area could decrease by over 18 km, leading to an operating cost savings of almost 10 per cent. In terms of time, these routes would lead to total savings of about 17 minutes or a 12 per cent decrease in time travelled. Overall, using the recommended routes would lead to a savings of 353,564 USD per year (22.72 million Indian Rupees/year). If such a system could be planned and adopted for the whole city, the cost savings would be considerable.

Source: Sanjeevi andShahabudeen (2016)

Exchange Rate : 1 USD = 64.26 Indian Rupees

3.3.3.2 Vehicle Tracking

Many businesses use vehicle-tracking technology to monitor supply and take-back of goods. In this technology, vehicles are fitted with GPS-tracking devices. These devices help generate real-time information on one or more vehicles, such as the location, speed, detours and current traffic. When this data is pooled and analysed, it enables generation of statistics, such as the total trip distance, average delays, idling or time spent in waiting. Online or off-line decisions can then be made based on these factors, such as re-routing vehicles to enable more collection within a certain timeframe and varying collection times to minimise the amount of time spent in traffic.

The barriers to implementing route optimisation and vehicle tracking are

- Cost of implementing a new system
- Poor internet or data systems for transmission of information
- Large volumes of data generated must be stored and analysed
- Technical knowledge to use this data
- Preference of workers to be not “tracked”

3.4 Reuse, Recycling and Recovery

For urban waste streams, MSW, C&D waste and e-waste constitute major waste streams of concern. This section focuses on recycling practices followed in Asia, including benefits and experience.

3

3.4.1 Recycling of MSW

Waste sorting centres play a key role in Integrated solid waste management (ISWM) and, thus, should be considered a key element in modern sustainable waste management. They provide waste pickers a safer environment to work in, encourage communities to recycle and reduce the amount of reusable and recyclable material sent to a landfill, thus increasing the life of the landfill and reducing GHG emissions.

The waste is separated by product, and the various items are then prepared for recycling, composting, treatment, and/or disposal.

Waste sorting centres, also known as materials recovery facilities (MRFs), receive, store, and separate waste into non-recoverable waste for disposal, organic waste for composting, and recyclable materials by type for preparation or treatment.

Generally, there are two types of MRFs: clean and dirty. Table 3.2 outlines the key differences between these two types.

Table 3.2 **Difference Between a "Clean" & "Dirty" MRFs**

Clean MRF	Dirty MRF
Accepts co-mingled recyclables that have already been separated at source	Accepts a mixed solid waste stream (e.g., organics, recyclables, and inert materials)
Sort recyclables to specifications and bale, shred, crush, compact, or otherwise prepared them for shipment to market	Separates recyclables through a combination of manual and mechanical sorting and may undergo further processing required to meet technical specifications for recycling markets
Commonly receive all mixed recyclables (e.g., corrugated cardboard boxes, newspapers, magazines, office paper and junk mail), often called single-stream recycling	Sends other wastes to respective facilities (e.g., organic waste to composting plant and non-recyclables to treatment facility or landfill)
In some cases, receive dual stream recyclable waste, where the two waste streams are paper and other recyclables (e.g., glass, ferrous metal, aluminium and other non-ferrous metals and plastics)	

Materials recovery is a popular option in the waste management system in developing Asian countries because source segregation is still minimal in most places.

MRFs in Japan are one of the best examples of integrated waste facilities that combine three processing facilities for sorting and recycling co-mingled recyclables, following a dirty MRF approach, and having an additional focus on green wastes. The combined MRF enables more efficient retrieval of resources from various waste streams while ensuring significant reduction of residual waste to be disposed.

Table 3.3 outlines activities of three types of recovery facilities in Japan.

Table 3.3 **Three Types of Recovery Facilities Operating in Japan**

Types of facility	Activities
Blended or co-mingled recyclables facility	Processes residential and commercial mixed recyclables (cardboard, glass, aluminium and different plastics) Bales out recovered materials and sends them out to processors to produce new products; processes waste at 45 tonnes/hour Recovers over 95% of the material processed
Dirty MRF	Processes MSW and removes organic material before sending residuals to the landfill Processes MSW at 25 tonnes/hour and organic waste at 37 tonnes/hour Sends almost 70% of the material processed for composting
Green waste	Processes yard wastes which are divided into different sizes Converts smaller materials to compost Grounds up larger materials and sends them to cogeneration plants as alternative fuel sources Converts over 99% material processed into new products.

Box 3.9 **Citizen Participation in Japan**

The city government of Shibushi, in Japan's Kagoshima Prefecture, is actively working with its citizens to reduce waste generation and promote recycling. Residents have organised sanitation councils to carry out thorough waste separation, which has led to remarkable improvements in recycling rates. As a result, the amount of waste disposed of at the landfill site has been dramatically reduced, which in turn has significantly extended the landfill's service life. Sorted recyclables are collected and taken to recycling facilities, where recyclables are sorted further and sold off to recyclers. Cooking oil is converted to diesel fuel, while organic matter is recycled as compost. To share the experience, the city of Shibushi and the Japan International Cooperation Agency (JICA) has implemented the technical cooperation at Depok, Indonesia, and at the Pacific Islands (Fiji, Samoa and Vanuatu).

Source: JICA (2015). For more information on JICA's technical cooperation projects, also see "Waste Minimisation and Recycling Promotion Project," available from *https://www.jica.go.jp/fiji/english/activities/technical02.html*

In Mongolia[14], four MRFs with composting equipment have been established with a capacity to process 20 to 30 tonnes per day of biodegradable wastes. In addition, Mongolia implemented a plastic recycling technology referred to as "styro/plastic densifier and grinding machine" with the assistance of the Ministry of Industry. The technology allows processing of wastes, such as polystyrene (Styrofoam™/Styropor ®) and plastics, to convert these waste fractions into hard-styro blocks or bars of different shapes or form that can be used by the city for structural or decorative purposes. The machine processes about 0.5 tons of Styrofoam/Styropor per day.

14 United Nations (n.d.).

In the Philippines, waste minimisation has been adopted by Unilever Philippines' "Project Eliminate," which aims to send zero waste to landfills. The project manages to reward the company with an 80 per cent reduction through conversion of packaging waste into co-fuel, while 50 per cent of cartons and plastics get recycled.

In Bangladesh,[15] 15 per cent of MSW generated in the country are recycled, resulting from the government's initiatives in developing guidelines and policies.

NGOs play a critical role in waste recycling. In India, the Annakshetra Foundation India plays a significant role in minimizing food wastage,[16] by developing an extensive network that allows "food donors" to donate unwanted or unused food. The NGO provides a service to collect excess food from donors' premises, stores and tests the food, and finally needy. If the food is not fit for human consumption, it is then sent for composting. In 2014, the Foundation recorded the distribution of about 3,000 tonnes of high-quality food, the creation of about 100,000 jobs and the delivery of social benefits to the poor.

Regarding efforts to reduce food waste in Korea, the country has taken a major step in introducing the Food Waste Reduction Master Plan in 1996. In 2004, collection drives for food waste from residential areas and restaurants were launched.[17]. The plan has managed to achieve the target of preventing food waste from being landfilled. Results became more robust in 2010 when voluntary cooperation in food waste reduction was signed between the Ministry of Environment, in collaboration with the Ministry for Food, Agriculture, Forestry and Fisheries, and the Ministry for Health, Welfare and Family Affairs, with food waste producers; this implemented a volume-based food waste fee system. Thus, food waste was reduced by 14 per cent from the municipal waste stream, while recycling has increased to 50 per cent.

In Thailand, the following MOUs were signed between public and private organisations:

- The "Memorandum of Understanding on Solid Wastes Classification" with the Federation of Thai Industries was signed, with the project launched in 2007–2008 to promote solid waste recycling as a way to generate extra income, improve the quality of life and optimise natural resource use.[18]

- The "Memorandum of Understanding on Recycled Solid Waste Management in Academic Institution" with the Federal Thai Industries and three leading universities was signed to set up to recycle waste management in universities in terms of solid waste classification, waste banks and supporting funds.

- The "Memorandum of Understanding on Used Bulbs Management" with Toshiba Lighting Co. Ltd. to promote safe disposal and recycling of used fluorescent light bulbs. It initiated further cooperation between local governments and the private sector.

In addition, there are other agreements with Umicore, which promotes the safe disposal of used mobile phone batteries; the Association of Japanese Housewives in Thailand, which promotes solid waste segregation, recycling, composting and hazardous waste separation; the Magic Box Co., Ltd., which targets the separation of milk and beverage packages; and the Wongpanich Group, which provides 40 recyclable purchase centres.[19] The Federation of Thai Industries assists in improving Bangkok's waste management system. In Thailand,[20] resource recovery from waste has thus played a critical role in the country's waste management system; it has achieved an 89 per cent rate for recyclables, 7 per cent for compost and biogas, and 4 per cent for waste-to-energy conversion.

An innovative complement to waste sorting centres is a reverse vending machine (RVM), a machine that accepts products (instead of dispensing them) and pays the user according to the quality and quantity of product(s) returned. RVMs are particularly popular in places with that have mandatory recycling laws or require container deposits.

Box 3.10 presents a case study on reverse vending machines in China.

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15 UNCRD (2010).
16 Sen (2015–16).
17 he Republic of Korea has successfully implemented a comprehensive policy aimed at food waste treatment and recovery. For a case study published by Innovation Seeds, a European Union-funded portal, visit the case study "South Korea's food waste reduction policies." Available from: *http://www.innovationseeds.eu/Policy- Library/Core-Articles/South-KoreaS-Food-Waste-Reduction-Policies.kl* (accessed 24 January 2017).
18 3R Knowledge Hub (2014).
19 Ibid.
20 Pollution Control Department (2009).

Box 3.10 **Reverse Vending Machines in China**

In China, Incom Recycling Company, a subsidiary of one of the largest bottling manufacturers in Asia, began installing RVMs across Beijing to collect disposable water bottles. Within a three-year period from 2012–2015, RVMs had facilitated the collection of over 18 million bottles. Users received mobile phone credit, transit passes, or a monetary payment depending on the quantity and quality of bottles returned. In turn, Incom reused these bottles to make new plastic bottles, thus helping to reduce its costs as well as the amount of new material required.

Source: *http://www.eco-business.com/news/two-innovators-helping-to-improve-recycling-in-china/*

The following sections describe recycling practices and experience on selected urban waste streams: C&D waste and e-waste.

3.4.2 Recycling of C&D Waste

Construction and demolition (C&D) waste dominates the waste stream in urban and rapidly urbanizing areas. C&D waste in Japan contributes about 20 per cent of the total, reaching more than 75 million tonnes in 2011.[21] Its extensive programme on the management of C&D waste resulted in very high recycling rates of materials within the C&D waste stream. Figure 3.10 shows the C&D waste recycling percentages achieved in Japan.

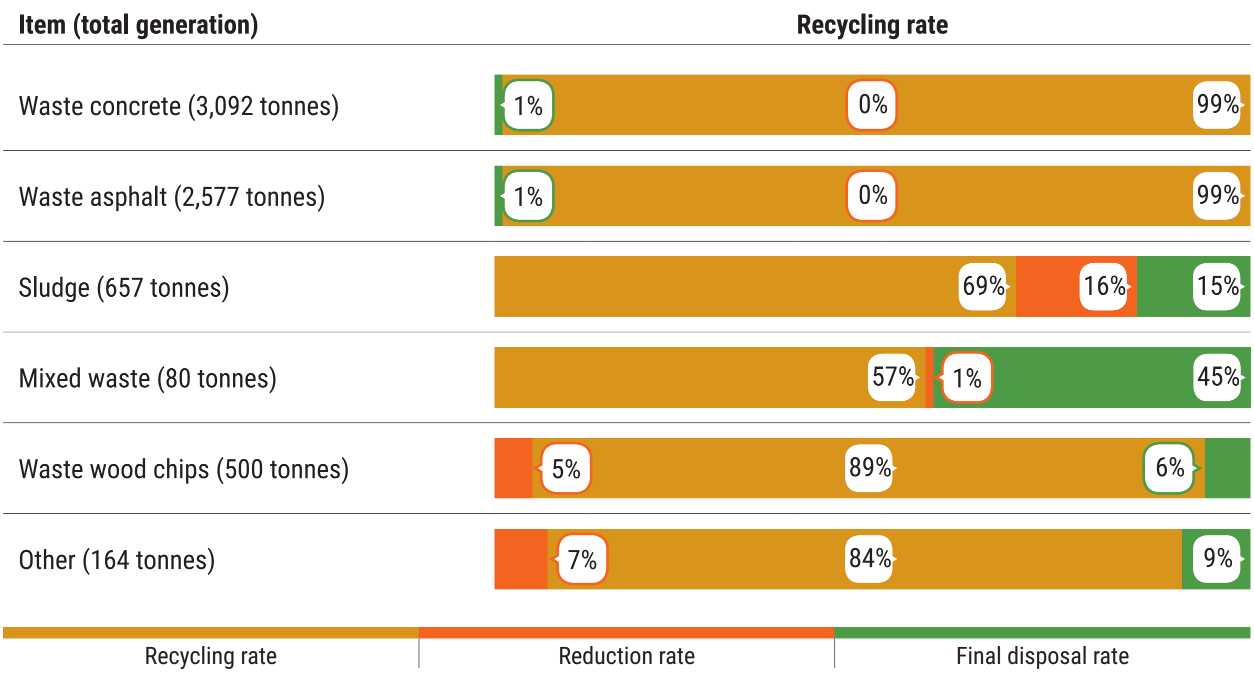

Figure 3.10 : Recycling Percentage Achieved in Japan, 2012

Source: Yonetani (n.d.).

21 Yonetani (n.d.).

In Singapore, the recycling of C&D waste reached 99 per cent where wood, metal, paper, and plastics are recovered and processed into aggregates to be used in construction activities. This involves dedicated recycling companies that recover resources from the waste stream via manual or machinery sorting. The sorted materials are then transported to Singapore's local recycling company to undergo further processing. Intact materials such as wood are reused within the construction sector. Other C&D wastes are crushed, screened and separated according to size into construction aggregates for building concrete blocks or road pavements.

Box 3.11 describes a case study on C&D waste recycling in India.

Box 3.11 **Case Study of C&D Recycling Plant in India**

The Municipal Corporation of Delhi, working in cooperation with the private sector, established a C&D recycling plant with the aim of diverting waste from landfill and developing the market for C&D waste. The plant, a public-private partnership in operation since the end of 2009, had an original design capacity of 500 tonnes per day that was expanded in 2014 to 2000 tonnes per day. Incoming material is inspected and weighed. Plastics, metals, wood and certain other materials are separated out by both manual and mechanical means.

The remaining waste is again separated, this time sorted into whole bricks for internal use and sold; large pieces of concrete and mixed C&D waste are managed using dry processing to crush and grade the concrete and C&D waste; wet processing is also undertaken for mineral processing and washing. The plant recovers products such as sand, stone and ready-mix concrete, and it uses these to manufacture other value-added products such as paving blocks and tiles, kerbstones and bricks. By early 2015, the plant had sold well over a million tonnes of recycled products

Source: *https://www.cdeglobal.com/news/2015/december/cd-waste-processing-in-india-delhi-shows-the-way*

3.4.3 Recycling E-Waste

Although C&D waste can be fully retrieved for other purposes, particularly to meet the needs and demands in the expanding construction sector, the recovery of e-waste creates numerous social and environmental health issues. In fact, electronic goods generally contain toxic substances, which call for proper treatment and disposal.

In Bangalore, India, ten informal e-waste dismantler units came together to form a full-fledged formal recycling company, E-WaRDD.[22] Figure 3.11 illustrates the e-waste recycling flow at E-WaRDD, Box 3.12 provides details on the e-waste management system in Japan.

22 Pasah (n.d.).

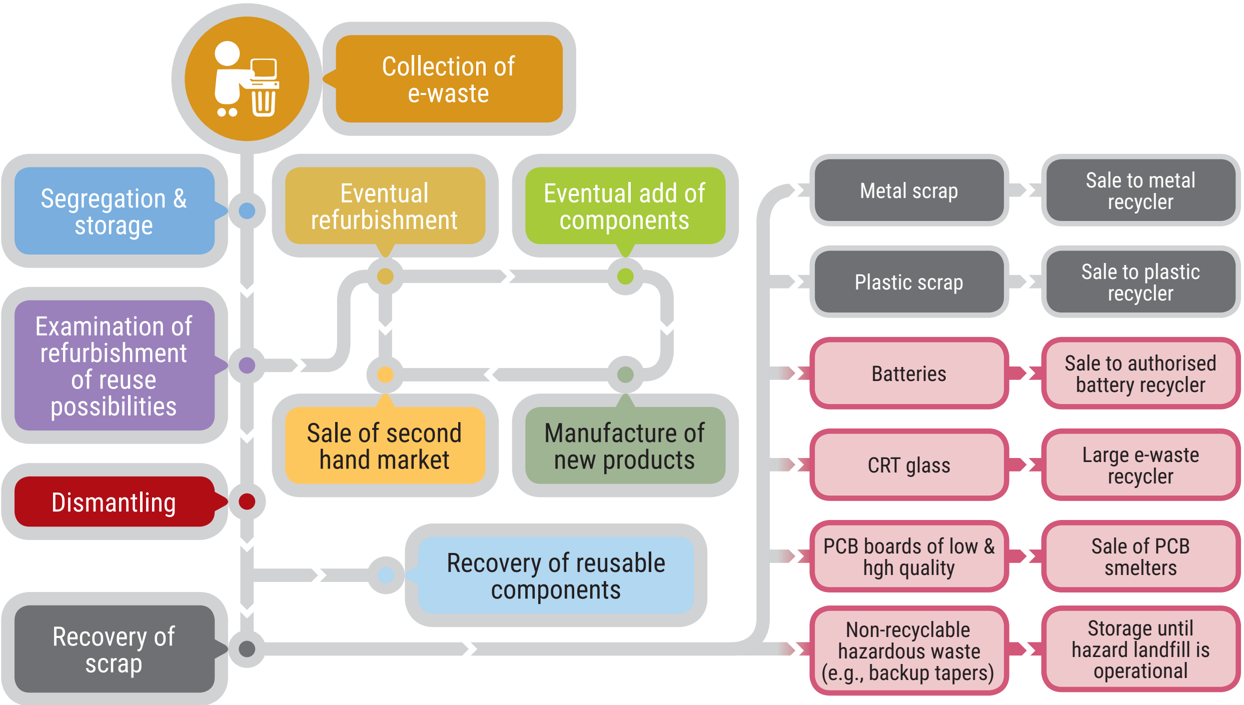

Figure 3.11 : E-waste Recycling Flow at E-WaRRD & CO, Gowripalya, Bangalore, India

Source: Pasha (n.d.).

Box 3.12 E-waste Management in Japan

The late 1990s saw an increase in the flow and complexity of waste generation in Japan resulting from rapid economic growth and change towards more effluent lifestyles. The immense dependency on electrical appliances expanded the electronic sector. Owing to technological development and rapid “obsolescence,” used electrical appliances became a major contributor to the waste. Japan, thus, initiated the Waste Electrical and Electronic Equipment (WEEE) programme focusing on recovery of materials. This programme was spearheaded after the Act on the Recycling of Specified Kinds of Home Appliances (Home Appliance Recycling Act) was enacted in 1998 and came into force in 2001, with the objectives to increase effective utilisation of waste and ensure appropriate disposal of waste residues after recovery.

The four categories of products targeted in the Home Appliance Recycling Act are:

- Home air conditioners
- TVs (cathode-ray tubes [CRT], LCD, and plasma TVs)
- Refrigerators and freezers
- Washing machines and clothes dryers

Today, Japan ranks as one of the top countries in the best practices in e-waste and home appliance management, recording notable levels of e-waste recovery and ensuing expanded business opportunities. In fact, in 2015 alone, a total of 10,878 appliances was collected at designated sites, as follows: 3,140 washing machines and clothes dryers (28.9%); 2,799 refrigerators and freezers (25.7%); 2,355 air conditioners (21.6%); 1,522 CRT TVs (14.3%) and 1,033 LDC and plasma TVs (9.5%).

The Recycling Act led to the creation of business opportunities. Today, Japan records significant level of e-waste recovery and is one of the top countries in the world in terms of e-waste management.

Source: *https://waste-management-world.com/a/japans-waste-management-situation*

3.4.4 Recycling in other Waste Sectors

Food waste, plastics and fly ash form other important waste streams that have high recycling potential.

Box 3.13 presents a case study on plastic waste management in Japan while Box 3.14 highlights the use of fly ash from coal-fired power plants. Box 3.15 presents waste reduction efforts taken by Kellogg's.

Box 3.13 Case Study: Plastic Waste Management in Japan

Japan's Waste Disposal Law was revised in May 2005 to stipulate that "first, emission of waste plastic should be reduced, after recycling should be promoted; any remaining waste plastic should not go to landfill as it is suitable for use in thermal recovery."

This provision in law is noteworthy because certain plastics (e.g., polyethylene, polypropylene and polystyrene) have high calorific values, making them suitable as fuels. In addition, the demand for refuse paper and plastic fuel (RPF) as an alternative fuel to oil has been increasing among pulp manufacturers.

According to the Plastic Waste Management Institute, Japan has achieved an effective plastic utilisation rate of 82 per cent in 2013, a figure which has been rising constantly.

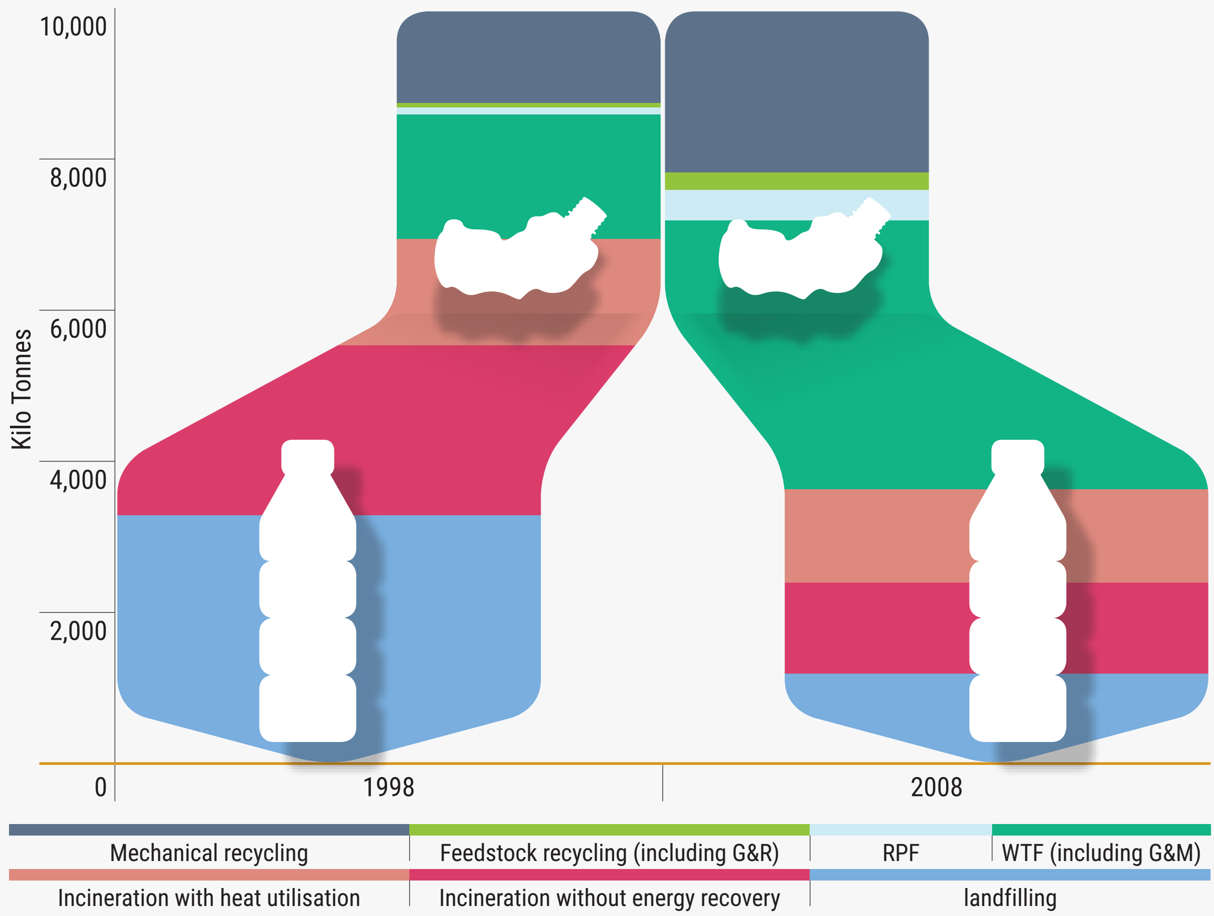

Figure 3.12 : Conversion of Plastic Wastes into Value-added Products in Japan, 1998–2008

Source: Plastic Waste Management Institute (Japan) (2013).

Box 3.14 **Use of Fly Ash from Coal-fired Plants**

Coal-fired thermal power stations, the main sources of power generation in India, produce a large quantity of ash as a result of the combustion process. For instance, about 110 million tonnes of fly ash was produced from the combustion of 300 million tonnes of coal in India in 2011. Fly ash can be compacted into bricks and unglazed tiles for use on pavements and has also been used in large quantities in road construction. Fly ash is suitable for use as an additive to cement. Its chemical properties enable it to act as an aggregator, thus providing strength and durability to concrete. Distemper, a medium used to treat walls, can be manufactured with fly ash and acts as a replacement for white cement. Distemper with fly ash has been used in several buildings in Tamil Nadu, India, on the interior surfaces with satisfactory results. Moreover, the cost of production is about 50 per cent of that of commercial distemper. The National Metallurgical Laboratory in Jamshedpur, India, has developed a process to use fly ash to produce ceramics with superior resistance to abrasion. Fly ash is a potential growth improver and provides vital nutrients (Ca, Mg, Fe, Zn, Mo, S and Se) to crops and vegetation when used as a fertiliser.

Vikram Cement in India carried out a study at a coal-fired power station to use the fly ash produced (a thermal plant by-product) in the manufacturing of Portland Pozzolana Cement. The fly ash generated in the thermal power plant, using 100 per cent pet coke, has been studied; it has been found to contain appreciable amount of anhydrite. Using anhydrite in cement reduces the setting time and increases the cement's compressive strength. This has been successfully used to partially replace natural gypsum and to produce better quality cement.

The utilisation of waste generated as a by-product of thermal power plants aides in the conservation of natural gypsum reserves, while attempting to solve the problem of disposal of waste of thermal power plant (i.e., gypsum anhydrite and other materials).

Source: Mohapatra and others (2010).

Box 3.15 **Food Waste Reduction: A Case Study of Kellogg's**

Kellogg's cereals and convenience foods are consumed in over 180 countries. The company had committed to decreasing their waste-to-landfill volume by 20 per cent (per metric tonne of food produced) between 2009 and 2015. It has met this waste goal in only one year and promptly set another one to achieve an additional 20 per cent reduction during the commitment period. This was also achieved in a year, delivering a 20 per cent reduction by the end of 2015, for a total decrease of 62 per cent since 2005. Moreover, the company has been working to increase to 30 per cent the number of plants sending zero waste to landfill by the end of 2016; at present, less than 6 per cent of waste goes to landfill.

Kellogg's works on three major areas to achieve food waste reduction.

- At the farm level: To eliminate post-harvest loss so that more food that is grown is consumed in numerous countries, such as Bangladesh, India, South Africa, the Philippines and Thailand. In the Philippines, Kellogg has partnered with the International Rice Research Institute and the Philippines Department of Agriculture to fund work to improve agronomic practices. In Thailand, Kellogg works to reduce post-harvest loss and has increased yields by 25 per cent by identifying sampling points within their processing operations.
- In manufacturing: To eliminate waste in its food processing, Kellogg captures edible by-products to feed people in need, and when not fit for human consumption, ensuring they are used for animal feed.
- Within the community: To ensure that its food production helps those in need either from natural disasters or chronic hunger in communities around the world.

Source: World Resources Institute and Netherlands, Ministry of Economic Affairs, "Kellogg's Commitment to Reduce Food Loss and Waste," Champion 123 Blog, 2016. Available from *https://champs123blog .files.wordpress.com/2016/09/kellogg.pdf.*

3.4.5 Secondary Materials Industry

Asia, being the main producer of waste in the world, also holds the potential to be the largest market for secondary materials. The secondary materials industry in Asia is growing very rapidly, especially in China and India. China has become the largest industry for secondary plastic products, as shown in Figure 3.13.

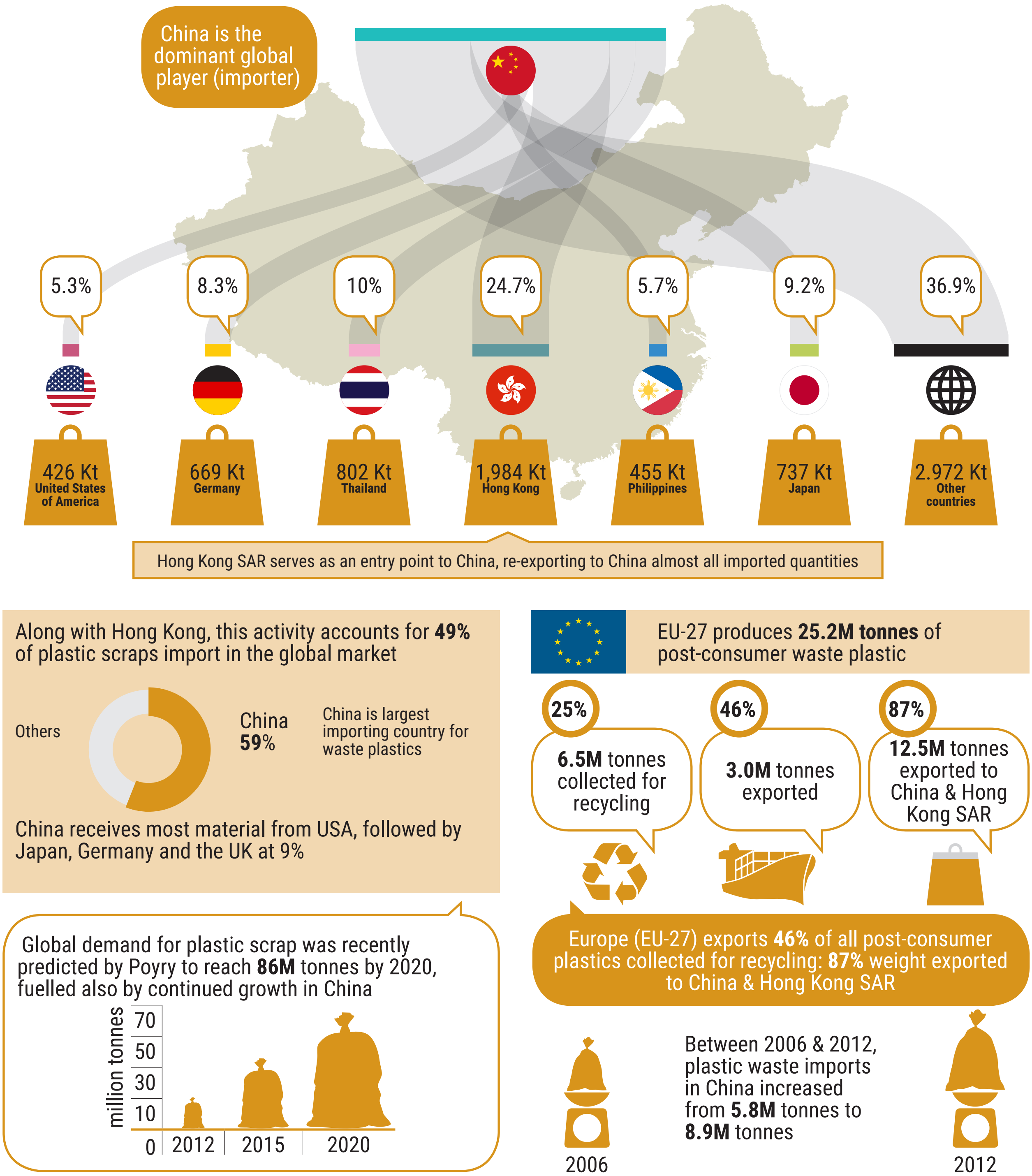

Figure 3.13 : Global Flow of Plastics to China

Source: Lerpiniere, D., Wilson, D.C. Velis C.A., and others (2014). Review of International Development Co-operation in Solid Waste Management. International Solid Waste Association, Vienna. available at: *https://www.iswa.org/fileadmin/ galleries/Task_ Forces/TFGWM_Report_Review_International_DCSWM.pdf* (accessed 13 February 2017).

Note: Kt = Kilo tonnes

China is also the largest importer of waste plastics, followed by Germany, Japan, Thailand and the United States, implying the crucial role played by Asian countries. This hotspot has a large share (56%) of global waste plastic imports (by weight). Eighty-seven per cent (by weight) of these plastics come from the EU-27. From 2006 to 2012, imports increased by 66 per cent, whereas recycling in local markets doubled. These secondary materials satisfy the increasing local demand for plastic products.

Figure 3.14 shows the trend in recycled plastic usage in China.

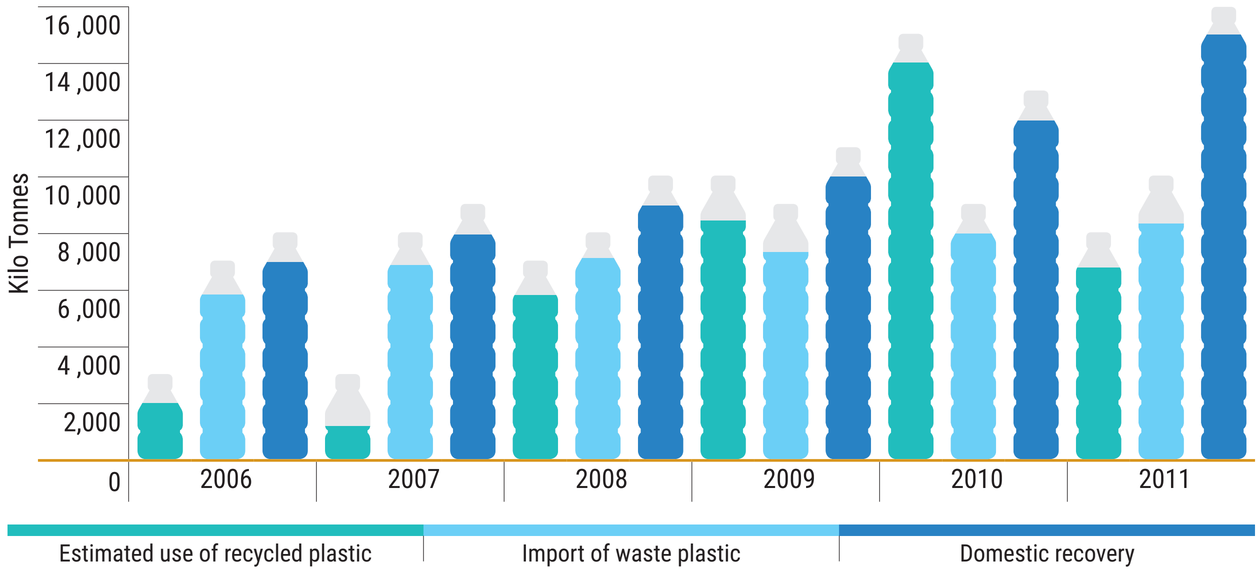

Figure 3.14 : Estimated Use of Recycled Plastics in China, 2006–2011

Source: Lerpiniere, D., Wilson, D.C. Velis C.A., and others (2014). Review of International Development Co-operation in Solid Waste Management. International Solid Waste Association, Vienna. available at: *https://www.iswa.org/fileadmin/ galleries/Task_ Forces/TFGWM_Report_Review_International_DCSWM.pdf* (accessed 13 February 2017).

The secondary materials market serves as the alternative to the extraction of virgin materials, and significantly reduces the GHG emissions.

Table 3.4 highlights countries in Asia that are leaders in the secondary paper industry.

Table 3.4 Leading Countries in Asia in Secondary Paper Industry, in Million Tonnes

Region	Country	Collections of recovered paper & board	Consumption of recovered paper	Net flows: Positive = imports negative = exports	Regional total net flows	
					2012	1997
Japan	Japan	21.7	16,8	-4.9	-5	0.06
PRC	PRC	44.7	75.0	30.3	30	1.6
Rest of Asia	Republic of Korea	8.8	9.6	0.8	8	2
	Indonesia	3.6	5.9	2.3		
	India	3.4	5.7	2.3		
	Republic of China	3.1	3.8	0.8		
	Thailand	2.7	3.6	1.0		
	Malaysia	1.2	1.6	0.4		

Source: Bureau of International Recycling (BIR, 2014).

3.5 Waste Processing and Treatment

Waste processing and treatment are crucial within the holistic waste management hierarchy. It is important that this step be examined critically to identify all potential routes and options in handling waste. Given that each type of waste requires different treatment and disposal options, there is a wide range of technologies adopted by Asian countries for waste processing.

Organic waste generally makes up the main fraction of the MSW stream in most Asian countries. Thus, the opportunities to reduce or divert the organic portion would result in a significant reduction in the total waste volume. Resource recovery can be achieved by various approaches. However, the efficiency of the technology selected is dependent on the characteristics and composition of the waste being processed.

The various technology options for MSW processing and treatment are given in Figure 3.15.

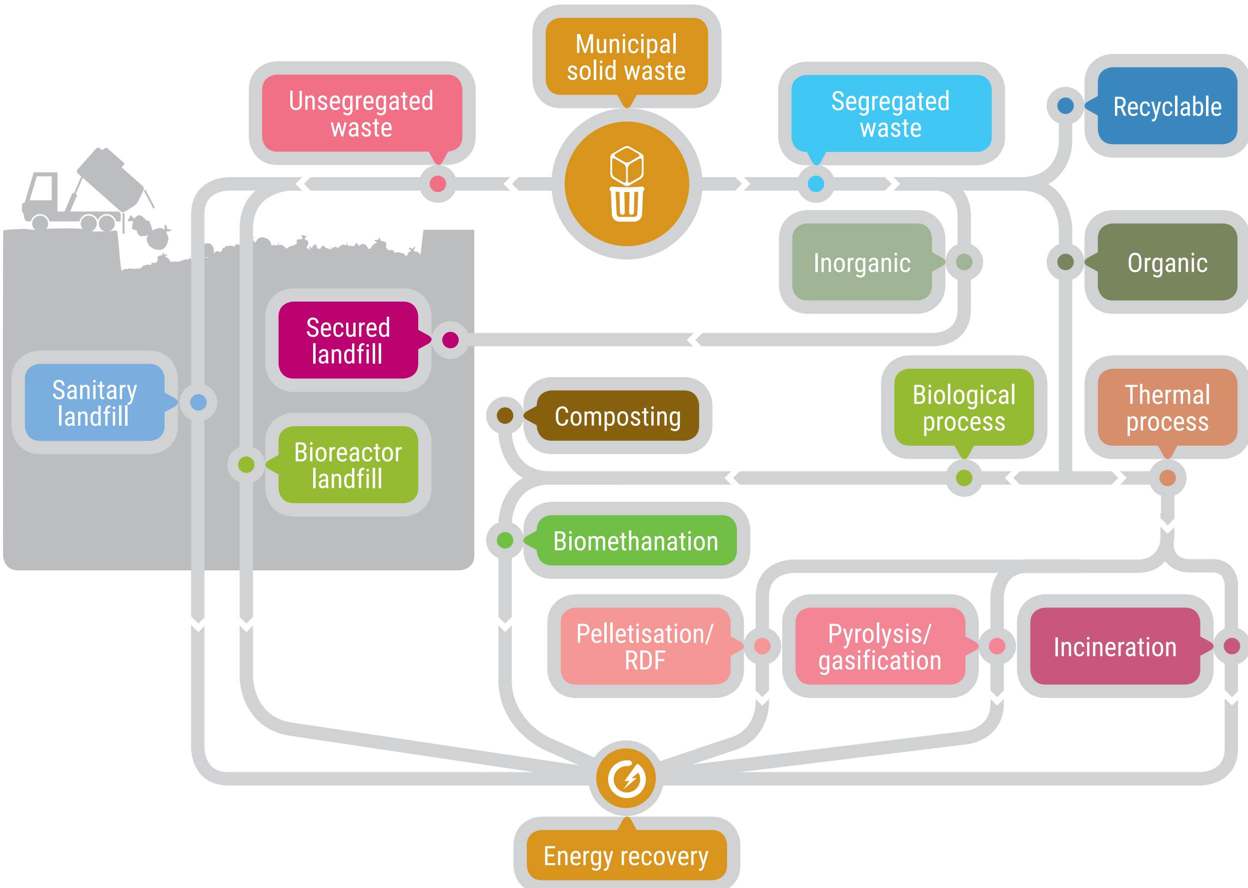

Figure 3.15 : Technology Routes for MSW Treatment, Resource and Energy Recovery

Source: ICRA Management Consulting Services Limited and The GOI ADB PPP Initiative (2011).

Note: RDF = refuse-derived fuel.

Regardless of the options included within a holistic waste management framework, waste disposal is still mandatory since, in most cases, total recovery cannot be achieved. Residues that are not usable need to be disposed at landfills.

Table 3.5 summarises the municipal waste facilities in some countries in Asia.

Table 3.5 **Municipal Waste Facilities in some Asian Countries**

Country	Treatment plants	Incinerators	MRF	Open dumpsites	Controlled landfills	Sanitary landfills
PR China	419	69	NA	NA	324	20
Indonesia	20	0	80	400	70	10
Republic of Korea	4,955	2,028	0	325	1,348 (which includes solidification and gasification)	
Malaysia	NA	4	1	261	10	12
Philippines	NA	26	2,361	826	273	19
Singapore	NA	4	1	-	-	1
Thailand	NA	3	NA	NA	20	91
Viet Nam	NA	NA	NA	49	91	17

Source: Borongan and Okumura (2010).

3.5.1 Technology Options for Treatment

There are three commonly used technology options for treatment of MSW. These are thermal, biological and mechanical. Each of these options is discussed in the sections below.

3.5.1.1 Thermal treatment

Thermal treatment is one technology that requires minimal waste sorting. It can treat co-mingled and highly heterogeneous waste easily. Nevertheless, the characteristics of the waste input into the thermal system need to maintain a certain calorific value to ensure a sustainable combustion process. Malaysia has seen several failures of combustion plants in which the calorific value of waste being fed into waste-to-energy facilities on certain islands (i.e., Langkawi, Pangkor, Tioman and Labuan) failed to reach a certain heating value.[23] As a result, the waste-to-energy facility was not self-sustaining, and additional fuel had to be injected into each batch of waste treated. By identifying the challenges in incinerating waste in Malaysia, the government has decided to conduct more detailed studies before selecting certain technologies and operators for combustion.

Waste-to-energy facilities reduce waste volumes by up to 90 per cent and are favoured in many countries that lack suitable landfill space. Viet Nam, for example, has 30 small-scale incinerators installed in rural areas, totalling 44 incinerators nationwide. This has been seen as the most practical waste management solution for Viet Nam.[24]

23 Aishah and others (2013).
24 Lam (n.d.).

It is undeniable that waste characteristics influence the selection of technologies for waste management systems in a country. The energy content of waste should ideally be above 6MJ/kg for thermal treatment, but the main obstacle in handling waste in Asia is the high moisture content. Another issue of concern is dioxin emissions owing to the presence of chloroplasts in the waste. However, the issues surrounding dioxin emissions from incineration can be addressed today, using advanced air pollution control equipment. Japan has been extensively incinerating plastic waste following the stipulations stated in the revised Waste Disposal Law of 2005, which requires that plastic waste undergo thermal treatment before being disposed into landfills.

In Japan, gasification technologies have also been introduced to produce value-added products from MSW. These technologies result in the production of syngas and char, which are useful for energy production (see Figure 3.16). An example is the Tokyo Rinkai Recycle Power Corporation, located in Tokyo Super-Eco-Town (Inner Central Breakwater area). The gasification process involves a fluidised-bed gasifier and swirling flow melting furnace system with a capacity to process more than 500 tonnes/day of plastic waste from industries, the combustible portion of C&D wastes (e.g., wood), and other such waste streams. About 23 MW power is generated on a daily basis.

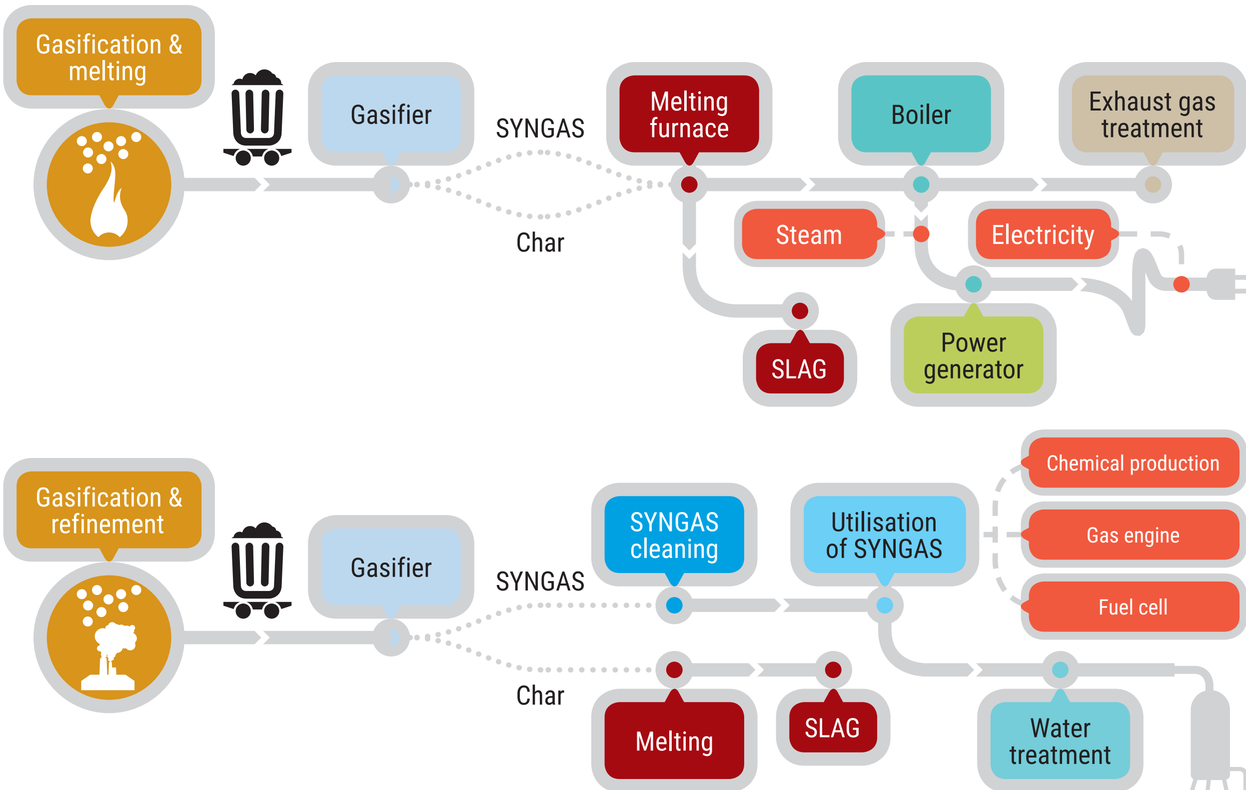

Figure 3.16 : Gasification Technology for the Treatment of MSW in Japan

Source: Furusawa (n.d.).

Energy recovery from thermal treatment has always been the main driver for the establishment of waste-to- energy facilities in most countries. The technology offers ease of operation while guaranteeing the substantial amount of energy produced. Yet, thermal treatment technologies may not be practical in many low-income countries owing to the high capital and operating costs involved.

Box 3.16 provides an overview of thermal treatment in Japan.

Box 3.16 **Thermal Treatment in Japan**

Japan is among countries that operate a large number of combustion facilities. Of Japan's 1,162 waste-to-energy facilities, 29.1 per cent are equipped with power generation facilities.[a] The other 764 facilities use residual heat to produce a total power generating capacity of over 1.9 million kWh.

Table 3.6 provides the statistics on energy generation and the use of heat in Japan in 2013.

Table 3.6 **Statistics on Energy Generation: Tokyo in 2013**[b]

Total generated power	1,130.1 million kWh
Electricity sold	571.6 million kWh
Income from electricity sold	9,804.3 million yen
Heat supplied (charged)	547,000 GJ
Income from heat sold	183.2 million yen

a. Government of Japan, Ministry of Environment (2014).
b. Clean Authority of TOKYO (2016, pp. 1-9).

3.5.1.2 Biological Treatment

Biological treatment is another available technology to treat waste before its disposal. The options include an aerobic process, such as composting, and anaerobic digestion, including biogas generation. Both options have their own advantages and disadvantages. Composting generally is a less sensitive process than anaerobic digestion. The products from anaerobic digestion, however, provide a higher market value than that of a composting facility.

Box 3.17 presents details of a composting programme in Viet Nam.

Box 3.17 **Composting Projects in Viet Nam**

Institute of Strategy and Policy on Natural Resources and Environment (ISPONRE), Viet Nam and the Institute of Global Environmental Strategies (IGES) established about 41 composting plants in Viet Nam in 2013. Most plants apply aerobic technology with compulsory aeration, whereas only two others use aerobic technology without compulsory aeration and one uses anaerobic technology.

Source: An (2012, pp. 1–15).

3.5.1.3 Mechanical Treatment

Mechanical treatment of waste is popular in handling heterogeneous wastes. This option is more popular among developed nations because the technology requires a substantial amount of investment. Yet, it has gained popularity in many other countries, including the developing nations in Asia, for managing co-mingled waste, particularly in increasing their resource recovery potential.

Mechanical treatment is a practical system to treat municipal wastes that are used in boilers or incinerators. This treatment can process mixed waste that contains a high organic fraction, such as food waste, into alternative fuels, while recovering recyclables such as metal, plastics and paper. The process of mechanical treatment revolves around four distinct phases: waste feed preparation, processing, post-treatment separation and biomass density separation. However, the efficiency of a mechanical treatment plant is highly dependent on the characteristics of the waste input.

Box 3.18 highlights a case study of a mechanical treatment facility in Republic of Korea.

Box 3.18 **Case Study: Improved Mechanical Treatment Facility in the Republic of Korea**

In the Republic of Korea, the largest manufacturing plant that can generate 100 tonnes/month of refuse-derived-fuel was not able to exceed 22 per cent yield. The actual operation, designed to yield up to 25 per cent , was investigated. Results from the study indicated that the actual input of MSW into the plant was slightly different than the waste characteristics identified during the planning stage. Thus, this discrepancy has led to reduced efficiency in the separating mechanism.

Nevertheless, after a comprehensive evaluation and modification to the facility's mechanisms, a significant increase in the production of refuse-derived-fuel has been recorded to reach about a 31 per cent yield.

Source: *https://www.degruyter.com/downloadpdf/j/rtuect.2013.12.issue-1/rtuect-2013-0016/rtuect-2013-0016.pdf*

3.5.2 Centralisation and Decentralisation in Waste Treatment

Historically, waste management services have been provided in a centralised manner. MSW is collected across a city and sometimes taken to transfer stations, depending on the distance to a treatment facility or landfill. From there, waste is compacted and aggregated onto bigger trucks, or even on barges and trains, and taken to centralised facilities. However, cities are starting to realise the benefits of treating and recycling waste closer to the place where it is generated. Decentralised strategies are thus becoming more widely accepted. Cities need appropriate systems for solid waste disposal and recycling, based on varying consumption patterns, level of industrial development, rate of urbanisation and type and quantity of waste generated.

Proper strategy implementation leads to efficient solid waste management. Depending on the context of a city, one strategy may be more suitable than the other; quite often, the ideal scenario is a combination of the two. Figure 3.17 shows the characteristics of centralised and decentralised waste management strategies.

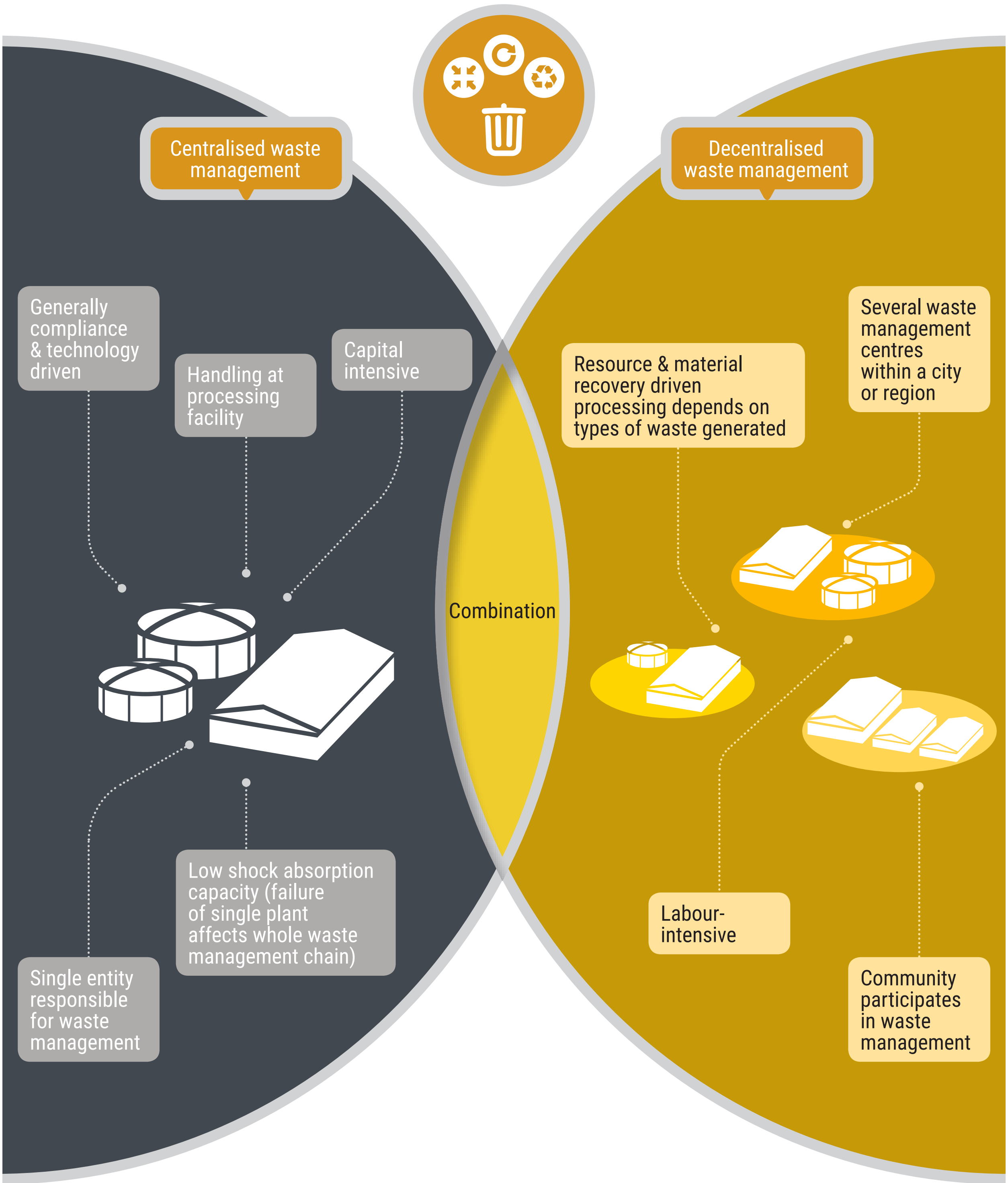

Figure 3.17 : Characteristics of Centralised & Decentralised Waste Treatment

Source: *http://www.unescap.org/sites/default/files/42.%20CS-Sri-Lanka-community-based-decentralized-solid-waste-management.pdf*

The advantages of decentralised waste processing and treatment are discussed in Box 3.19.

Box 3.19 **Economic, Social and Environmental Benefits of Decentralised Waste Processing and Treatment**

Economic Benefits

- Decentralised models are less capital-intensive and more labour-intensive than conventional models, thus providing more livelihood options
- The sale of recovered materials and products/by-products of decentralised treatment processes, such as manure, biogas and electricity, provide extra revenue
- Decentralisation saves on the costs of transportation
- Decentralisation often leads to innovation and hence value creation for the operator and investor.

Social Benefits

- Decentralised MSW management leads to the creation of green jobs, which provide safe livelihood options to the urban poor and self-help groups (SHGs) and the informal sector (i.e., waste pickers)
- This type of management leads to the empowerment of waste pickers who, otherwise, work in unsanitary and often dangerous conditions
- Decentralisation promotes entrepreneurship and opportunities for long-term community and private sector engagements.

Environmental Benefits

- Reduced amounts of waste going to landfills increase the landfill lifespan, while reducing pollution resulting from leachates and GHG emissions from landfills (landfills are significant contributors to methane emissions)
- Reduced transport of waste also contributes to reduced GHG emissions, which contribute to climate change mitigation as well as to improved air quality
- Additionally, the use of compost and manure obtained through waste treatment improves soil health and reduces the use of chemical fertilisers
- Decentralisation often leads to cleaner neighbourhoods, which reduce the spread of contagious diseases by curbing pest and rodent populations
- The formalisation of informal workers through decentralised waste management improves their working conditions and lowers health risks
- The recovery of recyclables contributes to lowering the extraction and production of virgin materials, indirectly reducing resource and energy consumption and associated carbon and water footprints.

Source: *http://www.unescap.org/sites/default/files/42.%20CS-Sri-Lanka-community-based-decentralized-solid-waste-management.pdf*

Box 3.20 presents a case study of decentralised MSW management from Matale, Sri Lanka.

Box 3.20 **Decentralised MSW Treatment in Matale, Sri Lanka**

Matale is a medium-sized city in Sri Lanka famous for its spice plantations and tourism. Even though the Matale municipality was spending 20 per cent of its total budget on SWM, there was no city-wide waste collection, and 95 per cent of the waste generated was dumped in an open area.[a]

The Matale municipality joined hands with a local NGO (Sevanatha Urban Resource Centre) and the Central Environmental Authority to establish in 2007 its first integrated resource recovery centre. Because over 70 per cent of the waste generated in the city is organic, the role of the recovery centre was to convert the waste to compost. Two additional recovery centres were opened by 2011, which all together process almost 135 tons of organic waste a month. The compost is sold for USD 80/ton to the Department of Agriculture, local farmers and nurseries. In addition, an average of 7.7 tons of recyclable waste are also collected and separated each month.

The amount of waste sent to the landfill has reduced by 30–50 per cent, while the waste recycled by the city has increased four times. A behavioural change has ensued through public awareness, with household separation of waste increasing from 10 per cent (2008) to 60 per cent (2015). In an acknowledgement to the success of the Matale programme, the Central Environmental Authority adopted the integrated resource recovery centre approach for its national solid waste programme.[b] Moreover, UNESCAP is replicating this model in ten additional cities across Asia, with certain modifications to suit the local context.

Figure 3.18 : **Stakeholders Involved in Matale Project in Sri Lanka**

a. UNESCAP (2015a, p. 98)
b. UNESCAP (2015b, p. 100).

Table 3.7 **Matale's Composting Facilities by UNESCAP**

Producer	Composting method	Quantity of waste managed daily	Monthly compost production
MEC plant	Box method	1,500 kg	2,500 kg
Individual families	Bin method	150 kg	675 kg
Institutions	Cage method	50 kg	165 kg

Source: UNESCAP (2010)

3.6 Waste Disposal

3.6.1 Controlled Disposal and Landfilling

Illegal dumping along the roadside or abandoned areas, and open burning are rampant, particularly among low- and middle-income countries. Under these circumstances, the discarded waste normally has no economic value so that dumping it indiscriminately is the most "practical" option. On the other hand, illegal dumping that occurred in transitory and developing countries like Malaysia and Thailand normally originated from the construction sector where C&D wastes are discarded at undesignated places to cut the cost of landfill tipping fees. As a result, C&D wastes, which generally consist of concrete, building blocks, wood, metal and dirt and sand are dumped outside landfills, which creates a public nuisance, particularly when they are mixed and contaminated with common domestic wastes. This scenario is more common if the responsibility of clearing C&D waste is not under the jurisdiction of the urban local bodies. Normally, small contractors are hired to collect and dispose the waste, where irresponsible ones dump the waste indiscriminately to saves on costs. Issues of illegal dumping in developing countries in Asia are so rampant that it is a real challenge for the local authorities to conduct effective monitoring and enforcement.

Disposal of waste in landfills without prior segregation is a common practice in most developing Asian countries. This is due to the absence of material recovery options by the waste collectors. Thus, a majority of the waste, which could have been recovered for recycling, are totally lost. This practice not only negatively impacts the economy, but also may cause detrimental impacts to the environment. Therefore, developing sanitary landfills has also been one of the issues of concern among the Asian countries. It is observed that GNI per capita of a country is inversely proportional to the percentage of waste that is directly disposed of in landfills or dump yards. It implied that waste generated by the higher income group has higher recycling potential and that a higher percentage of the waste can be recovered before its disposal.

The importance of waste disposal, the basic waste management requirement in a country, is unquestionable. In fact, all waste management systems require some form of final disposal, making the need for landfills inevitable. Thus, according to the current waste management scenario in Asia, more developing nations will have to upgrade their disposal facilities rather than venture into other options. This is because some of these countries lack sanitary waste disposal systems and are dependent on open dumping to dispose of their waste.

The trend shows that the majority of developing countries in Asia are investing in sanitary landfills than in waste treatment. This is considered necessary because the lack of sanitary landfills cause disastrous impacts to the public health as well as the environment. Regarding the recovery of resources, the informal sector has been effective in retrieving significant amount of recyclables that would otherwise have been landfilled.

Box 3.21 presents a case study of landfill dependency in Viet Nam.

Box 3.21 **Disposal Sites in Viet Nam**

In many areas in Viet Nam, waste is often either burnt, disposed of or discharged into vacant land areas or rivers, canals or ditches. According to the MONRE National Environment Report in 2011, the amount of disposed solid waste accounts for 76–82 per cent collected waste, of which about 50 per cent is controlled landfill and 50 per cent uncontrolled.[a]

Viet Nam has 20 disposal sites out of which only 17 are sanitary; most have been constructed by official development assistance funds. There are 458 operating disposal sites operating at various scales in Viet Nam; of these, 98 large-scale disposal sites are in big cities, of which 16 are sanitary sites. The remaining small-scale sites are temporary and do not have leachate collection and treatment systems. This method of DSW treatment makes environment pollutant and waste the land for burying.[b]

In 2014, according to the provincial reports (2012-2013), there are 458 landfills at the scale of over 1 ha with a total area of around 1,813.5 ha. There are 121 landfills (with a combined area of 977.3 ha or equivalent to 26%) which meet the sanitary standards. The remaining 337 disposal sites were unhygienic and had a total area of about 836.2 ha. Unhygienic disposal sites are mostly temporary, exposed, and lack a system to collect and treat leaching wastewater.[c]

In 2015, according to the investigation conducted by the JICA Solid Waste Treatment Project in Southern Viet Nam, there are totally 573 disposal sites at all scales, of which 29 per cent are hygienic and 71 per cent are unhygienic.[d] JICA also found that the percentage of disposed domestic solid waste in Viet Nam was about 56 per cent of collected waste with 44 per cent having been either recycled, composted or incinerated.

a. MONRE (2011).
b. Denmark, Danida/Ministry of Foreign Affairs (2012).
c. Tien (2014, pp. 1-26).
d. Wada (2016).

Box 3.22 lists the challenges in the implementation of engineered landfills.

Box 3.22 **Challenges in the Implementation of Engineered Landfills**

Challenges in implementing engineered landfills arise owing to the lack of the following:

- Planning for waste management while planning townships
- Proper institutional setup for the waste management, planning and design of urban local bodies
- Technical expertise
- Community involvement
- Expertise and exposure to city waste management using modern techniques and best practices
- Awareness among stakeholders
- Integrated waste management systems
- Improve the current waste management system.

Source: Tien (2014).

Closure and post-closure of landfills are another topic for consideration. Landfill closure issues are dependent on the type of landfill and pre-planning strategy. Understandably, post-closure issues are much more complicated especially if a country lacks clear policy or guidelines. This is a very important factor to consider in the planning stage itself because improper closure and the lack of post-closure monitoring could result in serious health and environmental risks. Also, there is an urgent need in developing countries to streamline (a) landfill closure and post-closure procedures and (b) land use after closure to prevent detrimental impacts.

3.6.2 Landfill Rehabilitation and Material Recovery

Because indiscriminate waste disposal practices cause losses of an average of 70 per cent of resources, landfill mining should be viewed as an immediate, prioritised action. Yet, the concept of landfill mining is still in its infancy in Asian countries. Nevertheless, countries such as Japan, Malaysia and Singapore have taken the first step in integrating this concept into their waste management systems.

Landfill mining and reclamation is a process whereby solid wastes that have previously been landfilled are excavated and processed. Processing typically involves a series of mechanical processing operations designed to recover one or all of the following: recyclable materials, combustible fraction, soil and landfill space. In addition, landfill mining and reclamation can be used as a measure to remediate poorly designed or improperly operated landfills and to upgrade landfills that do not meet environmental and public health specifications.[25]

Landfill mining activities were conducted by Holcim Cement to retrieve discarded tires in the Payatas Landfill in the Philippines. More than 600,000 used tires dumped there have been retrieved, cleaned and transported to Holcim's plant to be used as alternative fuel in the production of cement. Following tire recovery, the company will be recovering plastic residue to be used as additional alternative fuel. Holcim has engaged more than 5,000 personnel under the city's Waste Diversion Program.[26]

Box 3.23 discusses landfill mining in Taiwan.

Box 3.23 **Landfill Mining in Taipei City, Taiwan**

From 1968 to 1985, about 8.1 million m^3 of MSW was disposed in the former Neihu Landfill, located on the riverside in Taipei City. In particular, about one-third of the waste disposed at the landfill (2.5 million m^3) was located inside the river, thereby having great potential for environmental, ecological and public health risks. Once the Taipei city government introduced a series of MSW reduction policies, the incinerators had unused treatment capacity. Thus, the waste from the landfill site was removed from October 2006 to January 2013, where about 2.12 million m^3 of MSW was removed in total. After adequate recycling of construction waste, the majority of the MSW was sent to nearby municipal incinerators for energy recovery, and a small part of the incombustible MSW was disposed at municipal landfills, in line with the concept of "temporal storage" of landfills. The site is being reclaimed as a riverside park with over 15 hectares. This project has, indeed, facilitated materials utilisation, reduced environmental and ecological risks, and utilised the remaining capacity of existing incinerators, bringing about a great deal of benefit from a wide spectrum of perspectives.

Source: Weng and others (2015)

25 Environmental Alternative (n.d.).
26 For a feature story on tyre waste management, see "The Payatas Dumpsite: From Tragedy to Triumph, published by the local government of Quezon City, the Philippines. Available from: *http://quezoncity.gov.ph/index.php/special-features/207-the-payatas-dumpsite-from-tragedy-to-triumph?start=2* (accessed 24 January 2017).

3.7 Community Involvement in Waste Management

Initiatives at the community level by international and local NGOs have been found to significantly impact collection schemes in Asian countries. In Bangladesh, community-based waste collection was initiated by civil society activists in Dhaka, Chittagong and Khulna to improve the quality of their environment. Community initiatives, such as providing containers and transport, were later replicated across the country by NGOs and CBOs. Similarly, the local operational CBO, Waste-Concern, initiated door-to-door waste collection from households and vegetable markets, where waste is taken to a community-based composting plant and converted to valuable compost.

Also, providing significant impact are citizen and community participation, which is increasing in many cities in Asia. Sorting of waste at the household level, over and beyond the commercial and institutional levels, is becoming more effective thanks to awareness of the 3Rs. NGOs play a crucial role in mobilizing communities by creating awareness and implementing strategic approaches to improving waste management. The informal sector supports these activities through the separation and collection of waste at the primary level. It does so by applying the practical experience and local knowledge to improve waste management practices and the recycling system.

Public participation is an imperative in achieving holistic waste management as households are one of the largest waste-generating sectors. Thus, source separation at the household level is not only beneficial but also necessary in creating a sustainable waste management system in any country.

Trash walk – spearing plastic waste, Bali, Indonesia

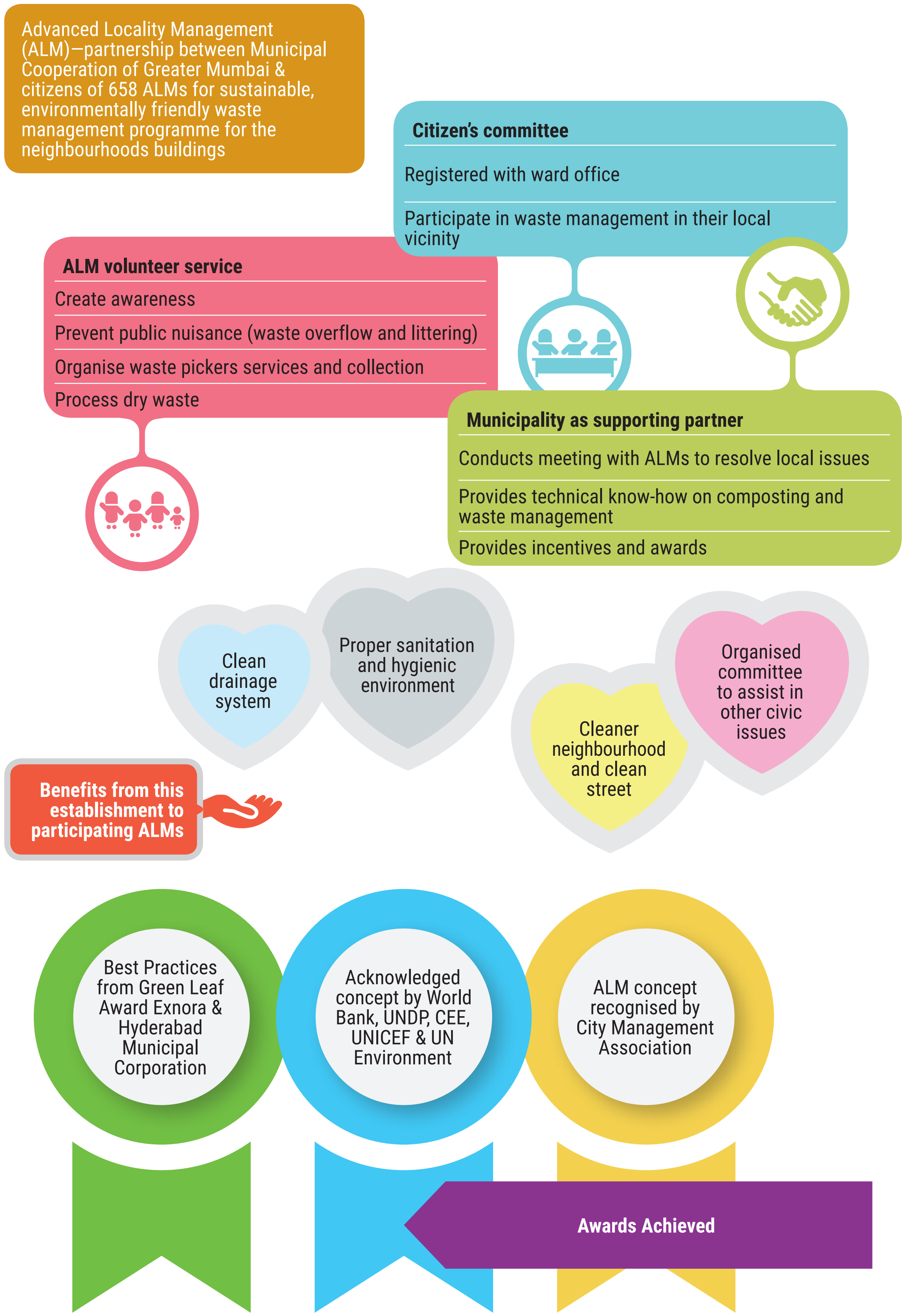

Figure 3.19 : Advanced Locality Movement in Mumbai

Source: *https://www.scribd.com/document/80563342/Advanced-Locality-Management*

Box 3.24 present an example of community-centric initiatives in Asia.

Box 3.24 **Examples of Community-centric Initiatives**

India: Clean City Championship
To introduce source segregation and door-to-door collection service among its citizens, the municipality of Warangal, India, launched a Clean City Championship. The competition required teams to convert the waste management scenario in their allocated zones within a week. This included conducting door-to-door collection of segregated waste and channelling that waste to recycling or composting areas. Intense planning preceded the actual event to ensure participation, route mapping, awareness and advertisement, and resource procurement. The campaign was one of its kind in India and inspired other cities and towns to adopt similar campaigns.

Source: Nadu (2013).

Waste Storage Bins, Yangon, Myanmar

3.8 Integrated Solid Waste Management

ISWM is a systematic, comprehensive framework to sustainable waste management covering all types of waste, all sources and stakeholders, and all aspects. ISWM encompasses institutional, social, environmental, political, technical, and financial aspects, and in doing so, considers various stakeholders including the public and private sectors and actors such as waste pickers, waste management companies and so on. This framework considers waste along the whole value chain, from generation to collection, transport, transfer and finally treatment and disposal.

The goals of ISWM are to:

- Improve the performance of the solid waste management system with a clear, sustainable policy
- Effectively balance costs and benefits with short-term strategies and long-term vision
- Protect public health and the environment.[27,28]

An ISWM policy is created by evaluating local needs and conditions and then selecting the most appropriate practices or technologies based on costs, benefits and a long-term strategy.

Important factors to consider when developing an ISWM policy are summarised in Table 3.7.

Table 3.8 **Factors to Consider when Developing an ISWM Strategy**

Institutional	Laws and processes: Do policies exist to allow the government to implement an ISWM strategy?
Social	Customs, practices, and public education: How much and what types of waste are generated? What public participation/awareness exists towards waste management?
Financial	Funding: How much and from where will funds be available for all aspects of solid waste (collection, transport, recycling, treatment, disposal)
Economic	Costs and job creation: How much does it cost to implement the suggested strategies and how many jobs will be created?
Technical	Location, equipment, training: Where will the facilities be built, what equipment is required, and what kind of training/technical knowledge is required?
Public Health and Environmental	Natural resources and human health impacts: How will the strategies and technologies select impact public health and the environment?

Source: Adapted from the U.S. Environmental Protection Agency

27 UN-Habitat (2010).
28 US EPA (2002).

Figure 3.21 shows the stakeholders, infrastructure and services involved in Viet Nam's ISWM approach. Moreover, Figure 3.22 illustrates the milestones needed to complete an ISWM action plan.

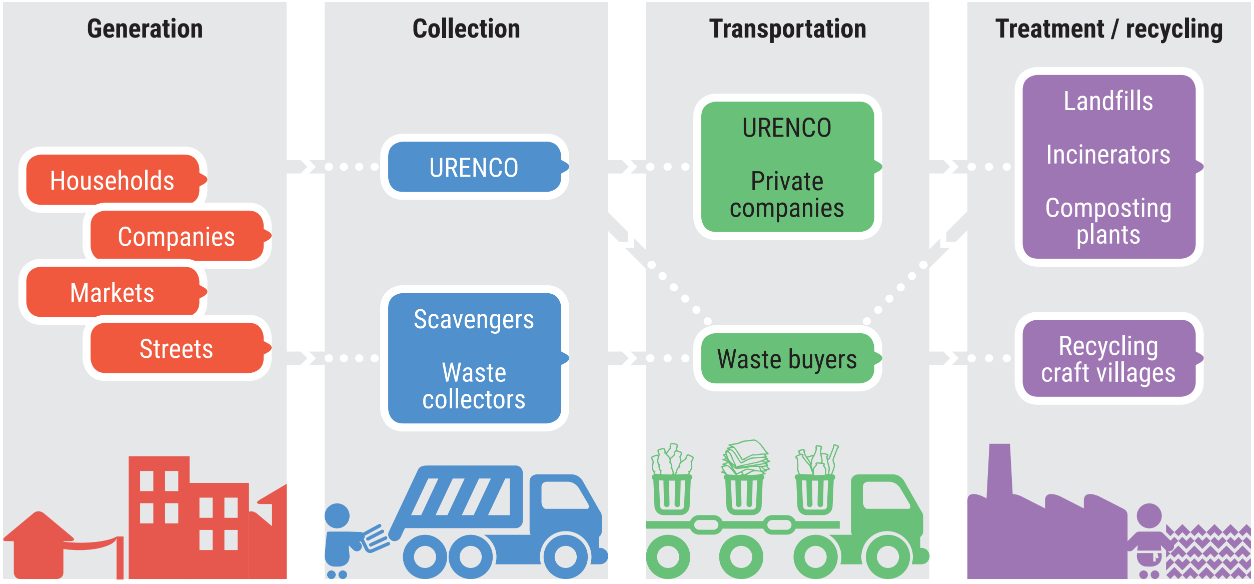

Figure 3.20 : ISWM Approach in Viet Nam

Source: VERP (2015).

Figure 3.21 : Various Milestones Followed to Arrive at the ISWM Plan in Viet Nam

3.9 Zero Waste

Zero waste is a concept that aims at promoting recycling and the reuse of resources such that no wastes are generated. Implicitly, zero waste recognises all forms of media, and stresses the holistic waste management of waste, residues and emissions. The concept is cantered on the 3Rs, effectively eliminating the waste in the cycle.

Table 3.8 presents the social, economic and environmental benefits of zero waste.

Table 3.9 **Social, Economic and Environmental Advantages of Zero Waste**

Social	Economic	Environmental
Increased livelihood opportunities, especially for waste pickers	Reduced waste disposal costs	Reduced overall waste
No exposure to toxic wastes and chemicals at landfill sites and at resource processing units	Reduced landfill and incinerator costs	Reduced toxic emissions and air pollution
	Increased employment opportunities	Reduced net carbon emissions
Reduced damage to environment and aesthetics, providing healthier emission-free surroundings.	Reduced costs incurred due to extraction, processing and transportation of resources	Reduced natural habitat destruction due to mining, drilling and blasting
	Possibly reduced costs due to food processing and canning.	Reduced chances of groundwater and soil contamination by landfill leachate.

The Korea Zero Waste Movement Network was launched as early as in 1997.[29] The Republic of Korea has been moving towards the goal of zero waste steadily. Since the 1980s, the country's landfill rate has decreased from 90 per cent to about 10 per cent, and recycling rates have increased from under 10 per cent to over 80 per cent. Under reformed legislation, the government aims to achieve a 3 per cent landfill rate and an 87 per cent recycling rate by 2025.[30]

Singapore's National Environment Agency (NEA) is collaborating with the JTC Corporation to build a pilot mechanical and biological treatment facility in an effort towards becoming a zero waste nation. The government's aim is to increase the current recycling rate of 61 per cent to one over 70 per cent by 2030.[31,32]

Several countries in South Asia, such as Bhutan, Bangladesh, India, Nepal and Sri Lanka, have formed Sunya—a multi-country, multi-stakeholder partnership called Sunya to move towards a zero waste society.

The concept of zero waste is applicable to both urban areas as well as to the industrial estates or parks. Zero waste parks are essentially demonstrations of industrial symbiosis or a network where wastes from one industry are used as raw materials by another.

29 The European Commission has published factsheets summarizing each initiative and describing the regional background, policy context and targeted waste stream. These factsheets also feature selected waste-prevention best practices: EC (European Commission). Available from: *http://ec.europa.eu/environment/waste/prevention/pdf/No%20Disposables%20Korea_Factsheet.pdf* (accessed 11 May 2017).
30 Waste Management Review (n.d.).
31 Yong-chil (2015).
32 En(2016).

Biogas facility, Surabaya, Indonesia.

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Box 3.25 describes industrial network approach in zero waste eco-industrial parks.

Box 3.25 **Eco-industrial Park in Ulsan City, the Republic of Korea**

An eco-industrial park is a community of manufacturing and service businesses seeking enhanced environmental and economic performance through collaboration in managing environmental and resource issues, including energy, water, and materials. Eco-industrial parks cultivate symbiotic relationships by developing waste and by-product networks among companies in a mutual and systematic manner.

Ulsan is the largest industrial city of the Republic of Korea with a number of industrial complexes at both the national and regional level. Ulsan industrial complexes have been continuously evolving from conventional industrial complexes to eco-industrial parks, based on sustainable development policies adopted by existing industries.

In many cases, the annual profit of the participating companies is more than the investment for infrastructure design and construction. In addition, social benefits add to increased employee and community satisfaction owing to employment generation and improved environmental performance.[a]

a. UNESCAP (2010).

"Biomass Town" is another approach towards reaching the goal of zero waste by focusing on the biomass. Here, a community attempts to use biomass comprehensively by addressing each step (e.g., biomass generation, conversion, distribution) and use is linked together among the stakeholders.

Box 3.26 presents details on a biomass town in Japan.

Box 3.26 **Biomass Towns**

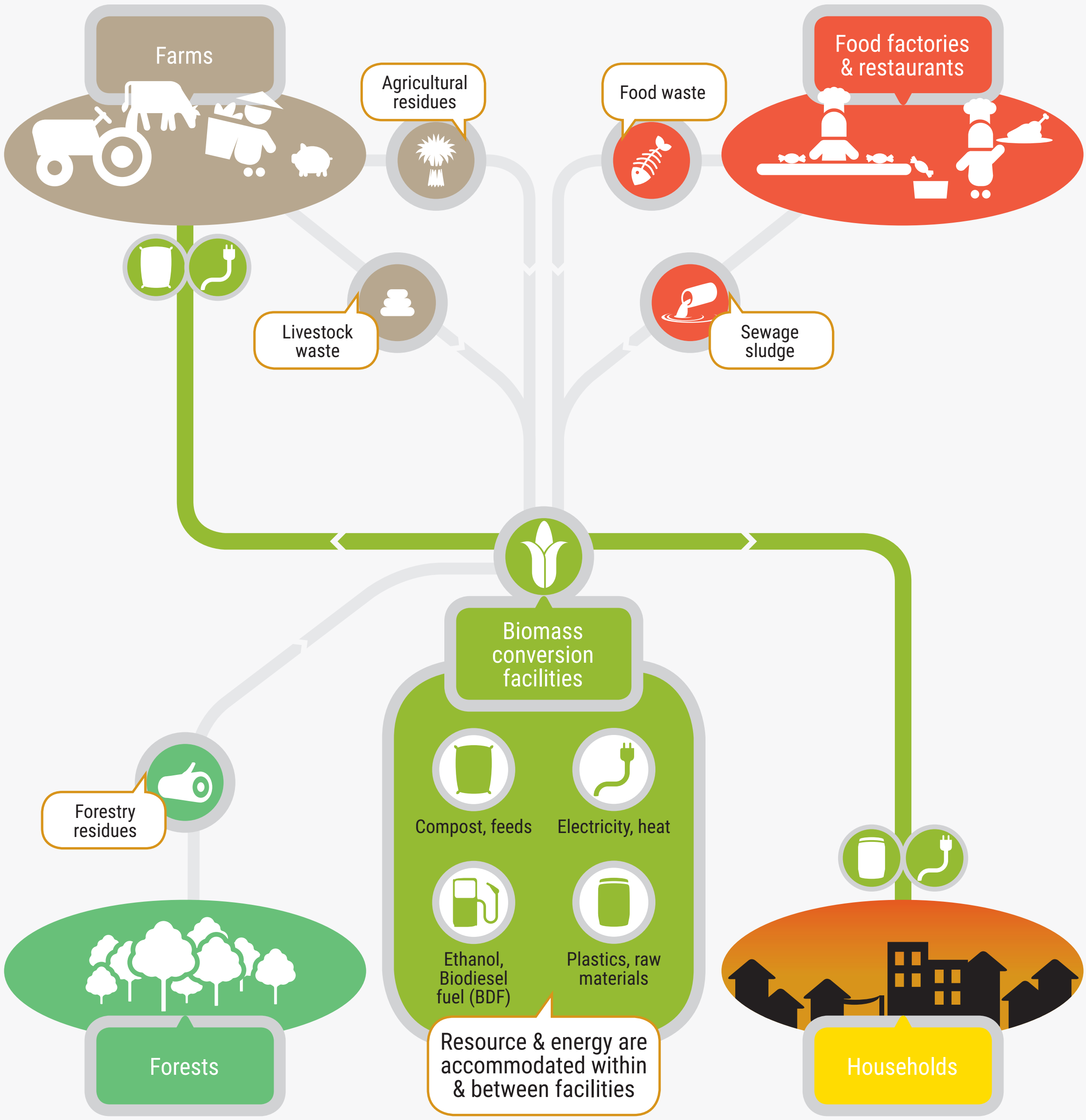

Figure 3.22 : Concept of Biomass Town for Zero Waste

Source: Yasuo (n.d).

In Japan, about 300 biomass town plans have been developed to date since 2005.

Figure 3.24 provides details on some biomass towns in Japan. Japan's Ministry of Agriculture, Forests and Fisheries supported the formulation of biomass town plans in Indonesia, Malaysia, Thailand and Viet Nam, to promote and disseminate the biomass town concept throughout East Asia.

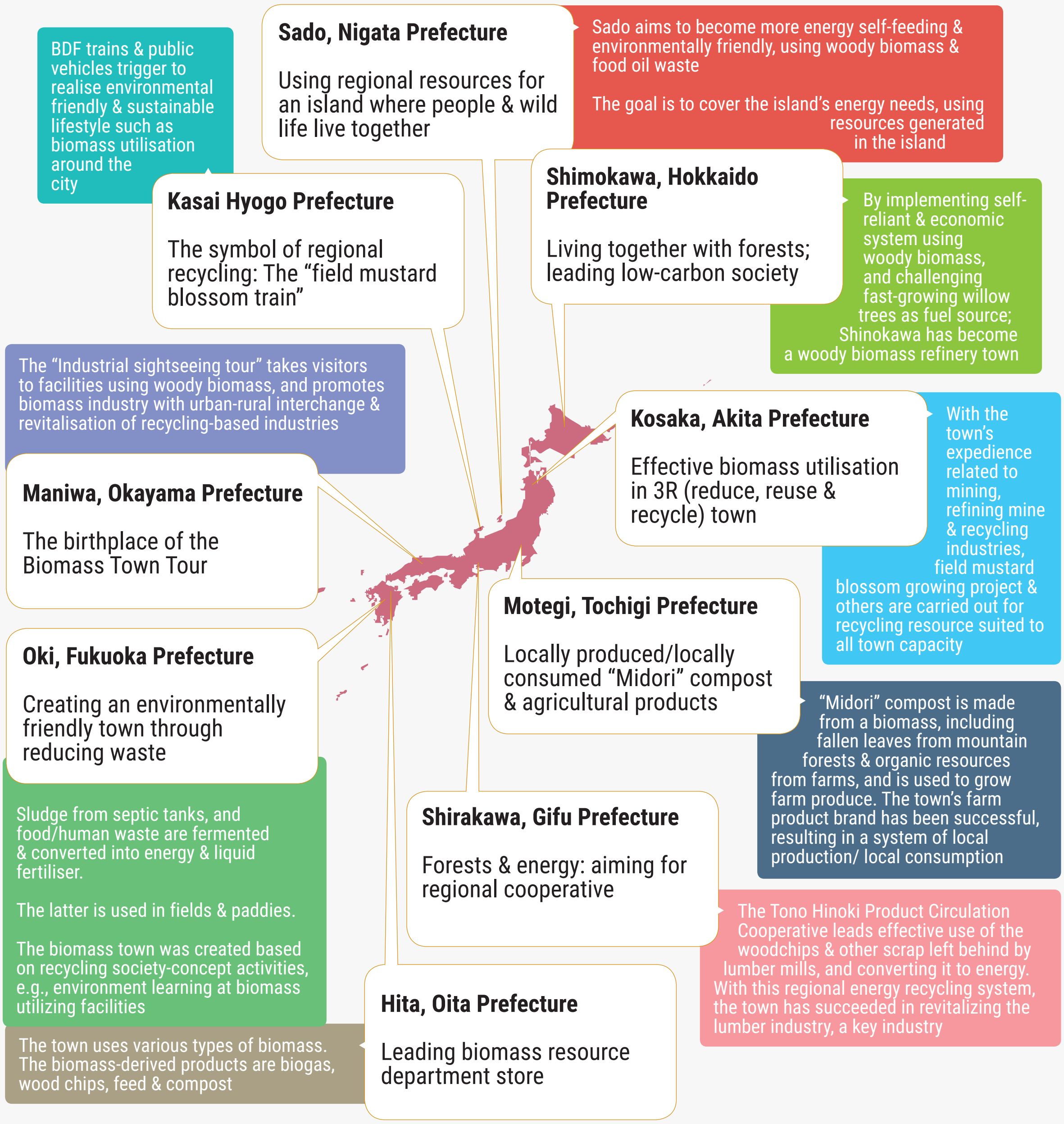

Figure 3.23 : Biomass Towns in Japan

Source: Yasuo (n.d).

3.10 Circular Economy

In Chapter 1, the circular economy was introduced—a concept that emphasises the integration of material and energy flows across the life cycle through a macroeconomic perspective.

The circular economy promotes greater resource productivity with the objective of reducing waste and evading pollution through creative, innovative manufacturing strategies. It is, thus, a paradigm shift from the conventional linear economy that does not address the 3Rs. Translation of this strategy is often done through ISWM with 3R and zero waste commitments.

The circular has been in the forefront in the EU, and in Asia, the lead has been taken by China, Japan and the Republic of Korea.

Sanitary landfill in Quezon City, Philippines.

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Key Messages

- Reduce, reuse and recycle, or the 3Rs, has proven to be the most practical strategy for sustainable waste management.
- Waste management hierarchy should begin with reduce, while disposal should be the last option.
- Most Asian countries suffer from the indiscriminate disposal of waste, resulting in economic and environmental consequences. Thus, priority action must be given to remediate and rehabilitate the dumpsites and to build basic waste management infrastructure.
- Landfill mining, although offering an option to remediate, is still in infancy stage.
- Green products and green public procurement play a major role in material and waste reduction and lower health- and safety-related risks across the life cycle. These strategies also lead to innovation.
- Waste segregation is important for successful resource recovery. Legislation to regulate segregation practices exist in most Asian countries. The informal sector plays a huge role in the segregation of recyclables in most Asian countries.
- Materials recovery facilities play a key role in integrated solid waste management, providing a safe environment for waste pickers to work, encouraging communities to recycle and reducing the amount of waste sent to landfills.
- Waste collection is another factor that determines the efficiency of a waste management system. Community-initiated waste collection schemes have been successful in several countries.
- Co-disposal of C&D wastes along with MSW is prevalent in Asia, Japan, the Republic of Korea, and Singapore; however, they have strategic C&D waste management programmes that should be considered as experiences to follow.
- Asia is one of the major generators of e-waste globally, with China, India and Japan being the highest generators in Asia. Several models of e-waste management involving producers (through EPR) or the informal recycling sector, or both, exist in Asia.
- The secondary materials industry in Asia is growing rapidly, especially in more populated countries such as China and India. The growth of this industry is important because it acts as an alternative to the use of virgin materials, thereby improving resource security and reducing GHG emissions.
- Practice of ISWM with 3Rs and zero waste commitment are steps towards building a circular economy framework. Asian countries should take efforts in this direction.

Waste Economics and Financing

4.1 Costs of Waste Management

Financial investments for projects or portfolios are judged by focusing on costs and revenues and considering the internal rate of return. Although public spending incorporates these financial aspects, public organisations are also charged with the responsibility to consider wider and long-term societal and environmental benefits and costs while assessing the effectiveness of the investments. Government-supported waste management investment competes with other high-priority portfolios like health, education and infrastructure development. In this context, it is important to highlight the wider and longer term environmental and social benefits to bring out the importance and advantages of investing in waste management infrastructure and to align waste management programmes with other government priorities.

Quantification and recognition of the direct as well as co-benefits that waste management contributes justify prioritisation of investments in the waste management sector. Benefits of sound waste management include reduction in risks to human health and ecosystems, resource recovery (materials and energy), reduction in the consumption of virgin resources, generation of employment (especially for the informal sector), reduction in the emission of greenhouse gases (GHGs) and reduced footprint of landfills. These benefits provide economic, social and environmental advantages while reducing risks to the public health, natural resources and ecosystems.

Costs of waste management include costs of collection, storage, transportation, processing and disposal. In Asian countries, collection and transportation costs dominate waste management expenditure. For example, collection and transportation expenses account for 46 per cent of total waste management expenses in the Kanagawa prefecture in Japan, as shown in Figure 4.1. This share can be even higher in the case of developing, more populous countries such as Indonesia, where 82 per cent of the waste management expenses are spent on waste collection and transportation services, as shown in Figure 4.2.

Mechanisms to fund formal household waste collection services vary across Asia, and even within countries. Generally, four basic approaches are followed:[1] direct charging via billing (e.g., the Maldives and Kunming, China), a waste fee added to a property tax (e.g., Bengaluru, India), a property tax (e.g., Delhi, India and Dhaka, Bangladesh) or the drawing of funds from general resources (e.g., Ghorahi, Nepal, and Quezon City, Philippines).[2] Charging mechanisms can be through local government, community-based organisations or even private-to-private arrangements. The system adopted tends to be the one that fits in with the local culture, a factor that is important to ensure sustainable waste management. Direct charging to households is often independent of waste quantities; it can be a flat rate based on non-waste-related or proxy parameters such as road frontage, the number of habitants in a house or property size or value. The advantage of charging by using this system is that it is easy to institute, and thus enforce, while at the same time, it offsets the cost of waste services to local government.

1 UNEP (2015).
2 Ibid.

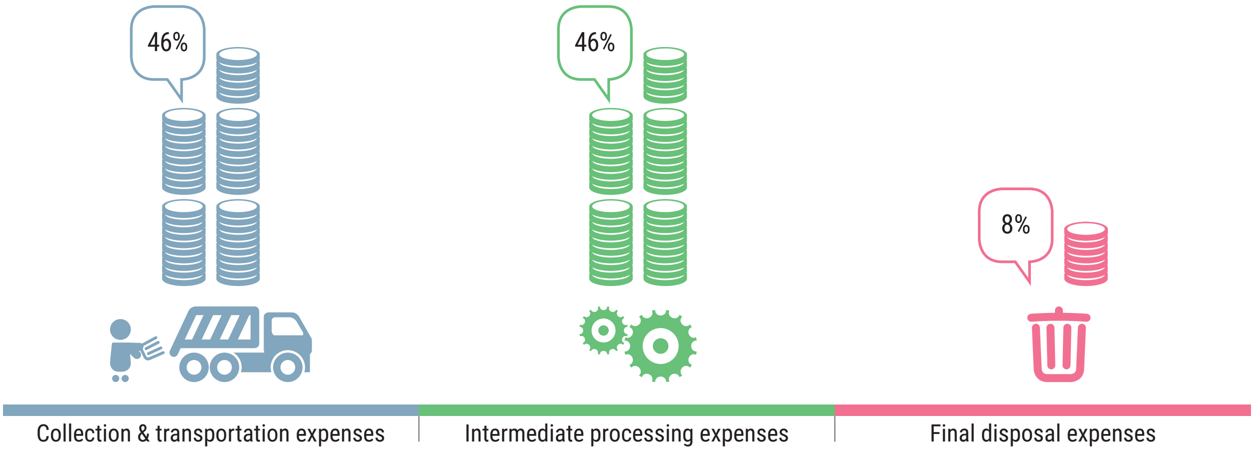


Figure 4.1 : Overview of Kanagawa Municipal Waste Management Expenses, 2011

Source: Ministry of the Environment, Japan (2014).

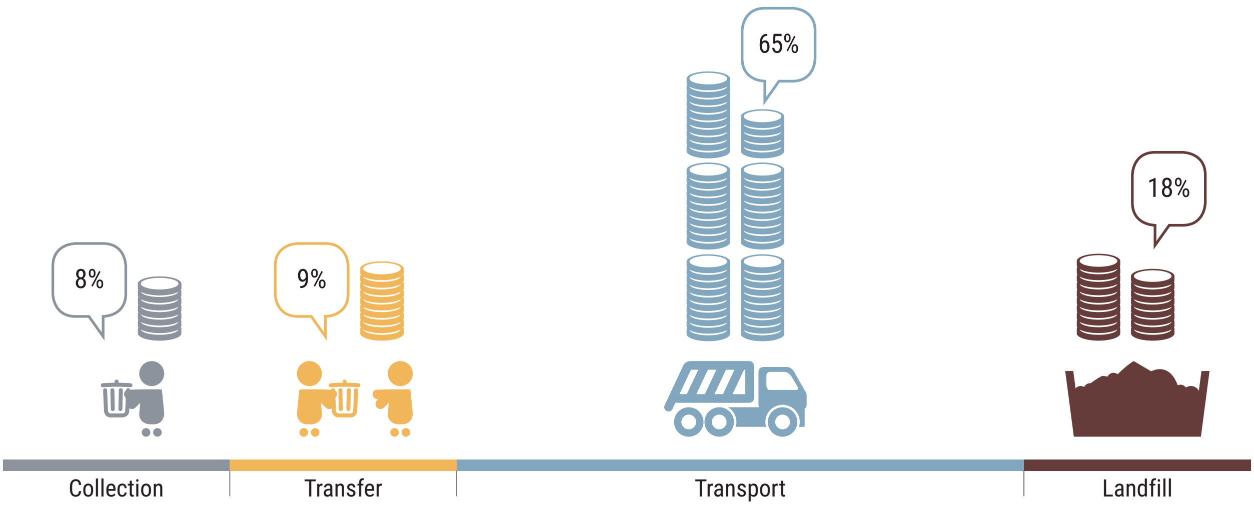


Figure 4.2 : Overview of Municipal Waste Management Expenses in Jakarta, Indonesia

Source: Rahim, Nakayama, and Shimaoka (2012).

As the system becomes more mature and there is more demand for people to bear the cost of their activities, the standard charge gives way to pay-as-you-throw systems.[3] The capability of fee collection is dependent on the efficiency of the enforcement mechanism in place. Collection through the local government system seems to be the most prevalent, with this system having very high collection rates. For example, the city of Surat, India, has a 92 per cent collection rate on its sanitation tax, which is collected at the same time as the property tax.[4] In fact, effectiveness of collection is better if the payments for waste management services are bundled with other taxes. The receipts from fees are never exhaustive, but around 90 per cent of collection is estimated to make the collection system sustainable. An examination of treatment and disposal methods of selected Asian countries indicates that disposal to land is the most favoured option (see Table 4.1).

3 Government of Hong Kong SAR, Environment Bureau (2012).
4 UNEP (2015).

Table 4.1 **Common Municipal Solid Waste Disposal Methods in Asia by Country Income Level**

Country	Income level	Solid waste disposal site	Incineration	Composting	Other
Cambodia	Low	100%	0%	0%	0%
China	Upper Middle	85%	15%	0%	0%
India	Lower Middle	75%	5%	10%	10%
Indonesia	Lower Middle	70%	2%	15%	13%
Japan	High	3%	74%	0%	17%
Malaysia	Upper Middle	93%	0%	1%	6%
Philippines	Lower Middle	85%	0%	10%	5%
Republic of Korea	High	35%	28%	37%	0%
Singapore	High	6%	94%	0%	0%
Thailand	Upper Middle	70%	5%	10%	15%

Source: Chin (2011); EMC (n.d.), Hoornweg and Bhada-Tata (2012)

Many cities in Asia have introduced variable pricing policies such as “pay-as-you-throw” or “volume-based waste fees,” in which fees are dependent on the amount of waste generated. However, these policies are more effective in middle- or high-income countries, such as the Republic of Korea and Singapore, where monitoring and enforcement capacities and the level of awareness of solid waste issues are high. The issue of municipal solid waste disposal fees is more severe in cities in developing countries. Although standards have been established and fees are collected in various ways, the actual payment rate is only 20 to 30 per cent owing to difficulties in municipal solid waste collection and measurement as well as the high labour cost involved in computing, collecting and managing waste fees.[5]

Two examples of bundling waste fees with other fee collections that have higher compliance rates than the average are shown in Box 4.1.

Box 4.1 **Examples of Fee Collection in Asia**

Case Example 1: Bangalore, India
Solid waste levies are collected along with property taxes, where the monthly rate for the levy is based on the property dimensions and type (i.e., residential or commercial). Although the fees are minimal, collection rates are about 40 per cent. This is mainly owing to lack of political will to enforce collection so that elected officials are not considered unpopular in future elections[a].

Case Example 2: Guangdong Zhongshan city, China
In 2005, Professor Chen Haibin and his team at the Huazhong University of Science and Technology in China developed a new method to improve the collection of municipal solid waste fees by combining the fee with water utility fees[b]. Through the analysis of large amounts of data, the proportional relation between waste generation and water consumption were analysed, and the water consumption coefficient of different income groups were calculated. This method helped in collecting waste fees at the lowest cost based on water supply charging system. The water consumption coefficient method has been adopted in Zhongshan, a city in the Guangdong province, where the payment rate of municipal solid waste disposal fee increased to 97 per cent. Because of this success, this method has been adopted and applied in Kunming, Xiamen and Haikou, where good results have been achieved.

a. UN-Habitat (2010).
b. Haibin and Pengheng (2005).

5 Ibid.

Table 4.1 shows that for countries with higher per capita income, the end-of-life options for municipal solid waste management change from land disposal (which can be anything from dumps to sanitary landfills) to incineration. Countries in the high-income bracket, like Japan and Singapore, that have severe shortages of land owing to relatively small land masses and high population densities, have moved from land disposal to incineration. Countries like the Republic of Korea, on the other hand, have adopted composting as well as incineration practices to divert waste from landfills. Apart from management of solid wastes, local government is often responsible for providing access to improved sanitation and hygiene on a household scale and wastewater treatment on an urban scale. To ensure the protection of community health, investments must be made in all the three components (i.e., solid waste management, sanitation and wastewater treatment). This holistic approach to waste management is not always followed across Asia (see Figure 4.3) and relatively less emphasis is given to sanitation infrastructure and wastewater treatment.

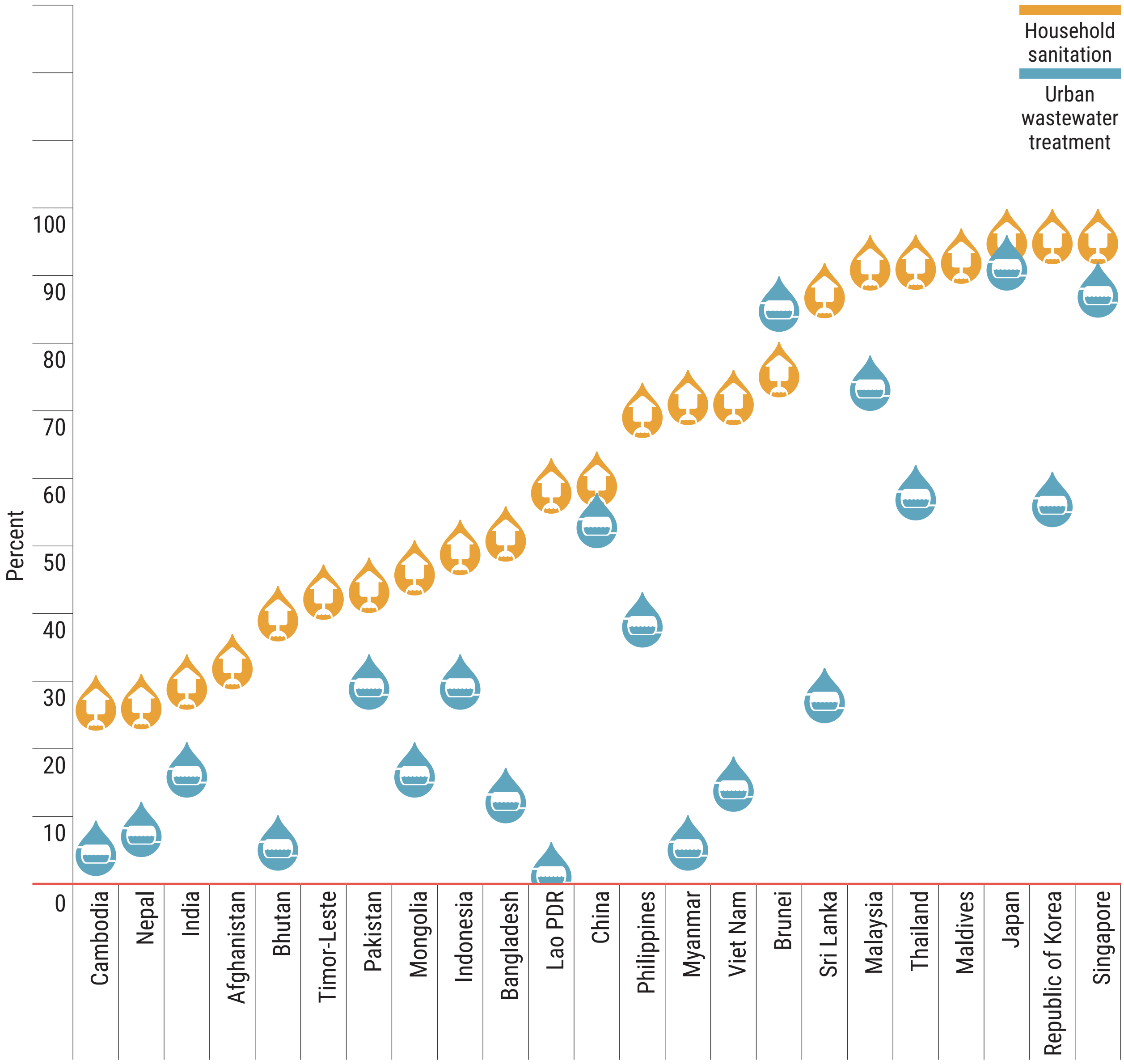


Figure 4.3 : Percentage Household Sanitation and Access to Urban Wastewater Treatment in Selected Asian Countries

Source: Asian Development Bank (2013).

4.2 Cost of Inaction

In managing environmental pollution, accounting for the economic damage caused to the environment, public health and the ecosystems is infrequent. In addition, the costs of compensation, remediation or restoration are not generally included. The levies, fines or taxes on the discharge of pollution are often not adequate to dissuade the polluter and meet the requirements of environmental compliance on a consistent basis. For sustainable waste management, appropriate use of economic instruments and their enforcement is extremely critical.

To internalise the environmental and social costs, environmental economists have suggested many methodologies over the years, but nonetheless, there is no generally agreed methodology.[6] Each methodology needs to be assessed regarding the context, the objectives and data limitations. In this regard, the scope of assessment is sometimes limited to effects on people living near waste management facilities or the facility workers themselves, while some studies examine the effects on the population of a city or region.

The economic impact of improper waste management may also be considered at the scale of an industry sector and on the value of assets. Some studies, for instance, include aspects such as loss of income or opportunity owing to wasted resources.[7] Additionally, methodologies use different valuation methods such as abatement costs (to clean up the pollution); willingness of people to pay for a cleaner environment; and property prices in the market as a function of the distance from a waste facility or the value of goods or services (where that exists).[8] The scope and relative emphasis of the methodologies on the parameters makes comparisons rather difficult. The costs of inaction result in land consumption and loss, air emissions, water and soil pollutants, remediation, litigation, extended proceedings, and finally, climate change and their impacts on the economy and lives of the people.

Figure 4.4 shows various components of unsound waste management, leading to significant costs of inaction.

6 UNEP (2015).
7 Ibid.
8 Ibid.

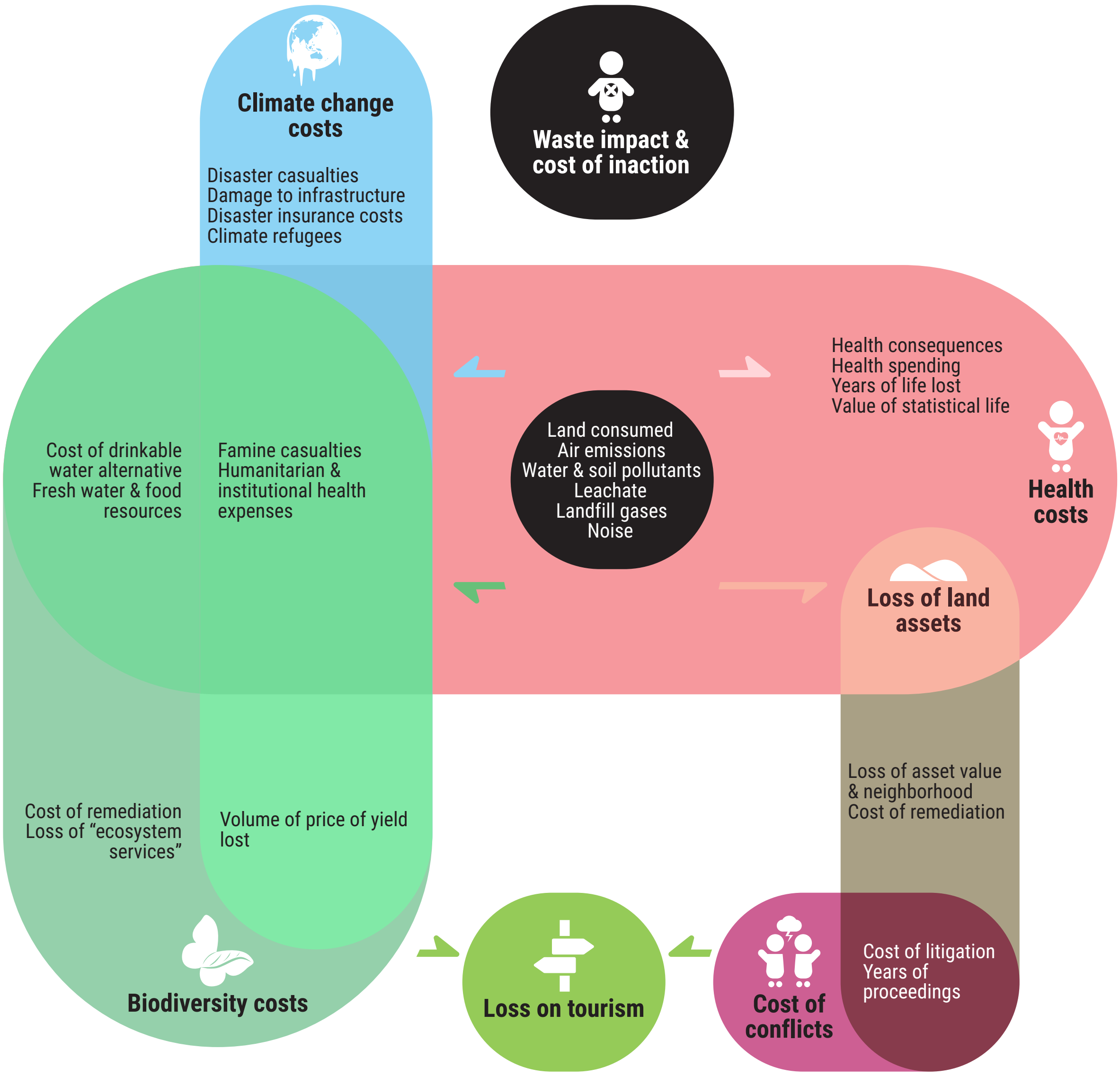
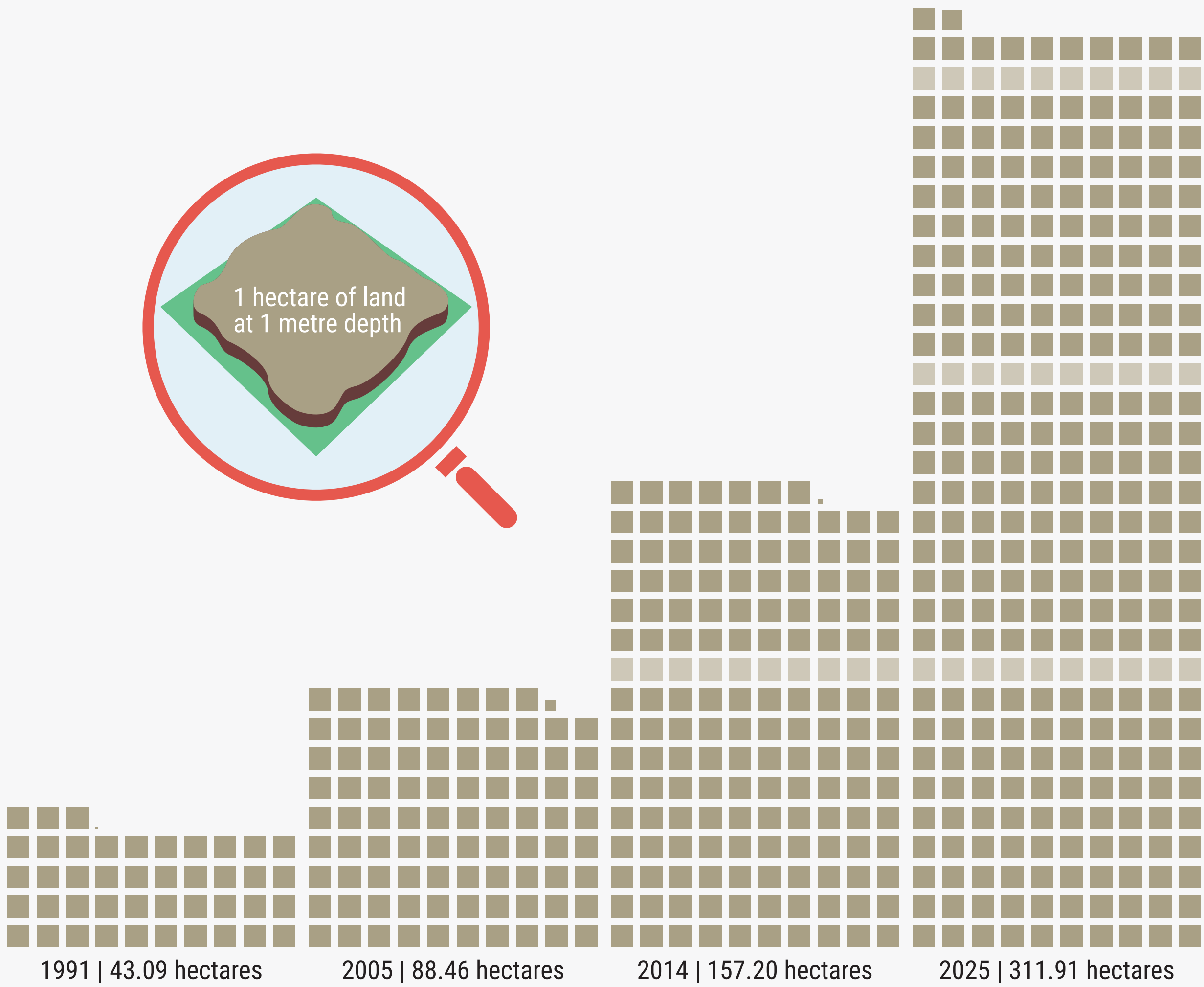


Figure 4.4 : Impacts of Unsound Management of Waste Leading to the Cost of Inaction

Source: 3R Forum (2015).

As shown in Figure 4.4, dumping wastes lead to significant human health and ecosystem impacts. Avoidance of the impacts can be achieved by following the preferred hierarchy of waste management (outlined in Chapter 3) where wastes are either avoided altogether or used as a feedstock for manufacturing. Unfortunately, many Asian countries still rely on end-of-pipe solutions to manage waste. Typically, this approach results in an ever increasing demand for landfill space, as demonstrated by Dhaka, Bangladesh (in Box 4.2). A circular economy approach avoids the impacts and provides greater productivity and a healthier world.

Box 4.2 **Increasing Land Requirements for Urban Areas of Bangladesh**



The city of Dhaka in Bangladesh disposes of most of its waste in landfills. The city has two official landfill sites, and in both, best practices in solid waste management are not applied. Finding and acquiring land for waste disposal is a serious issue because land is a limited resource in Bangladesh. In 2005, Bangladesh allotted 157.20 ha of land for waste disposal sites. The land requirement is expected to double, reaching 311.91 ha by 2025.

Source: Md. Maqsood Sinha (2016).

The Global Waste Management Outlook examined information from some studies that considered health impacts and environmental impacts. [9] Health impacts included diarrhea and gastroenteritis from direct contact, respiratory diseases and poisoning from burning waste, disease spread from waste-blocked drains, hazardous substances entering the food chain and health impacts from uncontrolled hazardous waste disposal; moreover, environmental impacts included water contamination, GHG emissions, impacts on fisheries and agriculture, biodiversity loss and amenity losses to both residents and visitors. These studies led to a conclusion that the cost (investments) of managing solid waste compared to cost of inaction is between 10 and 35 per cent. This conclusion was drawn for a typical city in a country that borders between low and low-middle income. More than half of the countries studied in this Asian Waste Management Outlook fall in this category. This conclusion underscores that it is "cheaper" to invest in sound waste management infrastructure rather than to "do nothing: and later pay for compensation, remediation and rehabilitation."[10]

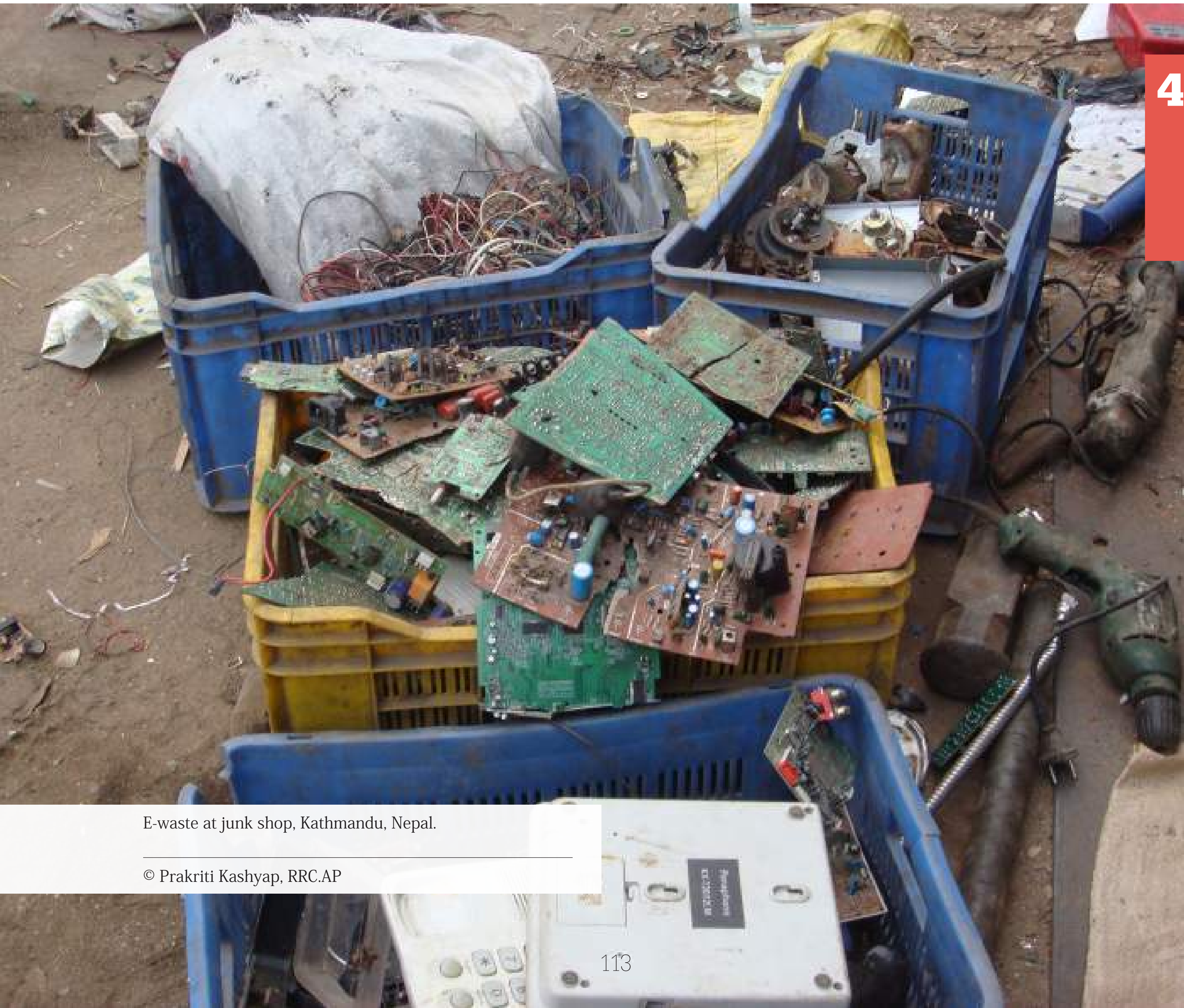
9 UNEP (2015a).
10 Ibid.

It is important to estimate and communicate the costs of inaction on waste management to the decision maker and especially to administrators and politicians. Such studies are needed on a long-term, sustained basis in Asia. Here, environmental economists and social scientists belonging to independent research institutions should take the lead in this regard. An example of the effects of inaction is shown in Box 4.3.

Box 4.3 **E-waste Crisis in Guiyu, China**

Arguably one of the best-known e-waste recycling centres in the world, the town of Guiyu in Guangdong province, China, receives hundreds of thousands of tonnes of e-waste annually from exporters who channel the hazardous waste illegally into China. Using primitive and potentially contaminating methods, the e-waste is mined manually for copper, gold and other metals. Migrant workers, who form much of the labour force, smelt computer parts in the open air to extract metals, use acid baths to separate precious metals from circuit boards and strip wires to recover the copper threads. The e-waste trade has made Guiyu's environment unfit for living. Water must be bought from a neighbouring town because the streams in Guiyu are choked with acid waste. Reports of lead poisoning, miscarriages, skin damage and other illnesses among workers and children are further proof of the unprecedented damage that e-waste has, and continues to, impact on the health on people of Guiyu.

Source: Chin (2011).



E-waste at junk shop, Kathmandu, Nepal.

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4

4.3 Opportunities and Benefits

Diverting waste from disposal through adoption of waste minimisation and resource recovery provides social, economic and environmental benefits. These benefits include economic benefits such as reducing consumption of virgin resources, the social benefits of job creation and the environmental benefits of reducing GHG emissions and water pollution. There are also additional co-benefits such as improving food, energy and water security. These benefits aid to move towards a circular economy. All of the above make the investments and operations of the waste management system sustainable as well effective and become models for others to upscale and replicate.

Box 4.4 provides an example of Bangladesh. The social, environmental and economic perspectives of benefits are described in the subsections that follow.

Box 4.4 **Economic Co-benefits Achieved through Composting in Bangladesh**

Composting in Bangladesh results in co-benefits of UISD 94 per tonne of GHG emissions reduction. These co-benefits are public and private, covering three sustainability perspectives—economic, social and environmental.

Economic:
- The public sector saves 1.1 m^3 of landfill per tonne of organic waste composted by not having to transport and landfill the waste (resulting in a UISD 23 saving), and in addition, there is a 25 per cent savings on the chemical fertilizer subsidy (UISD 4).
- The private sector has a 25 per cent savings in fertilizer usage by using compost (UISD 10)

Social:
- The public and private sectors benefit through the creation of four jobs for waste pickers to process 2 tonnes of waste each, which reduces 1 tonne of CO_2-eq. (UISD 8)

Environmental and Economic:
- The public and private sectors benefit through the increase in crop yield of 0.21 tonnes of rice per half-hectare resulting in a 1 tonne of CO_2-eq. reduction (UISD 49)

This Bangladesh example shows how small changes in moving thinking up the waste management hierarchy can have significant sustainability benefits.

Source: Md. Maqsood Sinha (2016).

Modern waste management practices can contribute to economic and social development in developing countries as well as obvious environmental benefits. For example, the Malaysian hazardous waste management system and the Kualiti Alam facility was set up as necessary infrastructure for the attraction of investments from multinational companies in the country, and was thus given highest priority by the Malaysian government. The high influx of multinational companies has provided much-needed work opportunities for Malaysian citizens and contributed to economic growth in the country.

4.4 Social

The social benefits of sound waste management extend beyond the waste sector. For example, in Dhaka, Bangladesh, grassroots organisations collecting waste have reduced litter in slums, thus reducing health- and safety-related risks and improving the environment while creating green jobs for residents.[11]

Social engagement tools enable the interaction between government and communities, providing the impetus for stakeholders to participate in waste minimisation and recycling. These tools provide for interventions that are not achievable through enforcement of legislation and regulation. Broad policy tools such as legislation and regulation may not be as effective at instituting social and behavioural change.

Social engagement tools are used in the local context, factoring in the social status and aspirations of people, accepted norms of behaviour, daily habits and the dominant issues that are discussed locally as well as globally. Provision of information is a very weak driver of change, but when used in combination with other tools of change, it can provide a very useful adjunct.[12] Unfortunately, many countries publish information on waste generation, but with no further action, there is no behavioural change.

A meaningful engagement with the local community helps in:

- Creating of green jobs;
- Bringing in ownership in management of waste especially on a decentralised basis; and
- Encouraging contributions in kind as well as in terms of financial resources, sometimes supported through corporate social responsibility(CSR) projects, especially by the private sector.

One of the key social issues is the support for waste pickers or scavengers at disposal sites. The issues include the need for registration of the waste pickers to prevent children accessing the site; the need for education on health issues associated with close contact with waste; the need for providing or mandating personal protective equipment; and finally, the opportunity for forming cooperatives. Cooperatives allow scavengers to pool their recoverables into larger quantities thus enabling them to sell to wholesalers rather than retail buyers at the landfill, thereby achieving much higher unit rate prices for their recyclables. At larger sites, it also facilitates easier control by the landfill operator because waste flows can be allocated progressively to different cooperatives, thereby avoiding the risks associated with numerous waste pickers traversing the site to access every individual load when heavy equipment is operating.

The distribution of informal sector jobs provides an interesting insight into the way the sector operates. The largest group of informal workers in Pune, India (28%) are authorised waste pickers, while in Quezon City in the Philippines, it is the street pickers (37%).[13] Second to that are the junkshop workers and buyers in Pune (24%) and the dump pickers in Quezon (26%).

Box 4.5 shows the statistics on job creation owing to the composting activities in Dhaka.

11 UNEP (2015).
12 Meadows (2009).
13 Scheinberg, Simpson, Gupta, and others (2011).

Box 4.5 **Composting in Dhaka, Bangladesh**

A project to generate compost from organic waste helped create 400 jobs for collection activities and 800 jobs to process compost.

Workers collect 700 tonnes of organic waste daily, which results in the production of 50,000 tonnes of compost per year. Aside from being paid, the workers are provided with health insurance, access to a day-care centre and a free meal. Co-benefits of the programme include cheaper compost for the city a reduced need for irrigation and improvement in soil quality through the use of compost.

Source: Sinha, and Enayetullah (2010).

Bank Sampah Bintang Mangrove, Surabaya, Indonesia.

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4.5 Economic

The potential contribution of the waste management sector to a country's economic development is substantial. Both the formal and informal sectors contribute to this development. There is a need to give more emphasis on job creation in the informal sector because this sector is many times more efficient than the formal sector. In Pune, India, and in Quezon, the Philippines, the revenues for materials for the formal sector are USD 2 and USD 4 per tonne for each city, respectively. In the same cities, the revenues from the

informal sector are USD 328 and USD 324 per tonne respectively.[14] Translating this to the wider Asian perspective, the combined potential contribution to economic development for 18 of the Asian countries covered in this AWMO[15,16] ranges from USD 869 million to USD 3.39 billion for the formal sector to USD 353 billion to USD 117 trillion for the informal sector.

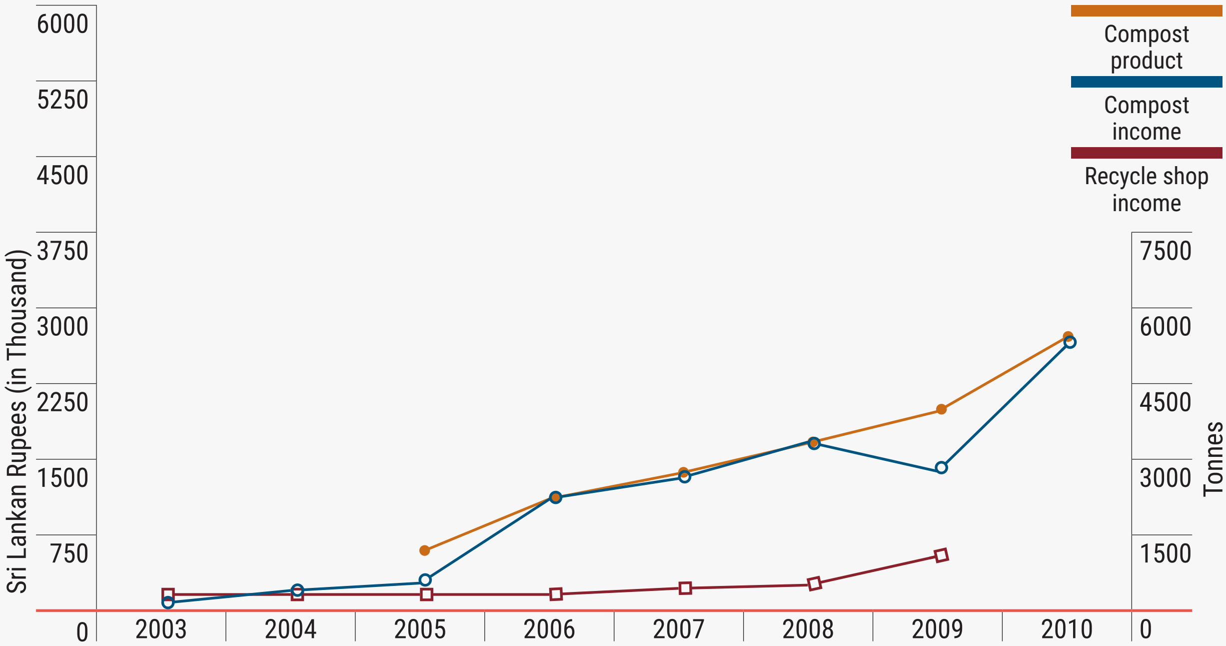
An example of financial gains owing to compost operation in Balangoda, Sri Lanka, is shown in Box 4.6. Here, impressive results were achieved by operating recycling centres with the engagement of the informal sector.

Box 4.6 **Job Creation through Waste Minimisation in Balangoda, Sri Lanka**

A common practice for waste management in Balangoda was to deposit 1 tonne per day of collected waste on the roadside. In 2001 the local population objected to the pollution of rice paddy fields caused by leachate run off from the waste. The local government's temporary response was to build a tank to collect the leachate. In late 2002 a contract for waste management was let to a private concern that had cut wages for the labourers. A public outcry ensued when the labourers resigned, and the project was taken over by the Balangoda Urban Council.

The start of waste separation occurred in 2003 where the waste was divided into decaying and non-decaying. In addition, recyclables were separated when grading the waste, and the biodegradable waste was converted into organic fertilizer (compost), using the windrow method. In 2005, land donated by the Commission of Land Reform was used to build a solid waste management centre, including a training facility. By 2008 a second facility for buying waste was built followed by the establishment at schools of five recycling centres. In 2010 the Balangoda Urban Council introduced a door-to-door waste collection system, instituted a waste levy on collection and collected biodegradables separately.

Results of the Balangoda programme are shown in Figure 4.5.



;Note: Income includes receivable amount

Figure 4.5 : Case Example: Income from SWM Products in Balangoda, Sri Lanka

For more information, visit the Balangoda Urban Council's Solid Waste Management Center website. Available from: *http://www.balangoda.uc.gov.lk/en/Compost/index.html* (accessed 13 February 2017).

14 Scheinberg, Simpson, Gupta, and others
15 The Asian countries covered by this Outlook are the following: Bangladesh, Bhutan, China, India, Indonesia, Japan, Laos, Malaysia, Maldives, Mongolia, Nepal, Pakistan, Philippines, Republic of Korea, Singapore, Sri Lanka, Thailand and Viet Nam.
16 EMC Country Master Database (n.d.).

4.6 Environment

Resource degradation and resource depletion are two significant contemporary challenges. Reducing waste helps to optimise resource consumption. One of the measures of waste reduction is material intensity, or in other words, the weight of materials needed to generate income. For developing countries in the Asia-Pacific region, material intensity has dropped dramatically at a compounding rate of about 1.5 per cent per year resulting in a 45 per cent drop over a 40-year period ending in 2010, the average decrease in material intensity being 3.1 per cent. A significant driver for this increase in efficiency is that these countries moved from being manufacturers of lower value-added products (e.g., steel components) to higher value-added products (e.g., electronic goods), which command higher prices per kilogram of material.[17] Singapore, Japan and the Republic of Korea reduced their energy intensity by 1 per cent per year over the past four decades.[18] China's economy has become more service-oriented, which makes it less energy-intensive. Additionally, it has invested in energy efficiency initiatives over decades. China has instituted mandatory energy performance standards in high-energy products like metal production, building materials and petrochemical industries.[19] We must note, however, that this is not the situation across all the developing countries of the region and the fall in the regional averages of material intensity may not be representative of the situation on the ground.

As shown in Chapter 1, the absolute figures on per capita material consumption in Asia are still high. Material conversion efficiencies as compared to Europe and North America are low. To improve this situation, sustainable waste management could be used as a strategy. Measures to reduce material and energy consumption and to improve material conversion and energy efficiencies will greatly help in achieving economic development as well as in meeting the interests of the environment. Besides making businesses in Asia competitive, these strategies reduce waste generation, GHG emissions and the consumption of virgin materials. Environmental benefits are conferred by better product designs (that use lean and biodegradable materials), design for disassembly to encourage take-back and decentralised waste treatment for resource recovery. Life cycle thinking employed in the upstream stages can lead to a reduction in costs associated with waste management.

An example that considers externalities is plastic. In 2012, 45 per cent of the world's plastic production came from Asia[20] (with two-thirds of that coming from China and Japan) and generated a cost to marine from plastic littering of almost USD 6 billion annually.[21] Proactive practices by the consumer goods industry through recycling, for example, could reduce this figure by 30 per cent, particularly through action by the food and soft drinks sectors.[22]

Clearly, there are significant benefits to be achieved through investing in greening waste management. Some of these benefits are highlighted in Box 4.7.

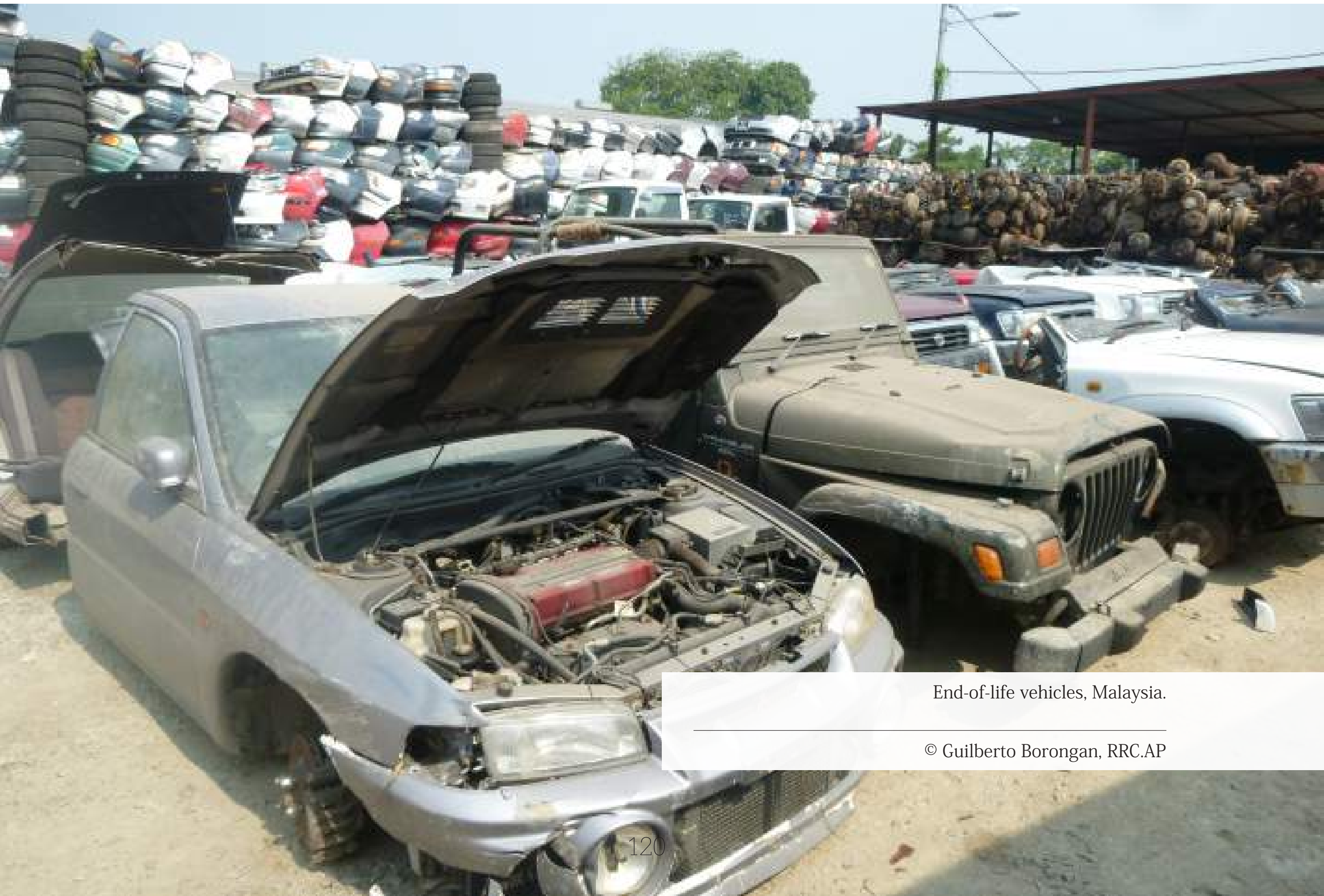
17 UNEP (2015b).
18 Ibid.
19 International Partnership for Energy Efficiency Cooperation (2016).
20 Plastics Europe (2013).
21 UNEP (2014).
22 Ibid.

Box 4.7 **Environmental Benefits of Investing in Greening Waste Management**

- For every tonne of paper recycled, 17 trees and 50 per cent of water can be saved[a].
- Recycling a tonne of aluminium saves 1.3 tonne of bauxite residues, 15 m^3 of cooling water, 0.86 m^3 of process water, 37 barrels of oil, 2 tonnes of CO_2 and 11 kg of SO_2[b].
- Recycling a tonne of steel saves 2 tonnes of CO_2 emissions, 15 GJ energy and 42,000 litre of water[c].
- Composting 1 tonne of organics saves 230 kg of CO_2 emissions and 6,000 litre of water[d].
- Recycling a tonne of glass saves 530 kg of CO_2 emissions, 5 GJ of energy and 1,000 litre of water are saved[e].
- Recycling a tonne of PET saves 1 tonne of CO_2 emissions, 55 GJ energy and 69,000 litre of water[f].
- Recycling a tonne of HDPE saves 1 tonne of CO_2 emissions, 51 GJ of energy and 23,000 litre of water are saved[g].

a. UNEP (2011).
b. Ibid.
c. Victoria State Government (n.d.).
d. Refer to the Victoria State (Australia) Government's "Life Cycle Assessment Calculator," available from *http://www.sustainability.vic.gov.au/publications-and-research/research/life-cycle-assessment/life-cycle-assessment-calculator* (accessed 19 April 2017).
e. UNEP (2011).
f. Victoria State Government (n.d.).
g. Refer to the Victoria State (Australia) Government's "Life Cycle Assessment Calculator."

As can be seen from Box 4.7, environmental impacts of waste extend beyond the boundaries of the disposal site. Leachate emissions from poorly run landfills and uncontrolled litter in municipalities cause social, aesthetic, environmental and health issues together with limiting drainage efficiency. The haulage fleet required has significant environmental impacts through air emissions from vehicles, added congestion of roads and litter from loading and carriage of insecure loads. In addition, there are economic impacts on neighbouring land values ranging from poorly run materials recovery facilities, transfer and waste processing stations and disposal sites.



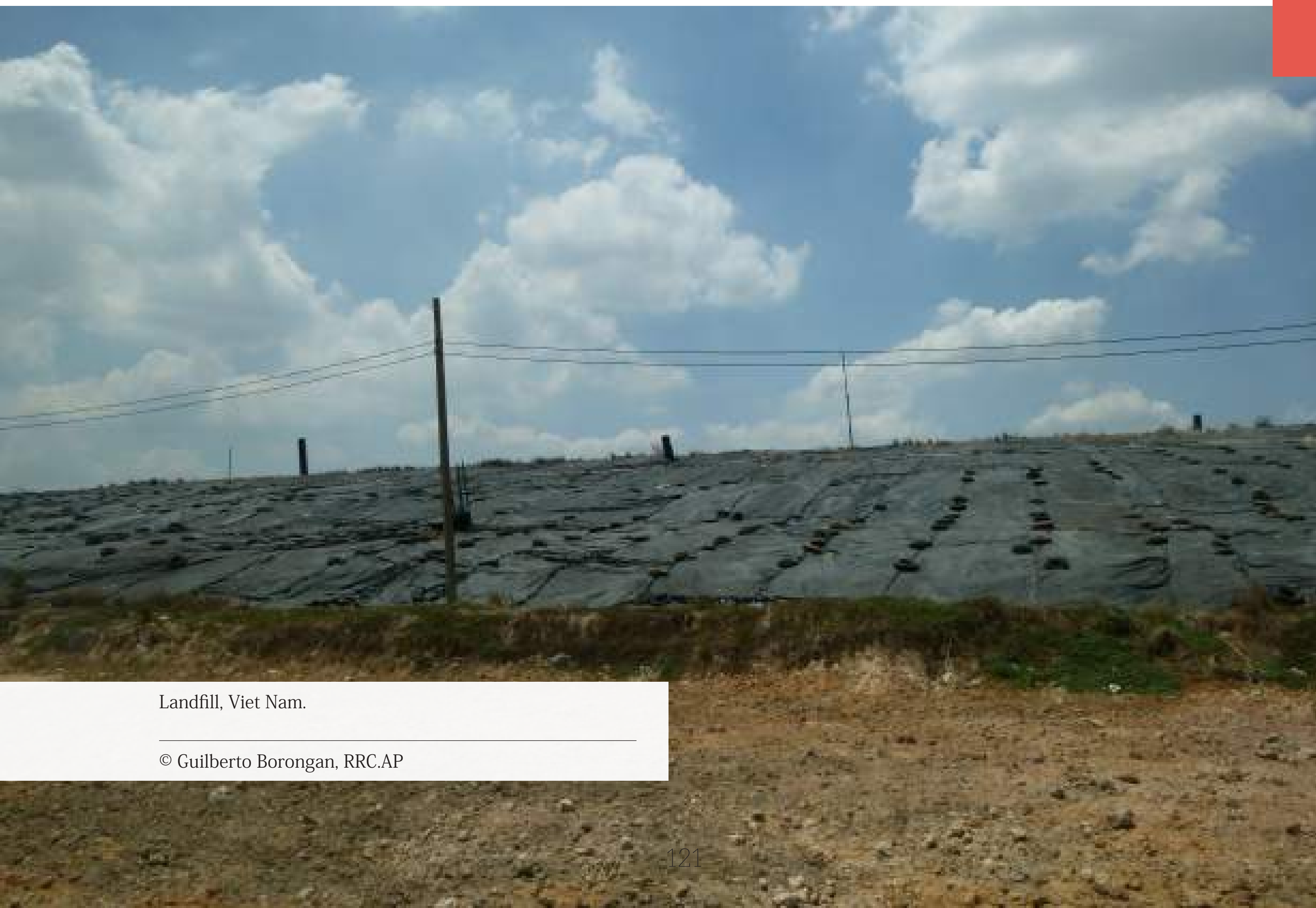
End-of-life vehicles, Malaysia.

4.7 Economic Instruments that Promote Resource Recovery

Promotion of resource recovery can be aided by various economic instruments to either encourage or discourage behaviour of the waste generator and the waste manager. This section covers various economic instruments that help to generate income or provide positive or negative stimulus to markets. These instruments are waste levies, tax breaks, subsidies, container deposits, material bans and material controls. These instruments can be used singly or in combination.

A prime driver for successful implementation of economic instruments is collaboration among key stakeholders in the process. For the waste sector, the key stakeholders are generally the national and local governments, manufacturers, retailers and the waste managers. Together, these stakeholders may create the effective promotion of resource recovery. The efficient, easy collection of waste are also preconditions for success.

A summary of the conditions for success in implementing market instruments is shown in Table 4.2. The following sections summarises some of the economic instruments listed above. Further details are provided in Annex C.



Landfill, Viet Nam.

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Table 4.2 **Conditions for Success, Strengths and Weaknesses for Various Market-based Instruments**

MBIs	Activities and requirements to establish and implement the instrument	Conditions for success	Strengths	Weaknesses
Charge system	The regulator needs to: • Set up clear rules • Collect the revenue	• Monitoring data on pollutant must be available • Enforcing compliance • Institutional integrity must be very high	• Charges proportional to pollution	• More complex to coordinate with different sources of pollution • Monitoring and enforcement are costly
Deposit refund	The regulator needs to: • Set up clear rules • Collect the revenue	• Front-end charge (deposit) combined with refund payable when quantities are turned in for recycling • Participation by	• Low legal, institutional, and political barriers • No need for monitoring when voluntary	• Difficult to enforce because of the voluntary nature of the scheme • High cost of implementation
Taxes	The regulator needs to: • Set up clear rules • Collect the revenue	• Enforcing compliance • Institutional integrity must be very high	• Multiple sources of pollution • No need to identify an abatement level • Works even when monitoring data unavailable • Easy to manage Generate revenues	• Do not always incentivise adoption of abatement technologies • May affect nontargeted activities • Politically difficult to accept • Distributional impacts can be distortive
Subsidies	• The regulator needs to set up clear rules	• Monitoring data on pollutant must be available • Enforcing compliance	• Incentive to actually change system	• Taxpayer gets part of the pollution burden
Tradable permits	• The regulator needs to set up clear rules	• Data needed for initial allocation • Tracking system required • Enforcing compliance	• Flexibility in their application • Cost savings for the regulator • Less efficient units of production are likely to stop operating	• Major regulatory requirements • Consistent legal framework • Political resistance

For more information on the World Bank's Hebei Rural Renewable Energy Development Project, visit *http://projects.worldbank.org/P132873/?lang=en&tab=map* (accessed 13 February 2017)

4.8 Waste Levy

Levies are financial contributions often imposed by national or local government on waste disposal to provide funding for waste minimisation programmes or to deter direct disposal. The levy is often charged on a weight or volume basis. Levies can be applied to solid, liquid and gaseous forms of wastes.[23] Typically, levies are imposed either nationally or locally. A national levy provides consistency for all participants. In contrast, local levies may face pressures from stakeholders who can negotiate with different jurisdictions to get the most favourable conditions. The size or the extent of the levy can determine its impact. Where the levy is small in comparison to the cost of disposal, it will have very little impact on waste recovery. However, even a small levy, if kept separate from general funding, can provide significant finance to fund awareness programmes and pilot projects to improve waste management. A large levy on the other hand can provide impetus to divert waste from disposal but can lead to illegal dumping.

Box 4.8 illustrates the impact of a levy in Kota Bharu in Malaysia.

Box 4.8 **Introduction of a Levy in a Willingness to Pay Survey in Kota Bharu, Kelantan, Malaysia**

Dwindling financial resources and rising population growth in Kota Bharu, the state capital of Kelantan in Malaysia, resulted in the lack of control in handling solid waste. This situation gave rise to adverse environmental impacts and public health. A study was undertaken to evaluate the willingness of communities to pay for waste management. In this context, it was found that people were willing to pay USD 4.40 per month. This sum represented about 0.4 per cent of the average personal monthly income. Young people showed a greater willingness to pay because it was suggested that modern education methods expose students to the influence of environmental and health effects.

It was also found that higher the participant's income, the more willing they were to support payments for waste management services and the employment status. Those who were employed were more willing to pay for services because they had a stable income. The response was comparable with figures obtained in studies from other parts of Malaysia and neighbouring countries. The imposition of levy implemented on the basis of willingness to pay raised the annual revenue of the city by 60 per cent.

Source: Rahimah and others (2012).

23 Seadon (2015).

4.9 Tax Breaks

Taxes and charges can be imposed on goods linked to polluting activities. A tax break or exemption provides for avoidance of those taxes and includes tax exemptions, deductions or credits. Tax breaks can be applied at either the national or local government level to encourage producers and consumers to choose less intensive inputs, product designs and packaging that have less undesirable or adverse environmental impacts.[24] The pre-condition for success for tax breaks is that they must be easy to administer, clear on their scope and the objectives of introducing the breaks. The tax break may be awarded initially on products belonging to focal waste-generating sectors and later upon experience the instrument may become broad-based.

The extent of the break can indicate the level of the "driver" that a tax break will provide. For example, tax breaks are often provided for the purchase of equipment that will reduce pollution in waste management services and facilities.[25] This equipment can be quite expensive because the tax is normally calculated as a percentage of the cost. The incentive from the tax break can be significant to encourage purchase of the waste management equipment. Tax breaks when combined with performance obligations can "force" the enterprise to make the process viable and operate on a sustained basis.

Box 4.9 illustrates a case study on tax breaks for waste ecoparks in Malaysia.

Box 4.9 **Income Tax Exemptions for Waste Eco-Parks in Malaysia**

Waste eco parks aim to promote waste recycling, recovery and treatment activities by industries, providing a sustainable solution to the waste management problem. The parks encourage investments in facilities and infrastructure towards holistic waste management activities.

The Government of Malaysia provides an income tax exemption of 70 per cent on statutory income derived from building rentals, waste receiving and separation facilities, and waste water treatment facilities located in a waste eco park. This tax exemption is effective from 2016 until 2025. Applications received from 1 January 2016 to 31 December 2020 are eligible to be considered for this incentive. Further, companies operating in such a park are eligible for an income tax exemption of 100 per cent on statutory income for a period of five years, if the activities undertaken in the park if they meet the prescribed criteria.

Source: Malaysian Investment Development Authority (2016).

24 Seadon (2015).
25 UNEP (2015a, p. 157).

4.10 Subsidies

Subsidies can be offered to goods linked to non-polluting activities. Subsidies can be applied at either the national or local level to encourage producers and consumers to choose lean materials and green products and services with low adverse environmental impacts.[26] Like tax breaks, subsidies should be easy to administer and be clear on what is within scope and the focal sectors. After some ground-level experience, subsidies could be broad-based to promote, for example, reuse or waste recycling across the sectors and stakeholders.

The size or extent of the subsidy can indicate the level of driver that a subsidy will provide. For example, subsidies are often used to introduce new or innovative services or to facilitate those that have identifiable social or environmental benefits, or both, but may not be economically viable. Subsidies are then provided as a gap financing measure. These subsidies help in reducing capital or operating costs.

Box 4.10 provides an example of subsidies offered by the Government of India to promote composting of waste.

Box 4.10 **Policy on Promotion of City Compost, Government of India**

The policy was approved by Union Cabinet and is effective from February 2016. Under the policy, a provision has been made for market development assistance of USD 22 (1,500 Rupee) per tonne of city compost for scaling-up production and product consumption. The objective is to lower the cost of city compost for farmers and to promote composting of city garbage. An Eco-Mark (India's green product certification scheme) standard for the compost would be applied to ensure that an environment-friendly quality product reaches farmers and other users.

Initially, marketing and promotion of city compost is proposed to be done through existing fertilizer companies. Relevant ministries or departments will carry out information, education and communication campaigns to inform farmers on the benefits of city compost, and they will also take steps to increase the introduction of compost plants across the country.

Source: Government of India Cabinet (2016).

While subsidies provide an effective mechanism to initiate or boost activity, they should only be seen as an interim measure. The aim of introducing a subsidy should be to assist in making the activity self-supporting over the long term. Without this goal, the inevitable removal of the subsidy will result in a return to pre-subsidy or similar levels of activity. Another consideration before the introduction of subsidies is their effect on the market and the current operators, so decisions need to be made on whether subsidies apply to current operators or to allow a wider community to participate. One disadvantage of allowing a wider community is that inexperienced operators may extend too far beyond their level of capability that can create an even larger waste problem.

26 Seadon (2015).

4.11 Container Deposits

Container deposits institute a monetary deposit on containers (often beverage containers) when sold. Return of the container to an authorised centre, or, depending on the jurisdiction, to the original seller, releases the deposit (sometimes deducting a service charge) to the redeemer. More sophisticated options can include reverse vending machines where people can insert their discarded containers into a machine that then returns the deposit. An efficient collection and storage system is needed to implement this economic instrument so that the location is secure from vermin and criminals. In low-income communities with many small stores, even the smallest deposit coin charge is a burden on the underprivileged and introduces security problems, namely, for stockpiled returned containers being stolen to then be returned to another location for a second deposit refund. An efficient accounting system is also needed that connects those selling the containers and those collecting containers with an agency that oversees the programme. A scheme of rewards and recognition can help in encouraging the instrument of container deposits.

Box 4.11 describes a deposit refund system in Korea.

Box 4.11 **Deposit Refund System in the Republic of Korea**

The Deposit Refund System in the Republic of Korea was first legislated in 1985 and covered refillable glass bottles for Soju, beer and soft drinks. Currently, the deposits are based on the volume of the container where less than 190mL attracts a 2-cent deposit and 1L or more between 9 cents and 26 cents. A handling fee of 1 or 2 cents is based on the container size. Both deposits and handling fees are regulated by the national government.

Producers are paid by the Korean Vessel Recirculation Association that uses their financial resources for: improving the rate of empty bottle recovery; collection stations; research and development for efficient recovery and recycling; offsetting any previous year's losses; and other activities for preservation of the environment. The success of the programme is such that of the 5.5 billion bottles sold annually, more than 95 per cent of bottles are recovered and more than 85 per cent are reused.

See "South Korea Deposit Refund System," in the Bottle Bill Resource Guide's Beverage Container Legislation around the World: South Korea. Available from: *www.bottlebill.org/legislation/world/southkorea.htm* (accessed 13 February 2017).

Styrofoam waste.

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4.12 Material Controls

Controlled wastes are wastes that are regulated owing to their toxicity, hazardous nature or potential harm to human health or the environment.[27] A precondition for success for material controls is a sound enforcement system so that controls are followed. Countries like Japan, the Republic of Korea and Thailand have enacted legislation to put the responsibility for waste management on producers. Items like packaging, e-waste, batteries, end-of-life vehicles are covered.[28]

Box 4.12 illustrates a multi-level/multi-stakeholder-based material control strategy adopted by the Republic of Korea on the management of e-waste.

Box 4.12 **E-waste Management Supported by Material Controls in the Republic of Korea**

The 1992 Act on Promotion of Saving and Recycling of Resources in Republic of Korea introduced waste charges and waste deposit fees for several products from industries to promote recycling. An extended producer responsibility (EPR) scheme was introduced in 2003 by amending the recycling law. Since 2004, the Ministry of Environment of Korea has carried out a feasibility study to restrict the use of hazardous substances in electrical and electronic equipment and to promote recycling of e-wastes by applying a systemic management for life cycle analysis from cradle to grave.

In January 2008, the Eco-Assurance Committee System in Korea was implemented under the Act on the Resource Circulation of Electrical and Electronic Equipment and Vehicles for resource circulation and environmental conservation. Five product groups and 27 WEEE items, including refrigerators, personal computers, electric ovens, audio equipment and mobile phones, are controlled to improve recycling capacity in the electronics industry.

A 2013 evaluation of the waste stream showed that 60 per cent of products were recycled by producers and the other 40 per cent through recycling companies. Analysis of the changes from 2003 to 2013 in the capture of units through the recycling system show that the recycling rate for audio equipment and personal computers had increased five-fold, for televisions four-fold, refrigerators three-fold, printers two-fold, although washing machines, air conditioners and copying machines stayed the same and mobile phones dropped slightly.

Source: Rhee (2016).

27 Seadon (2015).
28 UNEP (2015a).

4.13 Material Bans

Material bans are regulations prohibit the disposal of specified materials or products to landfill.[29] For bans to be successful, an alternative system must be available that is easy for consumers to engage with. Material bans are normally put in place help recyclers generate a viable market for a product that often would occupy a lot of space in a landfill (e.g., polystyrene or tyres) or could be a public nuisance. Material bans may not always work unless backed by enforcement and favourable economics.

See Box 4.13 for a case on material bans of plastic bags in Bangladesh.

Box 4.13 **Plastic Bag Ban in Bangladesh**

The Bangladesh Environment Conservation Act (1995) was amended to include a provision to allow the government to "[impose an] *absolute ban on the manufacture, import, marketing, sale, demonstration for sale, stock, distribution, commercial carriage or commercial use, or allow the operation or management of such activities under conditions specified in the notification, and every person shall be bound to comply with such direction*".

The amended Act was applied to polythene (or polypropylene) shopping bags or any other article that can be injurious to the environment.[a]

However, non-govermental organisations (NGOs) noted that a year after publicity about the ban, plastic bags made a comeback owing to a lack of enforcement. This was because the cost of the plastic bags was about one-tenth of the cost of alternative jute bags. To many, jute bags were not a cost-effective alternative.[b] It is important, therefore, to ensure that any alternative to a ban is economically attractive or appropriately subsidised.

a. Bangladesh (1995).
b. IRIN (2011).

29 Seadon (2015).

4.14 A Comparative Assessment of Economic Instruments

There is no discernible relationship between a country's income level and the application of the economic instruments. In all, seven countries in Asia have legislated waste disposal charges. Of these seven, two are high-income countries (Republic of Korea and Singapore), one is upper-middle (Malaysia), three are lower-middle (Bhutan, Philippines and Viet Nam) and one is low-income (Nepal).[30] Thus, there is a significant opportunity to legislate waste disposal charges in Asian countries to dissuade waste generation, generate revenues to support cleanup operations and improve waste management infrastructure.

Similarly, provisions for grants at the local and national level are not related to the country's income bracket. In Asia, eight countries have legislated grants to be made from either national or local government to support waste management. Of those eight, one is a high-income country (Republic of Korea), six are lower-middle (Bhutan, Indonesia, Philippines, Sri Lanka, Timor-Leste and Viet Nam) and one is low-income (Nepal).[31] This indicates that there is a predominance of lower-middle income countries in providing grants.

It should also be noted that the five countries mentioned above both legislate disposal charges and provide grants, which indicate these countries essentially institute a subsidised waste disposal service.

The four instruments landfill tax, pay-as-you-throw (PAYT), deposit–refund systems and extended producer responsibility (EPR) policies are compared in this section for their utility and cost.

A recent an assessment of economic instruments was carried out for countries with low municipal waste management performance based on the analytic hierarchy process.[32] In the utility-based assessment, PAYT turned out to be the most prioritised instrument for countries with low municipal waste management performance, closely followed by landfill tax. The positive effects of PAYT occurred immediately after its introduction, and the negative impacts of PAYT, such as illegal dumping to avoid charges, only partly occurred, immediately endangering the success of the instrument. The EPR and deposit–refund systems rank similarly as third and fourth priority. The deposit–refund system was found to be costlier than EPR. Combining both assessments, the landfill tax showed the highest cost–utility ratio and, therefore, has a higher priority than the following EPR, PAYT and deposit–refund systems.

30 UNEP (2016).
31 Ibid.
32 Kling, Seyring, Tzanova, (2016).

4.15 Benefits and Challenges

To summarise, the benefits of using economic instruments to promote resource recovery are six-fold, depending on the measure used:

- **Landfill lifetime**: As countries become more populous, cities expand and waste quantities increase. Thus, landfills get bigger and become surrounded by urban sprawl resulting in health and environment issues. Application of some of these economic instruments can increase the life of landfills by reducing the quantities of waste sent for disposal.
- **Health impacts**: Reducing the quantity of landfill waste reduces the health impacts of neighbouring communities and, thus, the costs of medical care and treatment.
- **Environmental impacts**: Recovery of resources reduces the extraction of virgin materials, reduces waste transportation and fuel consumption, and lowers GHG emissions. Resources recovered, such as biogas, reduce fossil fuel consumption and provide energy access. Production of compost reduces the consumption of chemical fertilizers. Inert materials that are separated and recycled (metal, plastic, glass) reduce risks to the environment.
- **Employment and entrepreneurship opportunities**: Resource recovery centres provide employment opportunities for both the formal and informal sectors (often called as "green jobs"). If provided micro-finance and similar incentives, resource recovery is practiced as a business especially by the youth and community.
- **Innovation**: Many resource recovery technologies or projects demonstrate innovation. These innovations are field-tested initially as pilot projects and are later funded either by governments or by the private sector for possible up scaling and replication leading to the establishment of the recycling or reuse market.
- **Responsible Production**: By influencing product design, packaging and encouraging EPR to maximise resource recovery, manufacturers often revisit their product design, including packaging to make it easier to disassemble and to increase recyclability of used or abandoned products. The materials used in making such products and packaging them also undergo a review to ensure that recycling can be carried out at reduced or no risks to consumers, workers and the environment.

Annex C provides a summary of the benefits applicable to each of the economic instruments discussed in the previous sections. The challenges of implementing the economic measures are four-fold:

- **Compliance**: Ensuring compliance is one of the largest challenges that administrators face. This comes in several forms: ensuring the activities targeted actually do what they claim, monitoring and auditing performance criteria.
- **Engagement**: Making the mechanism easy to engage with, especially when multiple and diverse stakeholders are involved or need to work together without conflicts.
- **Business impedance**: Convincing businesses that the marginal cost of the intervention or the impedance would provide significant societal good.
- **Economics**: Ensuring the measure has economic viability over the expected life of any equipment needed and that the measures do not undermine any current successful schemes.

Annex C describes the challenges in detail as applicable to each of the economic instruments discussed in the previous sections.

4.16 Waste Financing

This section focuses on the various models used to raise the finance needed for waste management infrastructure and services. In Asia, a significant investment in waste management is expected in the coming years. Recent estimates of spending on worldwide solid waste management alone range from USD 23B[33] to USD 33B[34] per year, with China and India each accounting for 3-10 per cent of this amount.[35] Various mechanisms can finance the waste management sector. These mechanisms include financing by national or local governments or by international financing institutions and other donors, investments from the private sector, community contributions, grants from trust funds or a combination of these. In developing countries, the ability of governmental institutions to borrow money can be limited owing to their heavy reliance on borrowing to finance developmental projects, thus leaving limited room for further borrowing for waste management infrastructure. Thus, other financing arrangements, such as providing grants or micro-finance to individuals or setting up micro-enterprises, can play a role in engaging various models of public-private partnership (see Figure 4.6).

The global trend is undoubtedly towards private sector involvement in all aspects of waste management. This is a key driver to obtaining access to the correct technical skills as well as establishing a contractual environment in which a municipality will only make payments subject to the operations meeting contracted key performance indicators.

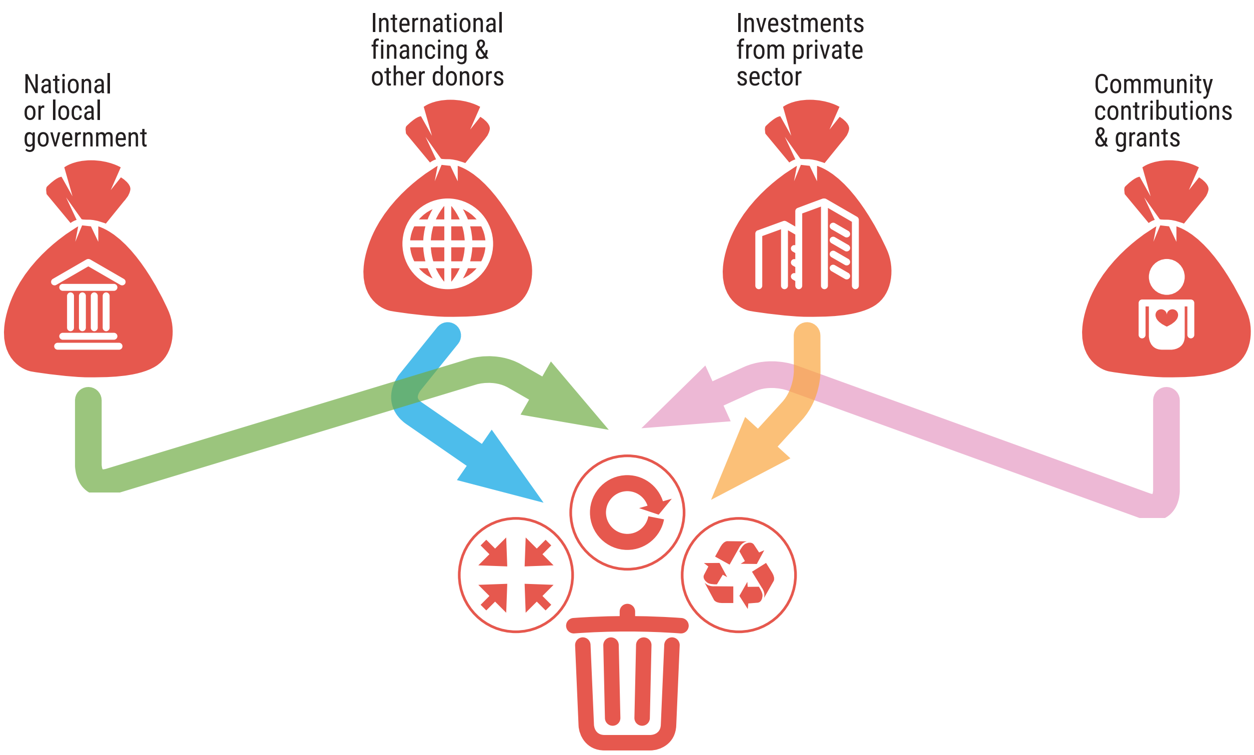


Figure 4.6 : Mechanisms to Provide Finance to the Sector

Source: Climate Bonds Initiative (2016).

33 Hoornweg and Perinaz Bhada-Tata (2012).
34 Whiteman and Soos, R. (2011).
35 UNEP (2015).

4.17 Government Sponsorship

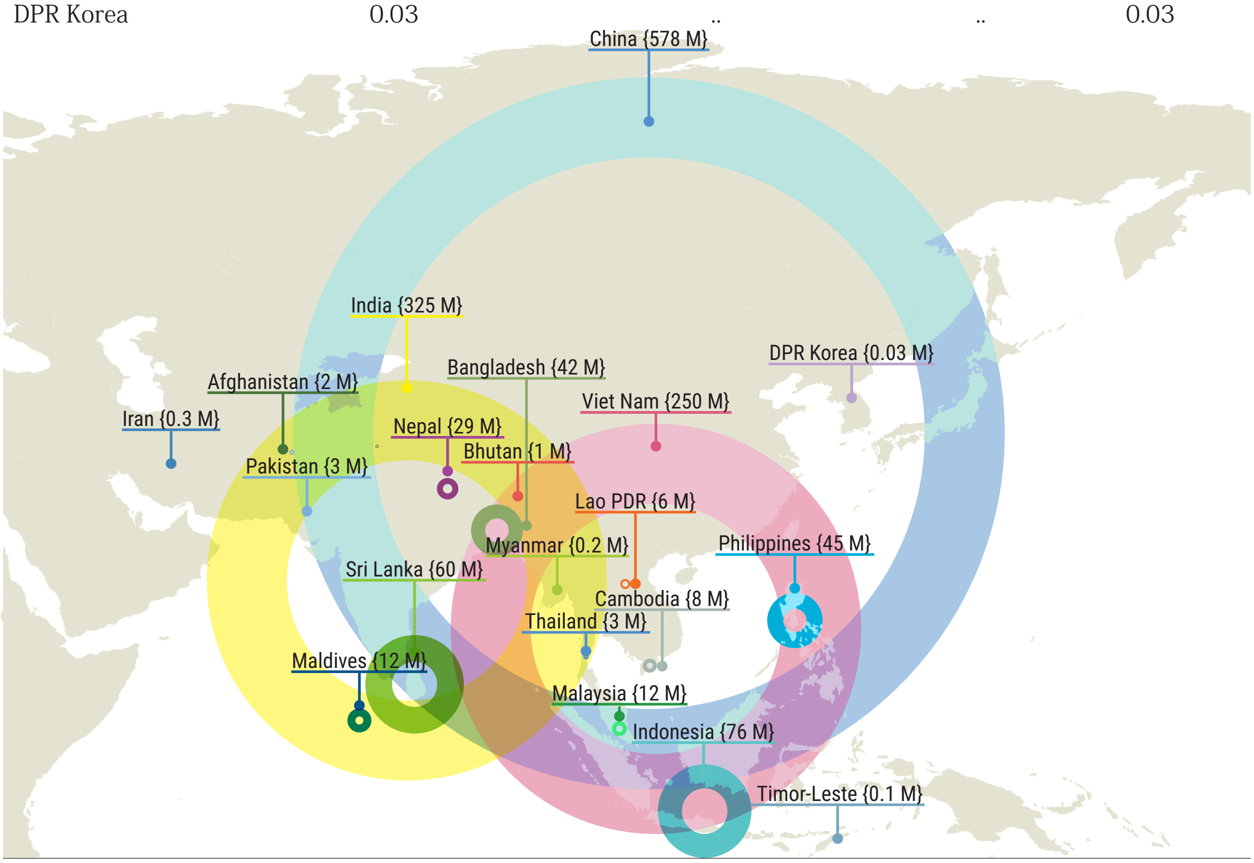
Most Asian countries share responsibilities for waste management between local and national governments. With the continuing trend towards urbanisation, local governments are stretched to provide infrastructure and services for their growing populations. Income for local governments tends to be a mix of local taxes, fines and fees. The better-established and more affluent municipalities can find more sustainable funding streams gained from renting out assets or striking public-private partnerships.

4.18 Financing through International Financial Institutions

International funds provided to Asian countries in 2012 for solid waste management amounted to USD 1.45B spread among 20 of the 25 countries covered in this Outlook, as shown in Table 4.3. This table represents 37 per cent of the world's total international funding for solid waste management programmes in 2012. Grants make up 20 per cent of total, concessional loans that have long-term repayments, and lower-than-market interest rates make up another 48 per cent, and non-concessional loans at market rates make up the remaining 32 per cent.

Table 4.3 Solid Waste Management Development Recipients in Asia, 2012 (Million USD)

Country	Grants	Concessional loans	Non-concession loans	Grand Total
China	65	263	250	578
India	18	108	196	325[a]
Viet Nam	56	183	12	250
Indonesia	35	40	..	76[b]
Sri Lanka	18	42	..	60
Philippines	19	25	..	45
Bangladesh	28	13	..	42
Nepal	16	14	..	29
Maldives	5	8	..	12
Malaysia	12	..	..	12
Cambodia	8	..	..	8
Laos	1	5	..	6
Thailand	3	..	..	3
Pakistan	3	..	..	3
Afghanistan	2	..	..	2
Bhutan	1	..	..	1
Iran	0.3	..	..	0.3
Myanmar	0.2	..	..	0.2
Timor-Leste	0.1	..	..	0.1
DPR Korea	0.03	..	..	0.03



Note: a. Received UISD 3M in the form of equity.
Note: b. Received UISD 3M in the form of equity.

Source: Lerpiniere, Wilson, Velis, and others (2014). Review of International Development Co-operation in SWM
Note: Note: DPR Korea = Democratic People's Republic of Korea

International financial institutions such as the World Bank Group, through its International Finance Corporation (IFC), it finances and provides advice for private sector ventures, focusing on private sector investments, such as waste-to-energy facilities. Moreover, through its International Bank for Reconstruction and Development (IBRD), the World Bank provides long-term loans and grants.

Boxes 4.14 and 4.15 provide illustrations.

Box 4.14 **Examples of Waste-to-Energy Plants Supported by the International Finance Corporation**

China

The IFC granted a convertible loan of up to USD 60 million to support Canvest, a regional waste-to-energy player with its main presence in Guangdong Province, China, to grow its business in China over a two-year period. As of November 2015, Canvest's operations in China secured seven projects with a total installed capacity of 12,400 tonnes per day, including an operating capacity of 5,400 tonnes per day under both build-own-operate and build-operate-transfer contracts. Included in the package were projects in prefecture-level cities in the Guangdong province (four in Dongguan, one in Zhanjiang, one in Qingyuan) and one in Laibin in the Guangxi Zhuang Autonomous Region.

Canvest raised USD 138 million from its initial public offer in December 2014. This was supplemented by the IFC's convertible loan and other bank loans to finance Canvest's capital expenditure. As part of the due diligence process, the IFC conducted site visits to waste-to-energy facilities and interviewed key company management personnel, operational and human resources managers and company staff members.[a]

Sri Lanka

Renew Gen Enviro Ventures India Pvt. Ltd. is a developer focused on the waste disposal market in and around South Asia. The developer secured a competitively awarded waste-to-energy concession in Sri Lanka from the Waste Management Authority of the Western Province in Sri Lanka. The project is a 25-year concession to build-own-operate a 10MW waste-to-energy project in the Western Province of Sri Lanka. The project processes up to 580 million tonnes/per day of municipal solid waste generating up to 10MW of electricity that is sold to the grid. The project uses a well-proven grate-based mass incineration technology that is suitable for unsorted municipal solid waste in conjunction with advanced emissions purification systems. Of the total project cost of USD 29 million, the IFC approved financing of USD 5 million.[b]

a. *http://ifcextapps.ifc.org/ifcext%5Cpressroom%5Cifcpressroom.nsf%5C0%5C0E07219C047253C085257EC9001546C4*
b. *https://disclosures.ifc.org/#/projectDetail/ESRS/32295*

Box 4.15 **IBRD Supports Bio-gas Facilities in China**

Every year, China produces 840 million tonnes of livestock manure, a key source of water pollution. In addition, 690 million tonnes of collectable crop residues are burned for fuel on open fields, which combined with coal used by rural households for cooking and heating, causes severe indoor and outdoor air pollution. China's central areas present very serious conditions. Thus, the IBRD funded a project to support the development of six state-of-the-art biogas facilities to serve as demonstration projects for efficiently converting agricultural waste (manure and crop residues) into biogas. Funding of USD 71.5 million was provided. The project produced 4.2 million cubic meters of bio-gas, and supplied biogas to 96,000 rural households. The remaining was upgraded to vehicle-quality fuel and used for public transportation. In addition to resource generation, this project reduces 58,780 tonnes of CO_2 -equivalent emissions annually.

Source: World Bank Treasury (n.d.).

Traditional waste management facilities, such as transportation and sanitary landfills, have also been financed through international financial institutions as shown in Box 4.16.

Box 4.16 **Improvement of Equipment for Solid Waste Management in Bangladesh**

Accompanying a rapid influx of people to cities and the expansion of urban areas, Bangladesh faces serious challenges in its deteriorating urban environment, including an increase in waste and growing slums. The living environment is worsening—particularly in Dhaka South and North, which together compose the capital, as well as in Chittagong, which is the second largest city in the country—owing to an increase in waste accompanying the rapid population increase and economic development.

On 20 May 2015, the Japan International Cooperation Agency (JICA) signed a grant agreement with the Government of the People's Republic of Bangladesh to provide grant aid of up to USD 13.4 million for a project to improve solid waste management equipment. The project will provide and outfit 150 waste collection vehicles (including compactors) and create a maintenance system for the Dhaka South City, Dhaka North City and Chittagong City Corporations. This project is expected to increase the amount of waste collected in the three target cities by 1,830 tonnes per day, a rise of 84 per cent. It is expected that this will contribute to the sanitation in the region, improve the living environment, and contribute to urban development in Bangladesh.

Previously, in 2009, JICA supported a programme for improvement of solid waste management in Dhaka City to move toward a low carbon society; it did so by providing 100 Japanese waste collection vehicles to what was then the Dhaka City Corporation. The vehicles have greatly contributed to solving the waste problem in the target area, and the "garbage trucks decorated with the Japanese flag" have become a beloved sight among the Dhaka residents. This project aimed to meet subsequent increases in waste collection, while also improving the image of waste management in the minds of residents.

In addition to these projects, since 2000 JICA has supported planning to increase the waste management capacity in each of the three cities with technical cooperation projects (e.g., Clean Dhaka Master Plan 2005); to carry out sanitation education and public awareness campaigns for residents through cooperation, volunteer dispatches and other activities (e.g., environmental education at elementary school); and to provide inclusive support for urban environment improvement in Bangladesh (e.g., Establishment of Waste Management Department in Dhaka City).

Source: *https://www.jica.go.jp/english/news/press/2015/150521_01.html; https://www.jica.go.jp/bangladesh/english/office/topics/press150520.html*

4.19 Results-based Financing

Results-based financing relies on the verification and achievement of pre-agreed targets to release finance or in-kind contributions to a project. This financing tool provides opportunities for innovation in the use of development finance in the waste sector to achieve results. Given the challenges that cities face regarding waste management and service provision, this tool can benefit the waste sector by ensuring that public funds for waste management are applied efficiently and transparently. The acquisition of baseline data is essential to determine the tool design that addresses sectoral needs. Achieving the maximum programme benefit requires all stakeholders to be involved from the outset. Improving services does not necessarily require new technology or people, it may just need better utilisation of available resources by working in a coordinated manner.

An example of a successful results-based financing programme is given in Box 4.17.

Box 4.17 **Output-based Aid in Municipal Solid Waste Management in Nepal**

Municipalities in Nepal generate about 700,000 tonnes of waste per year, but collection represents less than 50 per cent and almost all of the collected waste is dumped. Although municipalities spend on average 13 per cent of their total expenditure on solid waste management, the municipal collection systems are not planned and records are not kept. The main challenges for Nepal's municipalities are low levels of service coverage and poor financial sustainability. The results-based finance programme for Nepal is an output-based aid project. The subsidy helps participating municipalities to bridge the gap between the cost (including capital costs, operating and maintenance costs, overheads and other expenses) of delivering improved solid waste management services and the revenues that municipalities collect for SWM services. Payment is linked to improvements in services. Adequate staff training resulted in little need for new services or technologies. Tailored assistance was provided during the programme to aid municipalities to build staff capacity. One of the important factors of the programme was to allow the participating municipalities to set their own delivery mechanisms—as long as the services met the output standards and they are financially viable so that the delivery will be sustainable once the programme ends.

Source: World Bank (2014).

In other instances, results-based financing has been used by the World Bank in demonstration projects for improving solid waste service delivery and fee collection, promoting recycling and source separation, and strengthening waste collection and transport in under-served communities in China.[36]

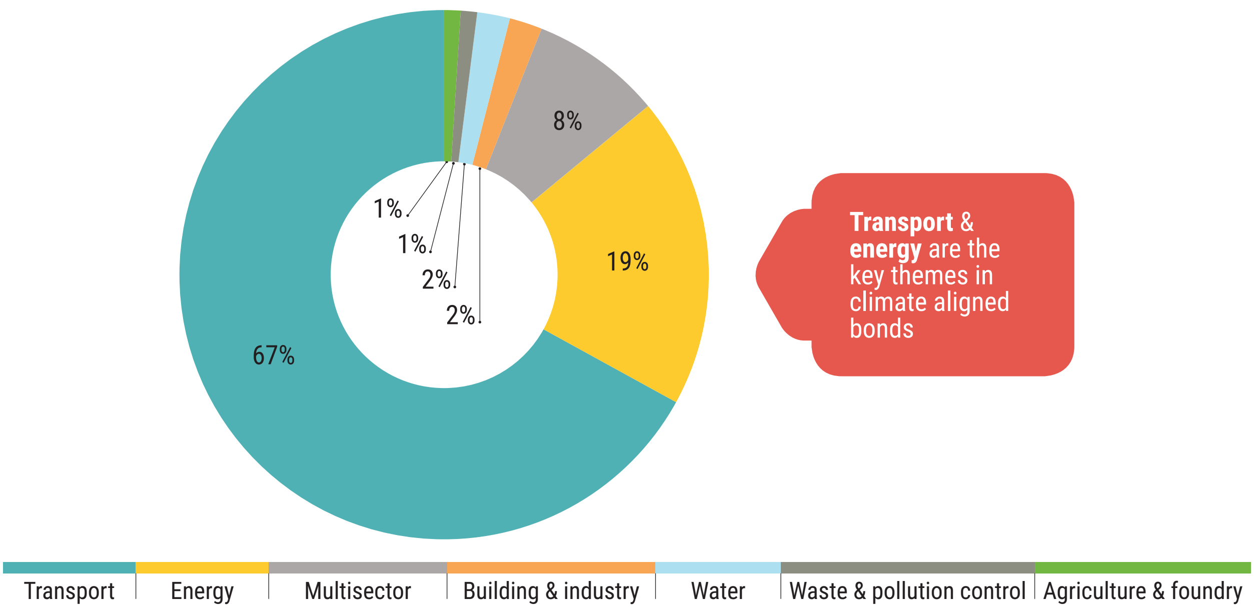
36 Ibid.

4.20 Climate-related Finance

Financing can be also utilised for waste management projects that can lead to reduction or avoidance of GHG emissions. Usage of the Clean Development Mechanism (CDM) as a tool for financing waste management projects through carbon credits was once very popular, but has now decreased owing to various reasons such as a steep fall in the pricing of carbon credits, high transaction costs and delays. For example, a waste management project in Denpasar, Indonesia,[37] and a landfill capping project in Mumbai, India, failed to secure anticipated revenues through carbon credits. Investors around the world are now increasingly attuned to the challenges of climate change and the energy transition needed to renewable sources. These investors are looking at investment tools that take environmental criteria into account.

A bond is a debt instrument with which an entity (government, multinational bank or corporation) raises money from investors. The bond-issuing entity acquires capital while investors receive fixed income in the form of interest. A green bond is very similar. The only difference is that the issuer of a green bond publicly states that capital is being raised to fund "green" projects, which typically include renewable energy, clean transportation and sustainable waste management.

Figure 4.7 shows a typical breakup of themes used in the green bond market to raise money.[38]



Source: Climate Bonds Initiative

Figure 4.7 : Global Statistics on Thematic Distribution of Green Bonds

37 UNEP (2015).
38 Lifegate (2016).

Currently, green bonds focusing on renewable energy and sustainable transport have a major market share. Bonds raised for sustainable waste management are yet to gain momentum and is, therefore, an opportunity. Green bonds for sustainable waste management will help in meeting countries' Intended Nationally Determined Contributions (INDC).

While green bonds remain a relatively small phenomenon, the market is expanding rapidly. In fact, investments in green bonds quadrupled in just two years, rising from USD 11 billion in 2013 to USD 42 billion dollars in 2015. Green bond investments are estimated to reach USD 100 billion in 2016. The Asian market for green bonds is dominated by China, South Korea, India and the Republic of Korea, shown in Figure 4.8

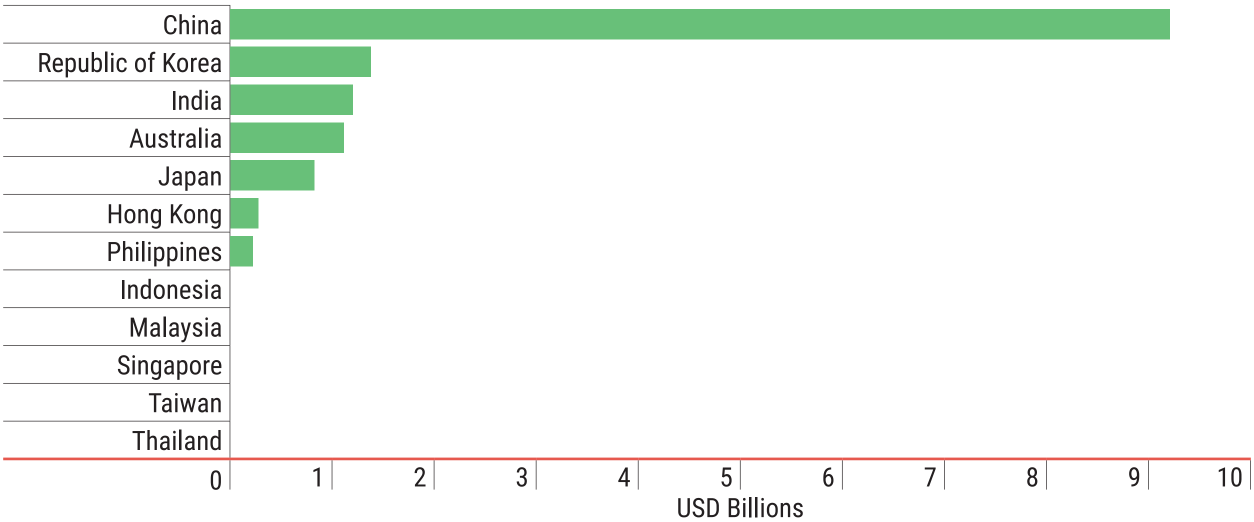


Figure 4.8 : Statistics on Green Bond Issuance in Asian Countries

Source: *http://www.lifegate.com/people/news/asia-finance-green-bonds*

China has taken a leadership role in this arena (see Box 4.18) followed by India and the Republic of Korea.

Box 4.18 **Green Bonds in China**

It is estimated that China needs an annual investment of at least RMB 2 to 4 trillion (USD 320 to 640 billion) to address environmental degradation and climate change. According to the People's Bank of China, public investment will only be able to meet 10 to 15 per cent of this total. The shortfall, which could be as much as USD 576 billion, will need to come from private sector investment.[a] Given this backdrop, development of China's green capital market has enjoyed the full and coordinated support of the government in the form of green bond guidelines issued by the People's Bank of China and the Green Finance Committee (GFC) in December 2015. The first issuers to respond to these guidelines were Shanghai Pudong Development Bank and Industrial Bank Co., which initiated green bonds raising 20 and 10 billion Yuan, respectively, in early 2016. Some analysts predict that issuance of green bonds in China could reach 300 billion yuan per year by 2020[b]. Projects that can be supported using green bonds belongs to six major categories: energy-saving, pollution, conservation and reuse of resources, clean transport, clean energy, protection of ecosystems and adaptation to climate change.

a. Global Banking and Markets (n.d.).
b. Ibid.

4.21 Private Sector Participation

Most Private Sector Participation (PSP) models are a combination or a hybrid of the public and private sector taking advantage of the stability of local government and political will and with the ability to mobilise resources, spur innovation and increase efficiency. Several options exist for private sector participation in waste management with the most common forms being contracting, leasing, franchising, concessions and competition, as discussed below.

- Contracting: Where a company has a fixed-term contract for the delivery of services after a competitive procurement process. This type of arrangement is common for services like municipal solid waste collection, street sweeping, curbside recycling, transfer station or disposal site operation, and wastewater treatment plant operation;

- Leasing: Where government-owned assets are leased to a private business to operate with profit-sharing and division of responsibility whereby the business is often responsible for maintenance and the government for upgrades;

- Franchising: Where the government awards an area a fixed-term monopoly for an area for waste collection services resulting from a competitive bidding process. Performance bonds and licensing fees payable by the franchisee are often conditions of the franchise and the franchisee recoups costs and makes a profit from direct charges to households and other establishments for collection services;

- Concessions: A long-term contractual agreement for a private firm to build and operate facilities like recycling or transfer stations; and

- Competition: Competing openly in which there are no pre-set conditions, and the government allows those who with the proper licensing qualifications to offer services.

The movement from local government control of waste to private sector participation can be a difficult decision for officials and politicians. The loss of control of the sector can have serious long-term effects to the extent that local government cannot gain information on waste flows and sector participants. One possibility is for privatisation to occur in stages with the first step being the corporatisation of activities to gain an understanding of the real costs of the specific solid waste management operation. Local government can then go out to obtain a non-binding tender for those same services and then compare the private sector offer both in terms of improved standards of operation and cost differential with their own corporatised activities. If the tender is non-binding, it allows the municipality to not award a tender and to continue operating as a corporation if it considers the public service delivery option preferable. This approach offers a gentle entry into possible private sector involvement. Privatisation does not necessarily involve a cost decrease. However, traditionally an increase in costs is compensated for by a greater increase in service quality.

Private investment in infrastructure for the water and wastewater sector shows that it is much greater in East Asia than in South Asia.[39] The challenges in gaining private sector participation are to overcome corruption and perceived corrupt practices and then getting the cooperation of the local people to work toward providing benefits for not only them but also the community at large.

39 Note: See the World Bank's "Environmental and Social Policy of Financial Intermediaries", a guidance note on tools for pollution management, prepared by Zhenfang Shi. This note is part of World Bank Group publication Getting to Green—A Sourcebook of Pollution Management Policy Tools for Growth and Competitiveness. Available from: *http://siteresources.worldbank.org/INTRANETENVIRONMENT/Resources/GuidanceNoteonMarketBasedInstruments.pdf* (accessed 13 February 2017).

Box 4.19 C&D Waste Recycling in Delhi, India

IL&FS Environmental Infrastructure & Services Ltd. set up a C&D waste processing facility, the first of its kind in India. The facility was set up on a design-build-finance-operate-maintain (DBFOM) basis for 20 years, in partnership with the Municipal Corporation of Delhi. The Municipal Corporation provided seven acres of land on a lease basis and facilitated the supply of C&D waste from various waste collection points in the city. IL&FS Environmental built the plant, procured the machinery and was also responsible for operations, monitoring and reporting. Since then, the plant has processed about 2 million tonnes of C&D waste, with an average daily processing capacity of 2,000 tonnes. The partnership model has inspired other local bodies in India to take initiative for recycling C&D waste. Delhi itself has sought to increase C&D recycling capacity to 3,400 tonne per day by concessions for an additional C&D waste processing facility in the region on a similar partnership model.

Source: IL&FS Environmental Infrastructure & Services Ltd. (n.d.).

C&D waste facility, Bangkok, Thailand.

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4.22 Micro-financing

Loans to poor and vulnerable people by banks are limited because of the lack of security and high interest rates. As a result, micro-financing has developed to provide a developmental finance opportunity for those who would not otherwise qualify. Micro-financing can provide the opportunity for entrepreneurs and small businesses to gain access to banking and related services. Within Asia, this type of financing often takes place within the context of the informal sector. For example, in Pune, India, the informal sector recovers 22 per cent of its waste, which reduces the burden on the Pune Municipal Corporation. Quezon City, Philippines, recovers 2 per cent through the formal sector and 23 per cent through the informal sector.[40]

Box 4.20 **PRISM Project in Nepal**

The Poverty Reduction of Informal Workers in Solid Waste Management Sector (PRISM) project in Nepal was conceived to improve the living conditions of informal workers in the solid waste management sector. The project was implemented by the Centre for Integrated urban Development (CIUD), Solid Waste Management and Resource Management Centre (SWMRMC), Nepal Reuse and Recyclable Goods Entrepreneur Associations (NRREGA) and UN-Habitat's Water for Asian Cities Programme Nepal. The project lasted for 36 months, from June 2011 to May 2014. The total project budget was about EUR 1,566,406 (about USD 1.638 million). Of the total project budget, 80 per cent was provided by the EU under its Investing in People Programme.

The project benefitted 4,000 informal waste workers (IWWs) of which 35 per cent were women workers within five municipalities of Kathmandu Valley. The IIWs income increased by 30 per cent through better bargaining power and enhanced knowledge to add value on recyclable wastes and, hence, to get better prices. The IWWs were provided with basic safety equipment and social protection schemes. About 2,000 IWWs are to be formally recognised for their services by their municipalities.

See "Project Overview the Poverty Reduction of Informal Workers in Solid Waste Management (PRISM), Nepal." Available from: *http://www.practicalaction.org/poverty-reduction-of-informal-workers-in-solid-waste-management-prism-nepal* (accessed 13 February 2017).

40 Scheinberg, Simpson, Gupta, and others (2010).

4.23 Contributions by Communities

Traditionally, the role of the community in waste management has been as one of being the recipient of waste disposal services. There is now a trend for the community to move towards more active participation in waste management with source separation and backyard composting on an individual scale. Community members are also getting increasingly involved in waste collection and street sweeping in their neighbourhoods; they are becoming involved in wider waste management planning. These developments have particular significance because now communities not only are service receivers but also are becoming service providers through active participation. In return, communities are looking for accountability from authorities and additional benefits, including efficiency improvements from their investments of time and effort. The increasingly active role of communities is being supported by education programmes in which volunteers and educational or research institutions provide knowledge and technical training while undertaking research to enable changes to take place.

Typically, community programmes to develop alternative waste management systems require low investment costs and are socially and politically acceptable. For example, a programme in Indonesia that operated for three years generated five activities using waste to produce valuable commodities.[41] From waste sorting and selling recovered materials to making compost, introducing seed farming from seeds collected from wastes and then selling the resulting seedlings to building public toilets with some United Nations development programme (UNDP) funding, the projects generated a community spirit this led to savings and grocery cooperatives and organised health, child and mothercare programmes for the community.[42] Other programmes have been just as successful. In Bangkok, Thailand, a slum instituted a waste-for-eggs programme whereby locals were able to exchange sorted waste for eggs with the costs met by the sale of recyclables.[43] This programme benefitted the community by providing employment for the poor in the community and removing waste from drains that caused localised flooding. Another Thai initiative resulted in environmental, health and financial benefits. The project involved fermentation of organic wastes to produce detergents that are used to clean toilets and treat wastewater, thus controlling waste and odour while providing a high rate of return on investment (8:1).[44] A novel approach was adopted in the Philippines, waste pickers working in the informal sector noticed that ashes from spontaneous combustion in the open dumps made ideal fertilizer, which they now sell to farmers. Similarly, fish bones and discarded fish parts were sold by waste pickers to fish sauce makers as inputs for their products.[45]

A project in Nepal that had adverse results provides some interesting learning. The solid waste management responsibilities of the Kathmandu municipal authority were taken over by the Solid Waste Management and Resource Management Centre, with some input from the city. The project failed on three counts. The failure was attributed to undermining the traditional participatory system of the municipality leadership, a lack of coordination between the centre and the municipality eroding the authority of the municipality and the centre's assumption that people could not pay fees for solid waste management, which did a disservice to mobilizing local resources.[46] This experience reinforces the argument that community initiatives need to be set up in such a way that they fit in with the culture of the community while working within established structures. When waste management infrastructure is developed by a local enterprise, then the sense of ownership by the local community often leads to more cost-effective solutions and long-term sustainability of the investments. For example, Ghorahi, Nepal, decided to finance a new landfill.[47] By drawing on local

41 Sinha and others (2000)
42 Ibid.
43 Ibid.
44 Ibid.
45 Ibid.
46 Sinha and others (2000).
47 UNEP (2015a).

Door-to-door waste collection by private sector, Kathmandu, Nepal.

expertise to provide a solution that met the local characteristics, instead of using landfill from abroad they sited the landfill on thick clay deposits to provide a low permeability barrier to ensure adequate environmental protection. Key project successes included the fact that it was a local initiative that drew on local expertise and knowledge, the identified objectives were met with low-technology solutions and the required funding was generated locally with some national input.

Key Messages

+ Prioritisation of waste management can occur best under conditions where the added social and environmental benefits are accounted for. It is important to highlight the wider and long-term environmental and social benefits to bring out the importance and advantages of investing in the waste management infrastructure.

+ It is important to estimate and communicate the costs of inaction on waste management to decision makers, administrators and the politicians. Studies conducted by environmental economists and social scientists belonging to independent research institutions are needed in Asia. The costs of managing solid waste compared to inaction is between 10 per cent and 35 per cent for a typical Asian city.

+ Options for waste collection systems depend considerably on local culture, the role played by the informal sector (i.e., waste pickers) and the ability and commitment of paying for collection services by the community. Fees collected for collection services often fall short of operating expenditures.

+ The choice of waste processing technology depends on the local context, such as availability of land, affordability or the per-capita income and extent of funding by the government. Countries with high per-capita incomes and limited availability of land, for instance, prefer incineration as the waste management option as opposed to landfilling. Levies, fines or taxes on the discharge of pollution are often not adequate to dissuade polluters and meet the requirements of waste-related on a consistent basis.

+ For sustainable waste management, the appropriate use of economic instruments and their enforcement is critical. Disposal charges and grants are the two most utilised options to mobilise funds within countries.

+ Economic instruments that promote resource recovery are not widely adopted in Asia with those providing for extended producer responsibility or product stewardship, the least adopted with the exception of material controls.

+ Economic instruments that promote resource recovery are not widely adopted in Asia with those providing for extended producer responsibility or product stewardship the least adopted with the exception of material controls.

+ International financial institutions (IFIs) mainly provide concessional loans, but growing economies receive significant non-concessional loans.

+ The informal sector plays a very significant part in making solid waste management sustainable. Financing should be available at the micro level to support the informal sector.

+ Community programs work well at the small scale when programmes fit with the culture of participating communities.

+ Meaningful engagement with local communities is necessary to ensure sustainable waste management operations. Community involvement helps in creating green jobs, bringing in ownership in the management of waste especially on a decentralised basis, and encouraging contributions in kind as well as in terms of financial resources, sometimes supported through corporate social responsibility (CSR) projects, especially those led by the private sector.

+ To ensure public health, investments in all the three components—that is, solid waste management, sanitation and wastewater treatment—must be made. A holistic approach to waste management is necessary especially in the growing cities of Asia.

Waste Governance

Chapter 5

5.1 Waste Management Governance

Waste management systems have evolved over time with organised practices already evident thousands of years ago. For example, before 2000 BC, Mahenjo-Daro in the Indus Valley, had solid waste management-related practices in place; Crete had sewer systems by the same time;[1] moreover, by AD 1295, air pollution controls banning soft-coal burning in London have been well documented.[2] In many countries, waste disposal is still a current environmental issue that demands public policy interventions in partnership with technology development, financing and institutional capacity building. In fact, waste management governance evolves over time to accommodate the rising quantities and complex characteristics of the waste streams, changing behavior and needs of the population and the impacts assessed on ecosystems and human health.

Initially, governments often respond to health issues by building environmentally sound disposal sites for the wastes and installing adequate treatment and control mechanisms to control associated wastewater discharges and air emissions. As the level of compliance increases and costs become prohibitive, waste is managed on a more preventative, proactive basis following a holistic approach. These strategies help reduce and divert waste from disposal to provide economic value added and reduced risks across the media.

Typically, there are seven groups of policy tools available to policymakers.[3] These seven tools are often used in combinations that are appropriate to the context, socioeconomic circumstances and the culture of the country. A more detailed description on how these tools operate can be found in UN Environment's *Guidelines for National Waste Management Strategies: Moving from Challenges to Opportunities*[4].

1 Worrell and Vesilind (2012).
2 Molak (1997)
3 NEP and UNITAR (2013, pp. 57-63).
4 Ibid.

Figure 5.1 : Seven Groups of Policy Tools

5.2 Policy and Legislation in Asia

Waste management governance responsibilities can be divided into national government (including relevant departments, agencies, entities, chief executives, the concerned ministries) and local government (including state, province, region and municipality). Although there could be other stakeholders, this AWMO focuses only on national and local government. National government has the responsibility to provide nationwide consistent policy and regulatory framework and address trans-boundary movements of waste. Local government manages local waste management-related issues. National waste management initiatives are often influenced by international agreements.

Figure 5.2 presents an overview of the adoption of Multilateral Environmental Agreements (MEAs) in Asia.

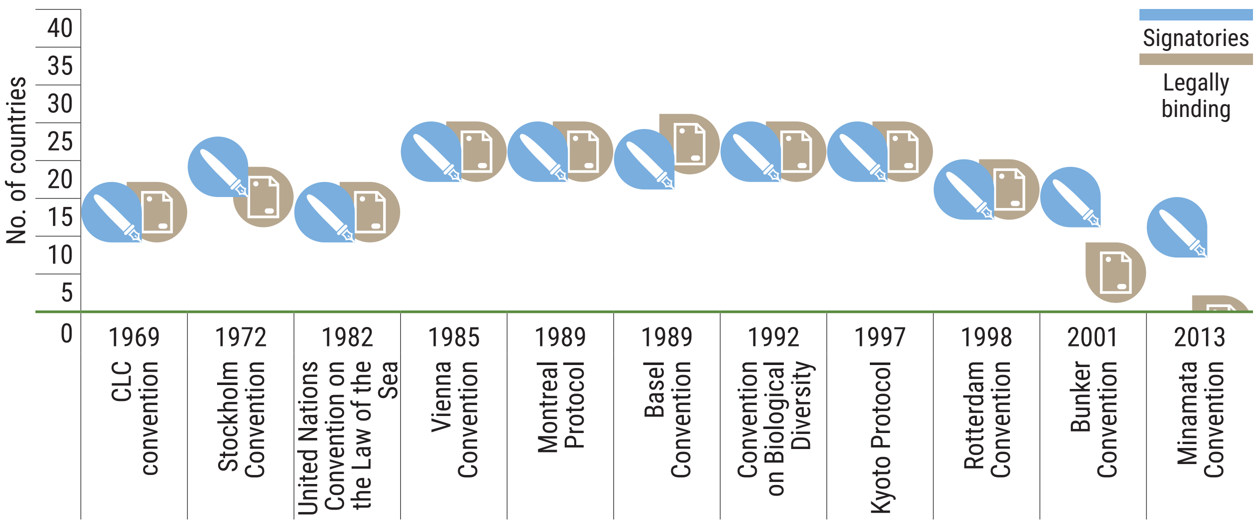

Figure 5.2 : Adoption of Waste-related Multilateral Environmental Agreements in Asian Countries

Note: For an overview of the Stockholm Convention and the status of ratifications, visit the Secretariat of the Stockholm Convention Clearing House web page. Available from: *http://chm.pops.int/Countries/StatusofRatifications/Overview/ tabid/3484/Default.aspx.aspx* (accessed 13 February 2017).
See also Parties to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Movements. Available from: *http://www.basel.int/Countries/StatusofRatifications/PartiesSignatories/ tabid/4499/Default.aspx* (accessed 13 February 2017).
For a list of parties, visit the Convention of Biological Diversity website. Available from: *https://www.cbd.int/information/parties.shtml* (accessed 13 February 2017).
For a list of member countries, including signatories and future parties, visit UN Environment's web page Minamata Convention on Mercury. Available from: *http://www. mercuryconvention.org/Countries* (accessed 13 February 2017).
UN Legal Affairs. Status of Ratification, Accession, or Approval of the agreements on the protection of the stratospheric ozone layer as provided by the Depositary. Available from: *http://ozone.unep.org/sites/ozone/modules/unep/ozone_treaties/inc/datasheet.php* (accessed 13 February 2017).
For the latest information on the dates of signature and receipt of instruments of ratification by the Secretary-General of the United Nations, as Depositary of the Kyoto Protocol, visit the UNFCCC's web page Status of Ratification of the Kyoto Protocol. Available from: *http://unfccc.int/kyoto_protocol/status_of_ratification/items/2613.php* (accessed 13 February 2017).

The conventions referring to the international movement of hazardous chemicals and waste are more-so accepted in the national governance of Asian countries. Conventions addressing critical global issues, such as biodiversity, ozone depletion and global warming, are also well recognised. Some MEAs focus on the dumping of waste in the marine waters but uptake has been low. The Minamata Convention on Mercury is a more recent addition, and currently, it has a low rate of uptake because it is the most recent and is still to gain full support.

Setting national waste policies and strategies is an important step in waste management. The most successful strategies are those that invoke a participatory approach,[5] where all sectors in waste management contribute and produce a plan that is tailored to the country's situation, culture and the priorities. The inclusion of practitioners from waste and business communities as well as non-government organisations is important as they often have quite different perspectives. These perspectives need to be reflected to come up with a common strategy. A synergy is necessary—through frequent dialogue and working in partnership. The policies should be built on an understanding of the successes already attained as well as the challenges to overcome. The policies should lay out the responsibilities of various stakeholders and set targets that may require a paradigm shift from the current business-as-usual. In coming up with the reforms or changes, it is important to ensure that there is a "reality-check" and a sustained implementation is possible. A periodic review of waste policies ensures that the policies reflect current situation and challenges and that the evaluation provides an opportunity for necessary adaptation and even a change of course.

National waste policies that are designed to change over time have the greatest chance of producing a successful result. It is, however, important that national policies resonate well with policies at the local level. Local government is best able to work towards an "urban equilibrium" or an "eco-balance." The quality of life of the citizens, their aspirations to secure sound livelihoods along with the nation's goals to achieve economic development need to coexist with the environment. To coexist, urban infrastructure must act as a balancing agent to manage the multimedia wastes and emissions produced. This will become increasingly important as urbanisation in Asia increases. The Tier 2 and Tier 3 cities of Asia that are poised for rapid growth must formulate holistic policies and ensure that the growth is managed—so that it is economically viable, socially acceptable and environmentally sound. One indicator of waste management-related governance is the number of legislative tools enacted each year.

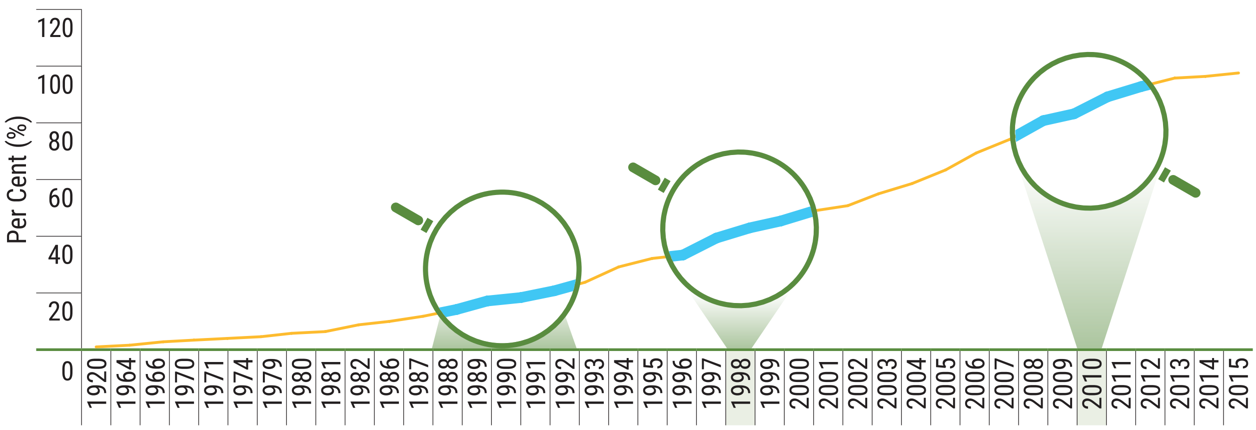

Figure 5.3 : **Legislative Tools Enacted Each Year in Asian Countries, 1920–2015**

See Appendix D

From Figure 5.3, it can be seen that peaks in the number of legislative tools occurred in 1988–1992, 1997–1999 and 2007–2011. The peaks occurred because of adverse events that may have happened few years earlier. Legislative tools do not occur immediately after an event or the "driver situation" because it typically takes about two years to pass legislation and about one year for regulations. For example, the first wave starting in 1988 was the result of the 1984 Bhopal disaster in India[6] that brought about a realisation

5 McKay (2016).
6 Broughton (2005).

of the environmental risks to humans and ecosystems on the planet. The second wave occurred during the time that waste minimisation, cleaner production and industrial ecology were being highly promoted. The third wave occurred in the early to mid-2000s because of the threats posed by climate change. There are two significant dips in the waves; the 1998 dip corresponded with the Asian financial crisis, and the 2010 dip occurred just after the 2008 global financial crisis. From these dips, it may be inferred that the governments react more strongly to financial pressures. Thus, for waste management programmes to succeed, financial flows to the waste management sector must be strengthened and sustained.

To observe the extent of formalisation, 226 legislative tools found on the ECOLEX[7] databases were examined for the 25 Asian countries being reviewed. (The list of the tools examined can be found in Annex D.) We must caution here that the ECOLEX database is not up to date. The conclusions drawn from analyzing the data, thus, have limitations; however, the broad deductions drawn may still remain valid.

The major legislative tools that Asian countries have adopted in some manner or other are shown in Figure 5.4. This figure shows that all countries have legislative tools that address solid, liquid and gaseous wastes to varying degrees. Many of the legislative tools focus on specific single-stream wastes. The tool of Environmental Impact Assessment offers the integration that is adopted by 80 per cent of the Asian countries. The assessment of adverse effects in environmental impact assessments provides a powerful mechanism to lower the burden on the environment from new developments and wasteful practices by business and the community at large.

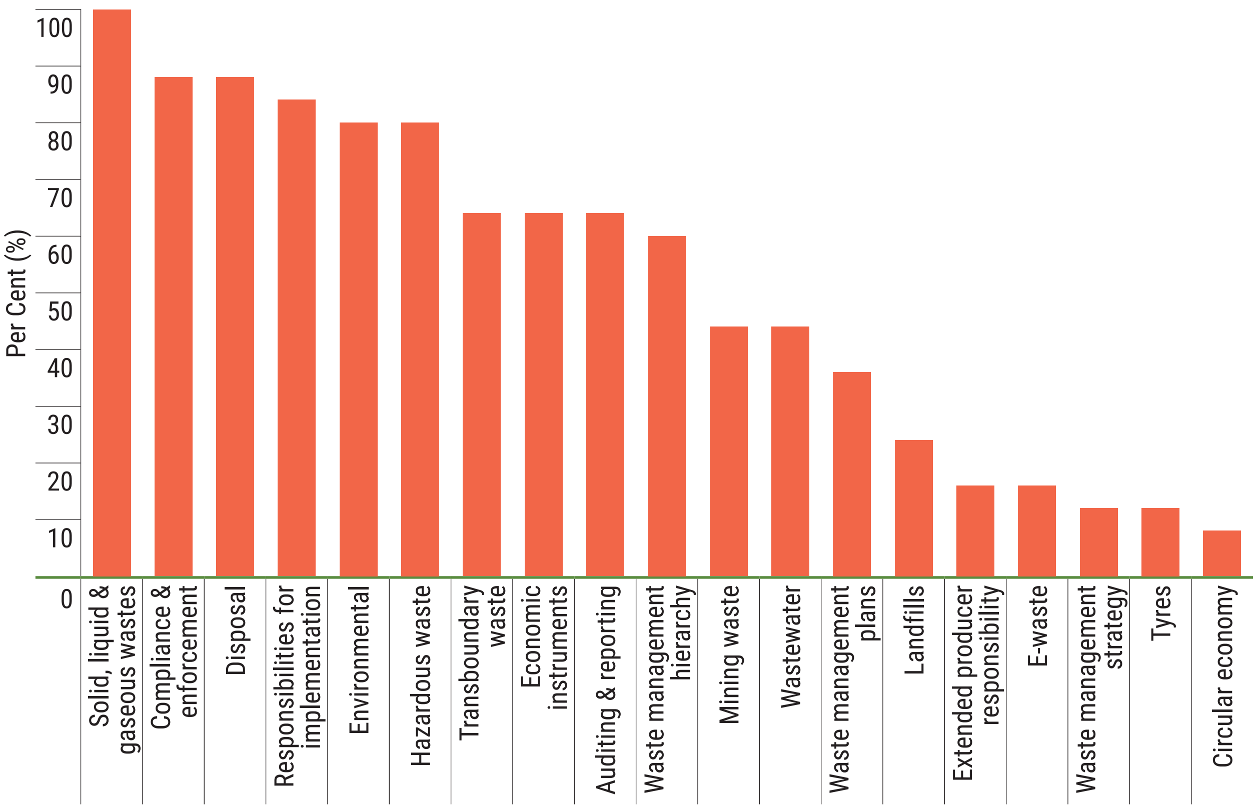

Figure 5.4 : Share of Asian Countries Adopting Various Legislative Tools

Source: *https://www.ecolex.org/result/?type=legislation&xregion=Asia*

7 UNEP (2016 for access to treaties, COP decisions, legislation, court decisions and the literature, visit ECOLEX: The Gateway to Environmental Law, a joint initiative of IUCN, UNEP and FAO. Available from: *https://www.ecolex.org/* (accessed 13 February 2017).

5.2.1 Compliance

To assist with compliance and enforcement, licensing or permitting systems are prescribed in legislative tools in 15 out of the 25 countries.[8] Where authorisation occurs, transboundary movements of waste are licensed at the national level, and local waste movements are licensed at the local government level. Enforcement is included in waste legislative tools in 17 out of the 25 countries in Asia and offences and penalties in 21 out of the 25 countries.

Box 5.1 illustrates enforcement of multimedia environmental and waste audits instituted in the State of Gujarat in India.

Box 5.1 **Enforcement of Multimedia Environmental/Waste Auditing in Gujarat, India**

Gujarat state has experienced three decades of significant industrial growth resulting in environmental pollution problems. From 1990–94, effluents from industries like chemicals, dye and dye-intermediates, power plants, pulp and paper mills, rolling mills, bulk drugs, pharmaceuticals and pesticides created pollution problems in the Khari Cut Canal and the Khari River. Farmers petitioned the high court, resulting in the Gujarat Pollution Control Board (GPCB) being responsible to implement an Environmental Audit Scheme for industries in this state. The scheme was introduced to enforce discipline among industries, provide necessary information to the GPCB and industry associations, and regularly monitor industries for environmental protection and sustainable development. Over time, the scheme has been modified so that the initial emphasis for auditors on biological sciences was expanded to include chemical, environmental and forensic sciences; industries assigning auditors changed to the GPCB assigning them; and industries controlling fees to GPCB control. The audits test for 16 water-quality parameters, 5 hazardous waste parameters, 10 ambient air parameters and 12 air emissions all under 16 national legislative instruments applied at the local level. Thus, a holistic approach to waste auditing is followed. The Board reports annually on its activities including the number of tests undertaken at the local level under each category of legislation.

Source: Joshi and others (2015).

However, as with many of the legislative tools, enforcement of environmental provisions seems to be quite lax. Despite 88 per cent of the Asian countries having compliance and enforcement tools (which include licensing/ permits and the allocation of liability as well as enforcement, offences and penalties), waste volumes and environmental degradation are still increasing. Waste management is not given a high priority by governments as well as by communities who are grappling with multiple issues that are more pressing, such as managing rapid urban growth or improved water supply. Liability provisions are found in the waste legislative tools only in 9 out of the 25 countries. Lack of liability allocation means that those culpable do not act in a responsible manner to reduce waste. Auditing is a necessary function to evaluate the effectiveness of the policy and regulatory framework. Unfortunately, in the Asian region, only 8 per cent of countries have auditing provisions in waste legislative tools.

8 Gujarat Pollution Control Board (2016).

5.2.2 Enforcement of Waste Management Hierarchy

Inclusion of waste-related strategies are generally reflected in legislative tools by citing associated procedures rather than the actual strategy itself. Currently, waste management strategies are provided for in the legislation in only 16 per cent of the Asian countries (see Figure 5.3). As shown in the figure, although the waste management hierarchy is referred to by 15 out of the 25 countries, closer examination shows that, only 3 out of the 25 countries refer to prevention, 8 to reduction, 9 to reuse, 11 to recycling, 7 to recovery, 8 to treatment and 22 to disposal. This indicates that the focus of many Asian countries is still limited to disposal. There have been examples, however, of a programmatic and cross-cutting approach being used to address all the key elements of the waste management hierarchy in a strategic manner.

Box 5.2 provides such an illustration in Sri Lanka.

Box 5.2 **A Comprehensive Approach to Policy and Legislative Tools to Promote Composting in Sri Lanka**

The policy framework for composting in Sri Lanka demonstrates how different policy instruments work together to provide a comprehensive set of tools to manage a waste issue. Composting of organic matter is a commonly used municipal waste management strategy in Sri Lanka. More than a quarter of the 42 urban councils in Sri Lanka have introduced compost management systems to tackle the high rate of degradable content in waste (76 per cent). Many enabling policies and programmes contribute to the promotion of composting initiatives in Sri Lanka, with the National Environmental Act of 1980 being the overall enabling legislation for the regulation of waste activities in the country.

The National Strategy for Solid Waste Management (2000) was the first strategy to specifically target solid waste management. The Strategy allocated responsibilities for national government, such as developing market conditions for the sale of recyclable waste and of the products made from recyclable materials, local governments and individuals. In 2007, the National Policy on Solid Waste Management replaced the 2000 Strategy. The new Strategy focused on the waste management hierarchy with prioritisation of waste avoidance over recycling and of recycling over the other forms of environmentally sound disposal.

At a local government level, the Municipal Council Ordinance (Chapter 252, No.: 16 of 194) stipulated the responsibility of municipal councils to ensure clean neighborhoods and the collection and disposal of municipal waste. This ordinance provides for any solid waste collected by the municipality to be the property of that municipality and can be sold or disposed of as seen fit by the council. Operating under the Municipal Council Ordinance, The Sri Lanka Standard 1246: 2003 (UDC 628.477.4) provides the specification for compost generated from municipal solid waste management and agricultural waste.

As part of a wider set of initiatives, the Pilisaru National Solid Waste Management Project was initiated by the Sri Lankan government to support composting initiatives. This project for a national approach for solid waste management was started in 2008 and ran until 2013. Its focus was on capacity building of local governments, thus promoting enhanced methodologies to operate in large-scale waste management processes with the establishment of decentralised compost plants at the local level. Under this programme, a three-year action plan (2008–2010) was prepared. The project scope included the establishment of a waste recycling bank system, establishment of waste collection centers, providing technical support, institutional strengthening and capacity building needs with a special emphasis on local government to promote sound waste management practices. The scope included establishment of compost plants at the local government level and the promotion of home composting.

Source: The 3RKH regional knowledge hub—a joint initiative of the Asian Development Bank, Asian Institute of Technology (AIT), UNEP Regional Resource Centre for Asia and the Pacific (UNEP RRC.AP) and United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP)—shares knowledge assets on the 3Rs, Reduce, Reuse and Recycle. For more information on composting in this country, visit Policy Analysis: Promoting Composting in Sri Lanka. Available from: *http://3rkh.net/index.php?option=com_phocadownload&view=file&id=601:policy-analysis-promoting-composting-in-sri-lanka&Itemid=238*

5.2.3 Linkage with the Economic and Non-Legislative Tools

Across Asia, 16 out of the 25 countries have legislated economic tools. The most popular tools are waste disposal charges (seven countries) and provision of grants (seven countries). In these countries, funds raised from waste disposal charges do not form the pool of money for grants, but instead go to general funds[9]. The next most popular economic tools are loans and grants for training and education found in in four and five of countries, respectively. Of the four that have loan arrangements, three also have grants, three have disposal charges and one has training and education funding. Of the five with training and education funding, three have instituted charges for disposal. Other tools used include programme funding (three of the countries), tax incentives (three), tax or environmental exemptions (two) and levy collection (one). Non-legislative tools also provide a valuable economic incentive. Waste exchange centres provide useful information on waste streams available for reuse, recycle and recovery. The Waste Exchange of the Philippines[10] links companies that mutually benefit from waste-to-waste exchanges. Over 600 waste streams are advertised with another 130 waste streams sought for exchange. Each waste stream is assigned a code to ensure company and locality confidentiality. When two companies reach agreement, the Waste Exchange withdraws and leaves the companies to negotiate directly. Co-processing, the use of waste as a raw material or a source of energy to replace fossil fuels in energy-intense industries, provides another economic tool to reduce waste for disposal.

An example is given in Box 5.3 that illustrates how waste can be avoided with an economic advantage.

Box 5.3 **Co-processing of Waste Materials in India**

Co-processing in India was introduced in 2005, after the Central Pollution Control Board formulated guidelines for co-processing of waste materials as alternate fuels and raw materials. Since then, government bodies have sought to mainstream co-processing as possible waste treatment/ disposal approach, by publishing the following white papers:

- Hazardous Waste Management Rules including the co-processing of hazardous waste in cement kilns as an acceptable disposal option
- Technical guidelines for setting up environmentally sound pre-processing facilities to prepare homogeneous waste mixes suitable for co-processing in cement kilns
- Emission standards for co-processing alternate fuels and raw materials in cement kilns including hazardous waste

Refuse derived fuel (RDF) can be utilised as alternate raw materials from sources such as the following: municipal solid waste, hazardous waste, industrial plastic waste, dried sewage sludge, biomass, slaughterhouse waste, poultry litter and used tires can be used as alternate fuels in cement kilns, whereas fly ash, blast furnace slag from the steel industry, lime sludge, red mud from the aluminum industry, foundry sludge/sand, chrome sludge, lead zinc sludge and phosphate chalk can be utilised as alternate raw materials.

Gujarat state, for example, co-processed 1.89 million metric tonnes of hazardous waste between 2009 and 2014[a]. The state aims to achieve co-processing of hazardous waste in cement kilns to at least 15 per cent total substitution rate (TSR). To achieve the target, associations of major industrial clusters and cement plants are being encouraged to provide pre-processing facilities and waste exchange banks or collection centres for hazardous waste.

Source: Gujarat Pollution Control Board (2015).

9 UNEP (2016).
10 Harris and Lang (2015).

5.2.4 Involvement of Multiple Stakeholders

Critical to improving waste management capacity is cooperation between national and local governments and recognition that the private sector is a key actor. Ideally, the role of national government (or local government) is to provide the conditions so that stakeholders at the local level can institute effective waste management practices. Allocation of responsibilities is important so that regulated activities have an oversight. Twenty-two countries stipulate responsibilities for national government and 19 out of the 25 state local government responsibilities. In addition, 17 out of the 25 countries allocate responsibilities to the private sector, particularly waste industries. Nine out of the 25 countries provide for roles for the public, generally for them to follow the waste management rules; ten out of the 25 countries recommend setting up advisory groups, either at the national or local level. These advisory groups provide advice and guidance to officials and, in some cases, officials are accountable to them for their actions. The use of advisory groups, particularly when they are expertise-based, can assist waste management considerably. Non-government organisations can also provide valuable assistance in mobilizing the public. This has been included in legislative tools in seven out of the 25 countries. Finally, the role of the media has been legislated in four out of the 25 countries, mainly to disseminate success stories to promote better waste management.

Increased private sector involvement at the city level is very important to forge with governments' efforts on enforcement of acts and rules as well as for mobilizing funds and bring in innovative technologies. For local level and decentralised solutions, governments should encourage entrepreneurship and allocate funds to promote waste-related businesses amongst the youth. Here, political, financial and technological support will be needed to establish and operate waste management businesses profitably. Governments can do this by launching incubation and microfinance schemes or bringing in developmental finance institutions to provide technical and financial support.

Box 5.4 provides some illustrations.

Box 5.4 **Examples of Promoting Entrepreneurship in CleanTech Sector**

Government of Rajasthan, India, Waste Management Start-up Policy
The state government of Rajasthan has a start-up policy in place to promote entrepreneurship in areas such as social services, clean tech, information technology, garments and crafts. Under this scheme, the government is actively promoting waste management entrepreneurs by providing mentoring, research and development, technical and financial support to entrepreneurs at the ideation, pilot and execution stages.[a]

Asian Development Bank and Ideaspace, Philippines
The Asian Development Bank (ADB) in partnership with Ideaspace, a start-up incubator and accelerator, organised a major clean tech event in the Philippines and brought together 200 participants from the clean tech sector including start-ups, investors, policymakers and researchers. The five-day event gave start-ups an opportunity to exhibit their services followed by panel debates, tech talks and ideation workshops. ADB continues to work with start-ups, provides expertise and advise to help scale up businesses while supporting industry growth. The ADB has a USD 6 billion annual climate-financing target.[b]

a. India, RPCB, Jaipur (n.d.).
b. ADB (2016).

5.2.5 Gradual and Phased Approach

Policy frameworks must reflect relevant acts and rules, strategies and action plans. In Bangladesh, a comprehensive framework has evolved over time (see Table 5.1). This pattern of progression represents a typical phased and hierarchical approach to ensure successful implementation to manage waste. It may be observed that in Bangladesh a progression took place from broad national interventions (1995 and 1998) to local level focusing on urban areas. This progression addressed the challenges expected due to the increasing rate of urbanisation. Subsequently, a major regional agreement was reached in 2004 that was responsible for propelling several projects and activities on waste management between 2005 and 2008. This was the period when environmental issues such as climate change were at the forefront of international attention. This led to the promotion of projects under the Clean Development Mechanism (CDM) in the waste sector. In 2005, the stage was set for good waste management practices from large cities to Tier 2 and Tier 3 cities. The scope of action was expanded to address hazardous wastes, particularly those causing health issues like lead-acid batteries and biomedical wastes.

Table 5.1 Development of a National Policy Framework in Bangladesh, 1995-2008

Date	Type	Name	Summary of issues relevant to waste
1995	Action Plan	National Environmental Management Action Plan	Promotes waste management hierarchy promoted
1998	Policy	National Policy for Water and Sanitation	Directs waste recycling; organic waste to be used for compost and biogas
1998	Policy	Urban Management Policy Statement	Privatises services and for slum dwellers to get sanitation and solid waste disposal
2004	Other	Dhaka Declaration on Waste Management by South Asian Association of Regional Cooperation Countries	Encourages NGOs and private companies to establish community-based composting, segregation of waste at source, separate collection and resource recovery from wastes, especially focussing on composting
2005	Rules	Draft National Solid Waste Management Handling Rule	Incorporates waste management hierarchy
2005	Strategy	Poverty Reduction Strategy Paper	Promotes environmental management systems with focus on waste segregation at source along with waste management hierarchy
2005	Strategy	National Sanitation Strategy	Achieve 100% sanitation coverage by 2010 with emphasis on recovery and recycling
2005	Action Plan	Dhaka Environmental Management Plan	Promotes recycling as an environmental management systems for industry
2005	Action Plan	Solid Waste Action Plan for Eight Secondary Towns in Bangladesh	Promotes the waste management hierarchy
2006	Policy	Draft National Urban Policy	Emphasises clean development mechanism and recycling
2006	Statute	Fertiliser Act	Promotes composting and subsequently sets standards
2006	Rules	Lead-Acid Battery Recycling and Management Rules	Incorporate waste management hierarchy
2008	Rules	Medical Waste Management Rules	Promulgate standards for measuring medical waste
2008	Other	Circular to Promote Compost	Promotes composting

Source: UNCRD, AIT/UNEP RRC.AP and IGES (2009).

5.2.6 EPR, Product Stewardship and Green Procurement

Cross-sector life cycle-based tools are emerging in Asia. Extended producer responsibility (EPR) and product stewardship consider that waste responsibility is more than an end-of-life issue. In the EPR, the manufacturer or importer takes responsibility for waste generated by their products across the life cycle. With product stewardship, all members of the supply chain have a shared responsibility, and it is up to the parties to negotiate who takes what responsibility. Both approaches are based on the polluter pays principle.[11] More details on application of this principle is provided in the UN Environment Guidelines.[12] The adoption of EPR or product stewardship is not widely occurring in Asia at the national level. This is not surprising as most Asian countries are struggling to have effective basic waste management implementation. Procurement is an important strategy that resonates well with the EPR and product stewardship. To ensure minimal extraction of resources and low environmental and social impacts, promotion of "green" products is necessary. Policies on green procurement support or complement the waste management governance and in specific the "Reduce" element of the 3Rs.

Table 5.3 highlights some Asian countries where green procurement is legislated or incentivised. Countries in the Asian region could follow up on the experience.

Table 5.2 Green Procurement Policies and Incentives in Asian Countries

Country	Green Procurement Policies	Incentives (examples)
People's Republic of China[a]	Law of Public Purchasing	Feed-in tariff, tax rebate, programmes and funds
Japan[b]	Act on Promoting Green Procurement	Awards for green procurement practices, subsidies and tax cuts to promote green economy
Malaysia[c]	Sustainable Procurement policy	Feed-in tariff and green investment tax allowance
Philippines[d]	National Action Plan on Sustainable Public Procurement	Fiscal incentives and feed-in tariffs schemes
Republic of Korea[e]	Act on the Promotion of the Purchase of Environment-Friendly Products	Fiscal incentives for renewable energy and feed-in tariff
Singapore[f]	Singapore Green Plan	One-year accelerated depreciation, allowance for energy efficient equipment and technology, tax incentives for renewable energy, green mark incentive scheme for existing buildings and for design prototypes
Thailand[g]	National Green Procurement Plan	Feed-in tariff and fiscal incentives for sale of carbon credits.

Source: APEC (2013).

a. Perera and others (2007).
b. Perera (2007).
c. Virtucio (n.d); Buniamin and others (2015).
d. Virtucio (n.d).
e. Lai (2014).
f. Virtucio (n.d.) and Lai (2014).
g. Perera (2007).

11 UNEP(2016a).
12 UNEP and UNITAR (2013).

5.3 Information-driven Instruments

Information-driven instruments (which are different from reporting requirements put on waste generators and handlers to report to governments on their activities) are important to enable decision makers to make informed decisions. Decision makers can be anyone from national policymakers and politicians to householders deciding on end-of-life options. However, the mere presence of information will affect changing behaviour. The information itself needs to be tailored to meet the target audience's daily reality and concerns. Information that seeks to grab people's attention needs to be bold and simple enough to compete with everything else going on in people's lives. Presentation of information needs to be reinforced at a local level in some way.

An analysis of 13 Asian countries showed that only two countries (Cambodia and the Philippines) did not have informational activities.[13] In the other countries, the most popular information instruments were awareness campaigns with 14 of these in 7 countries. Of particular note is that in the 1980s and 1990s, Indonesia conducted individual campaigns aimed at "greening" cities, rivers and the air, thus, covering all media. The Republic of Korea was also active, conducting three awareness campaigns on product design, eco-labelling and one targeted at non-government organisations. Bhutan adopted three codes of practice for solid waste management, sewage and hazardous waste management, all which provided guidance for those operating those sorts of businesses. Other types of information tools used by countries in the Asian region are waste management plans (Bangladesh and Thailand), courses (China and Thailand), publicity brochures (China and Singapore) and running industrial-scale pilot programmes (China).

An example of how the use of information-driven instruments is driving change is given below. This portal can be a one-stop shop for waste generation data, national policies, waste management plans, information and results of publicity campaigns.

Box 5.5 **Bangalore Score Card**

Bangalore, a metro city in India, collects about 4000 tonnes of solid waste per day. Janagraha, a Bangalore-based NGO, compiled the ward-level data to communicate the extent of waste collection coverage across the city. Wards were given scores of "1" to "10" based on the extent of waste collection and presence of garbage in open spaces, with "1" representing the worst performance.

Green blocks indicate >=7 on waste collection, whereas yellow indicate score of <=3 on garbage. (See the city quality score map on page 5 of the Ward Quality Score Databook 2013, available from: *http://janaagraha.org/files/wqs/WQS_2013_Databook_Eng_comp-.pdf* (accessed 19 April 2017).

13 Visvanthan and others (2008).

Waste bin, Bali, Indonesia.

© Nang Sian Thawn, RRC.AP

Box 5.6 presents examples of portals and platforms relevant to UN Environment's Global Partnership on Waste Management.

Box 5.6 **Examples of Portals/Platforms on Waste Management**

Global Partnership on Waste Management, UN Environment: Launched in 2010, the Global Partnership on Waste Management (GPWM) is a networking and partnership platform for international organisations, governments, businesses, academia and NGOs. The platform was developed by the UN Environment, International Environmental Technology Centre (UN Environment, IETC). Its objective is to share resources, provide information, identify information gaps and develop capacity to promote resource conservation and efficiency. The areas the GPWM focuses on are waste and climate change, agricultural waste, integrated solid waste management, e-waste management, marine litter, waste minimisation, hazardous waste management and metal recycling. The GPWM website provides resources like global waste management databases; country-wide waste management status, including national policies, strategies and institutions working in the sector; global map of ongoing activities related to various waste types and waste management guidelines developed by international organisations. The GPWM forum also holds meetings and conferences in which representatives from various countries meet to discuss and learn about waste-related activities.

International Partnership for Expanding Waste Management Service of Local Authorities (IPLA)[a]: United Nations Centre for Regional Development (UNCRD) launched IPLA in 2011 with an objective to share knowledge across national boundaries and to spread best practices to accelerate the uptake of waste-related infrastructure and services. It provides information regarding various stages of waste management, such as prevention, minimisation, segregation, collection, transport, recycling, recovery, reuse treatment and disposal. IPLA aims to move towards resource-efficient and zero-waste societies through collaborations amongst a wide range of partners, including governments, business and the financial sector and civil society. IPLA provides access to useful information like funding opportunities, capacity building and training programmes, educational material, training kits and global and regional networks.

3R Knowledge Hub (3RKH)[b]: 3RKH is an online Knowledge Hub launched in 2005 with an aim to promote global action on the 3Rs. It provides information and resources related to waste reduction, reuse and recycling. Institutions like the ADB, Asian Institute of Technology (AIT), UNEP Regional Resource Centre for Asia and the Pacific (UNEP RRC.AP) and United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) came together to develop 3RKH.

3RKH aims to create, collect and capture 3R knowledge and disseminate these as knowledge products. They liaise with academic, research and relevant scientific and technical institutions, the private sector and civil societies for collection of data such as the following: city waste profiles, case studies of flagship projects and available technologies. 3RKH also lists waste sector experts on their website.

Integrated Waste Resources (IWR)[c]: The Program on Capacity Building for Waste to Resource Management was proposed under the Australia-India Council Grants Program 2014–2015. This year-long programme is an initiative to improve the level of education in waste management amongst professionals and students in India. The agencies responsible for programme implementation are Environmental Management Centre LLP, Mumbai (EMC) and Griffith University, Australia. The programme has been approved and funded by the Australia-India Council under their grants programme, and has been funded by the Department of Foreign Affairs and Trade, Australia. The three major outputs produced by EMC and the university were the integrated waste resources web portal, training toolkit and the toolkit guidance manual. All final outputs and workshop reports are available for download. The website also hosts a dashboard on waste to resources that was developed by EMC for the *Global Waste Management Outlook*.

a. UNCRD (2012).
b. Asian Instiute of Technology (n.d.).
c. EMC, Griffith University (2015).

5.4 Monitoring and Reporting

One of the important goals of policy is to improve the quality and comprehensiveness of information to help make assessments and take appropriate decisions. Monitoring provides information on progress, and reporting provides an opportunity to inform policymakers and others responsible for decision-making processes. Within the 25 countries that were analysed in Asian region, 12 countries have legislative provisions for monitoring and 13 for reporting. Specific legislative tools are usually required for local and central governments to monitor effectiveness of policy measures and legislative tools. Within the Asian region, nine countries have requirements regarding submission of waste-related data, which indicates that the majority of governments do not have formal system of waste-related monitoring and reporting.

5.5 Effectiveness of Legislative Frameworks

Legislative tools have variable adoption in Asia countries. While different countries have different cultures that require diverse approaches to legislative tools, and the mere presence of a tool does not necessarily indicate compliance, the presence (or absence) of a tool can indicate the level of sophistication of a waste management system. All countries in the Asian region acknowledge that waste emissions can occur in the solid, liquid or gaseous states, and most realise that compliance and enforcement are needed to institute change in the populace. Most countries regard waste as an environmental issue and recognise that managing hazardous waste is particularly important, though fewer countries have legislative tools to deal with transboundary issues under the Basel Convention. In terms of legislative tools, there may be opportunities for countries to formalise the use of waste management plans and to start to consider EPR or product stewardship for more problematic wastes like e-waste and tires.

Mere adoption of legislative tools (legislation, regulation and miscellaneous items such as notices and administrative provisions) does not ensure good waste practices. Likewise, the presence of regulatory frameworks does not mean that the measures are effective in managing wastes—there also needs to be a commitment to implementing the legislative tools as well as utilizing other policy measures. Implementation of policies can be a significant barrier in many countries owing to competing priorities for government's attention. Additionally, countries may manage the waste streams in ways other than legislative tools. However, the adoption of legislative tools signals formalisation of proposed action by countries and is an indicator of government's commitment to the cause.

Table 5.3 shows the experience of effectiveness of various legislative tools.

Table 5.3 Experiences on Effectiveness of Legislative Framework

Country	Legislation	Effectiveness
Malaysia	Law of Public Purchasing	Only applicable to five states (under the ruling of federal government)
Sri Lanka[a]	Solid Waste Act (2011)	Only carried out to certain degree in some parts of country, not mandatory to segregate waste
Philippines[b]	Ecological Solid Waste Management Act, widely known as the Republic Act No. 9003 (RA 9003)	Introduced waste segregation at source, establish penalties for violation, and facilitate creation of special fund for incentives. Introduced innovative approaches in creating Cebu Environmental Sanitation Enforcement Team (CESET)
Viet Nam	Law on Environmental Protection (2005)	Not effectively implemented. Informal recycling occurs actively throughout the flow of waste from source to disposal.
Maldives[c]	National Waste Management Policy (2008)	Requires voluntary sorting by islanders to certain extent Imposed green tax on tourists to protect the environment
Indonesia[d]	Waste Management Law of 2008 (No. 18/2008)	Not effectively implemented. Informal recycling occurs actively throughout the flow of waste from source to disposal
Japan[e]	Law for Promotion of Utilisation of Recycled Resources (1991), Containers and Packaging Recycling Law (1995), Home Appliance Recycling Law Efficiently (1998) Fundamental Law for Establishing a Sound Material-Cycle Society Law for the Promotion of Effective Utilisation of Resources (2000), Construction Material Recycling Law, Food Waste Recycling Law, End-of-Life Vehicle Recycling Law	(2002) Efficiently improve waste segregation at various sources. On average, for all types of materials, recycling exceeds 22 per cent Five types of garbage including combustible (food waste); non-combustible (plastic wrappers, polystyrene); recyclables (newspaper, plastic/glass bottles, metal cans); PET bottles; and bulky items (e.g., furniture, white goods)
Singapore[f,g]	Environmental Public Health Act	Act (amended 2002) Introduced waste sorting at source in National Recycling Programme. Recycling of 59 per cent of all waste

a. Policy and Regulations- Uva Province, Sri Lanka (2009). Available from: *http://www.unep.or.jp/ietc/spc/activities/GPWM/data/T2/AB_3_P_PolicyAndRegulations_SriLanka.pdf* (accessed 13 February 2017).
b. Premakumara and others (2013).
c. For more information, visit the Maldives Conservation Portal's web page, Environmental and Social Due Diligence: Ari Atoll Solid Waste Management Project, Maldives Climate Change Trust Fund. Available from: *https://maldivesconservationportal.org/publications/environmental-and-social-due-diligence-ari-atoll-solid-waste-management-project-maldives-climate-change-trust-fund/* (accessed 5 May 2017).
d. Ibid.
e. Tsukada (n.d.).
f. For more information, see "Waste Separation in High-rise in Other Countries," Waste Management Association of Malaysia. Available from: *http://www.wmam.org/main/index.php/news- articles/287-waste-separation-in-high-rise-in-other-countries* (accessed 13 February 2017).
g. ADB (2013).

5.6 Barriers and Challenges

One of the perceived significant challenges to better establishment of a circular economy is the absence of the formalised waste diversion sector. The absence of this sector means that it is much harder to track the waste management process and to determine where the operations and gaps appear. Although it may appear that this needs to be "fixed," history reveals this situation is not actually significant. Developed countries had a situation in which the informal sector was the recycling industry, and growing urbanisation provided the volumes needed to enable a formalised sector to appear and grow.[14] The cholera epidemics of the late 1800s provided the impetus to politicians to focus on sanitary conditions which led to the development of the formalised sector.[15] Formalisation required the ability to handle greater quantities of material and, as affluence increased, increasing labour costs drove the need for technological solutions.

In Asia, the influence of the informal sector often far exceeds that of the formal sector. For example, Pune, India has no formal sector and the informal sector recovers 22 per cent of its waste. Quezon City, Philippines recovers 2 per cent by the formal sector and 23 per cent by the informal sector.[16] The informal sector encompasses four main activities:[17] waste collection, particularly in areas not serviced by municipal waste collection services where entrepreneurs charge a pickup fee to residents and sometimes sort for reuse or recycling; recovery of recyclables, for on-selling; manufacturing, using the recovered materials from waste as raw inputs; and service provision, which includes street sweeping and cleaning facilities like bus stations. Those engaging in the informal sector are often new migrants to a city;[18] children, as part of a family enterprise; women; laid-off workers; the elderly, who have insufficient funds to support themselves; and the disabled, unable to find other employment.

Rather than try to eliminate the informal sector, a much better approach is to integrate it into the waste sector. A major characteristic of the informal sector is its invisibility. Thus, raising the integration of the sector requires raising awareness of the political decision-makers of the contribution of the sector as an appropriate waste management system. The experiences of the informal waste management sector can feed into the policy processes in several ways:[19]

- Action learning and scenario modelling (for example, the data on Quezon City, Philippines, provided the starting point for the integration of the informal sector into the National Solid Waste Management Strategy)
- Integration into waste management planning during development of the plans at municipal level where a participatory approach can have the greatest impact
- Feeding pilot experiences into national policies and legislation. For example, Indian studies demonstrated that 95 per cent of e-waste recycling was conducted by the informal sector and that by dividing labour between the informal sector (for collection and dismantling) and the formal sector (for recycling) produced better quality with higher efficiency. This led to an e-waste agency involving formal and informal recyclers; moreover, government bodies and policies for the sound management of e-waste, by both sectors, were introduced into the national environmental policy and the national guidelines for e-waste management.

14 Melosi (1981).
15 GIZ (2011).
16 Scheinberg and others (2011).
17 Gunsilius and others (n.d.).
18 Ibid.
19 Ibid.

A significant barrier is created by the lack of enforcement of waste management legislation. This is a common occurrence in Asia as well as throughout the world. Significant movements in waste management are generally the result of other activities in the country, region or world. Another barrier is that in many countries multiple government departments are assigned overlapping responsibilities in waste management activities. For example, waste management responsibility in India is spread among five government departments. Coordination of activities can be very difficult with so much overlap. A mechanism to overcome that sort of barrier is to have an interdepartmental committee or taskforce that oversees and coordinates work.

At the local government level for small to mid-size municipalities, one option is to adopt a regional approach to the provision of disposal or reprocessing facilities by using a cluster. However, the main barrier is often political given that mayors and CEOs of municipalities do not wish to cede responsibility or power to a neighbouring entity. This seems to have been successfully overcome in Thailand, where, for example, in the north-eastern region, cities such as Buriram accept waste from nearly 20 neighbouring municipalities.

Zero Baht Shop, Bangkok Thailand.

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5

5.7 Strategies to Overcome the Barriers

The development of waste management can eventually lead to the integration of waste management across media and, thus, take a holistic approach. Striving for holistic waste management has encompassed various approaches over the years, from cleaner production and industrial ecology[20] in the 1990s to cradle-to- cradle[21] in the 2000s— and now, the circular economy.[22] Each of the concepts is based on the notion that waste is a whole-of-life consideration and can cross media boundaries. Although there are obvious examples within Asia of the adoption of circular economy, such as in Japan's Basic Act for the Establishment of a Material Cycle Society[23] and China's Circular Economy Promotion Law,[24] many other Asian countries have done the groundwork to enable them to move towards a circular economy as well. This involves consideration and introduction of legislation that enables a move towards a circular economy.

The groundwork includes integrating solid, liquid and gaseous wastes. As can be seen from Figure 5.2, all countries have legislation covering all three media and, in addition, 76 per cent countries have provisions for environmental impact assessments. As shown in the figure, the additional aspect of 60 per cent of countries legislating for some form of the waste management hierarchy shows that the idea of moving towards a circular economy is starting to take hold. While most legislation in developing countries directly addresses recycling and the lower end of the waste management hierarchy, it does show a shift in thinking towards getting beyond disposal alone and recognizing the potential economic and social benefits from reduced environmental impact achieved by diverting waste from dumpsites and landfills to revenue-generating activities.

The ascent up the waste management hierarchy can be assisted by using demonstration projects. For example, the development of the informal sector can provide an excellent opportunity for cities to quantify the economic, social and environmental benefits while embracing the elements of the waste management hierarchy. Application to Pune City in India[25] demonstrated that out of a daily generation of 1,491 tonnes of waste, 600 tonnes were diverted to providing jobs to the informal sector and environmental benefits (USD 3 million per year for GHG emissions), while the formal sector showed a net cost of USD 2.2 million per year for GHG emissions. Quantification of the total economic benefits to the city would be a useful statistic, and moving separation upstream to benefit the health and safety of waste pickers could provide more materials that could be reused, thus further driving the circular economy.

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20 For in-depth information on resource-efficient and cleaner production, visit UNEP DTIE's Sustainable Consumption and Production Branch web portal on this theme. Available from: *http://www.unep.fr/scp/cp/* (accessed 13 February2017).
21 McDonough and Braungart. (2002).
22 Ellen MacArthur Foundation (2015).
23 See the Government of Japan's statute (effective 2 June 2000), The Basic Act for Establishing a Sound Material-Cycle Society (Act No.110 of 2000). Available from: *https://www.env.go.jp/en/laws/recycle/12.pdf* (accessed 13 February 2017).
24 Foreign Direct Investment (2008).
25 Gunsilius, and others (2011).

5.8 Referral Framework for Assessment of Policies and Implementation Capacities to Deliver Sustainable Waste Management

Waste management-related priorities differ between countries in the region. These priorities will depend on the gravity of the situation, institutional capacities, availability of finance and political will. Solutions need to be country-specific and customised but keeping in view a common vision. To assist countries to draw from the proposed strategic action plan and come up with a customised national plan of action, a Referral Policy Framework (RPF) may be proposed.

The RPF presents the "ideal state" the countries would like to strive for on policies (laws and regulations) and implementation capacities. The road maps (actions and timing) to reach the RPF will be different, depending on the situation, priorities and political will in the country. Gap assessment of a country following the RPF will provide a rationale for national programme on waste management, partnerships and collaborations. The RPF will help in setting targets, prioritizing gaps, undertaking policy reforms, building institutional capacities, setting partnerships and stimulating investment flows. A scorecard system can also be developed on the basis of the RPF to help in comparative assessments and in self-assessments to understand the progress made. Currently, such a RPF does not exist in the waste management arena.

The development and application of RPF will help in

- Identifying gaps in waste-to-resource-related policies and regulations
- Facilitating and undertaking policy reforms on a prioritised basis at the national/subnational and local levels
- Achieving harmonisation keeping in view transboundary waste/material flows, an important aspect according to the Basel Convention
- Building institutional capacities (training, knowledge hubs, technology transfer/adaptation) towards implementation, monitoring and enforcement
- Setting up of reporting systems/score cards for data collection, progress made and impact assessment.

Figures 5.5 and 5.6 show frameworks that could be used to assess policy equivalence and implementation capacities in the waste management sector.

Figure 5.5 : Referral Framework for Policy Assessment

Source: Environment Management Centre LLP (n.d.)

PAYT = pay as you throw
EMS = environmental management system

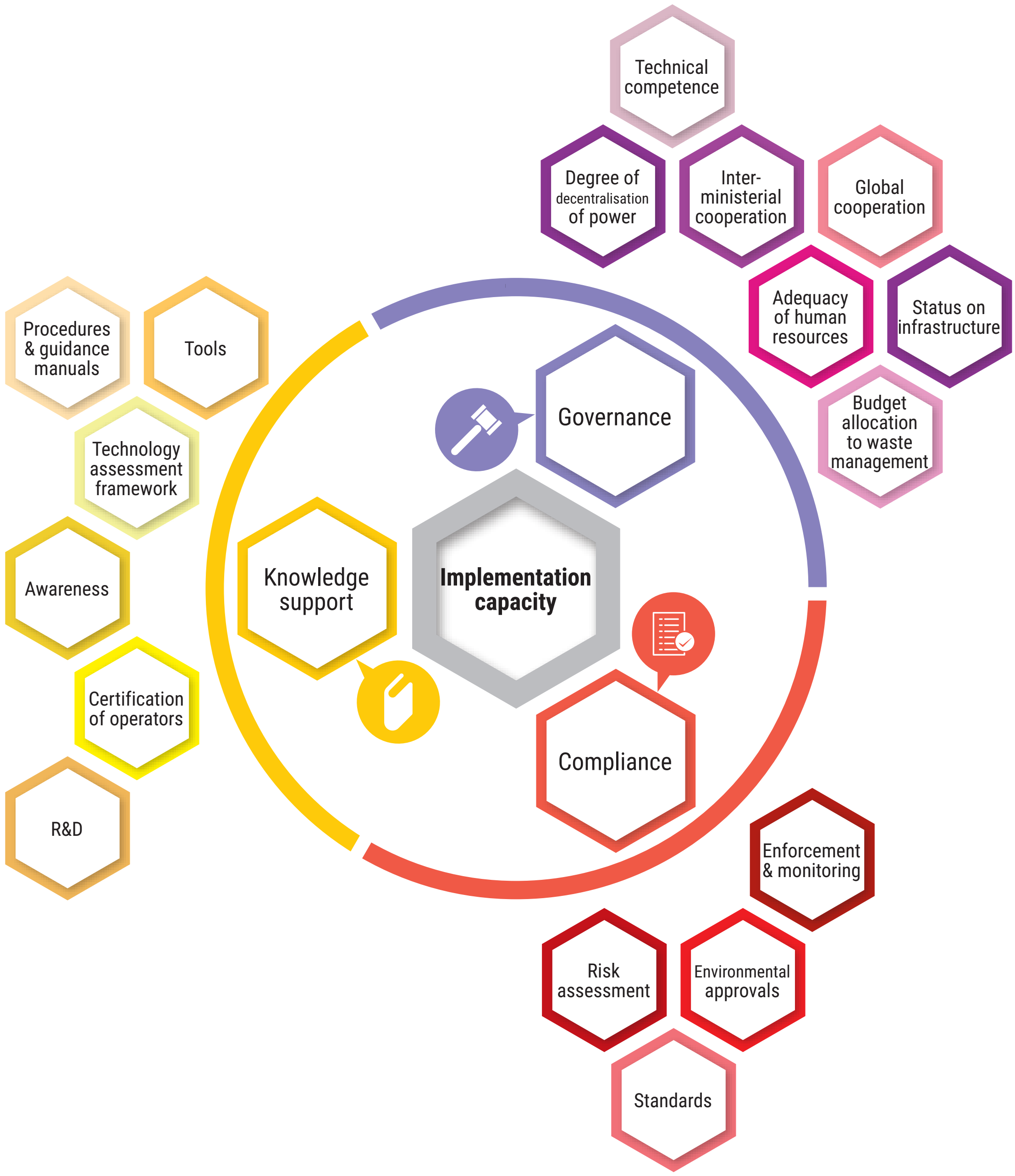


Figure 5.6 : Referral Assessment of Implementation Capacities

Source: Environment Management Centre (n.d.)

R&D = research and development

Key Messages

+ Most Asian countries have clearly defined responsibilities for waste management and recognise the importance of national and local governments working together.

+ Adoption of policies and regulatory frameworks need to be coupled with implementation and enforcement. The step from legislation sanctioning enforcement of the actual application in the community is still a major obstacle for many Asian countries.

+ About half the countries have monitoring or reporting requirements, or both, but very few have auditing, inspection or oversight provisions.

+ The focus in many Asian countries is still on achieving adequate disposal, but a third of Asian countries legislatively encourage job creation through the application of measures that are higher up the waste management hierarchy.

+ Extended producer responsibility or product stewardship provisions are only found in 3 of the 25 Asian countries surveyed. The adoption of a circular economy in legislation is only mentioned in the more developed countries in Asia.

+ Environmental impact assessments provide a powerful tool to assess the effects on the environment of proposed developments and discharges.

+ Economic tools are starting to play a stronger role in Asian countries with the most widely applied ones being waste disposal charges and grants from mainly national or sometimes local governments. Economic instruments focusing on the polluter pays philosophy are more evident in developed Asian countries.

+ Waste management plans should ideally address multiple media, such as solid, liquid and gaseous emissions, following a holistic strategy. Integration of legislation to provide a holistic waste management approach is occurring gradually but many of the basic elements to enable the links are already present.

+ Transboundary waste movement and managing hazardous wastes is covered by about two-thirds of the Asian countries.

+ Reform in waste legislation is often a response to national or international events or to disasters and not always on a proactive basis. National waste-related policies should be reviewed for their effectiveness and should be adapted responding to the feedback received as well as capturing regional or global trends.

+ Most countries have informational activities to educate the population or provide information for policy-makers.

Waste and Resource Management Indicators

6.1 Waste Management Indicators

To monitor and improve on waste management, it is necessary to collect information over time that will indicate the effectiveness of policies and programmes. It is, thus, crucial to identify key environmental and related performance indicators and relevant data/information that characterise those indicators. The related terms "environmental data," "statistics" and indicators need differentiation.[1] Data come from large numbers of raw observations and measurements. These data are processed and structured, using agreed upon statistical methods to produce results that help in assessment or drawing the inference. Indicators are then used to present the results in a form suitable to communicate information by aggregating the data that is processed. Information, when supported through practical experience, takes the form of knowledge.[2]

The choice of indicators and underlying data is crucial to assess the effectiveness of waste management. Table 6.1 shows the criteria for environmental indicators proposed by the Organisation for Economic Co-operation and Development (OECD).

Table 6.1 OECD Criteria for Environmental Indicators

Description	Relevant indicator
Policy relevance and utility for users	• Provide a representative picture of the environmental conditions, pressure on the environment of societal responses • Simple, easy to interpret and demonstrate trends over time • Responsive to changes in the environment and related human activities • Provide a basis for international comparisons • National scope or applicable to regional environmental issues of national significance • Compatible with reference values, allowing assessment of the significance of related values
Analytical soundness	• Theoretically well-founded technically and in scientific terminology • Based on international standards and international consensus regarding validity • Linkable to economic models, forecasting and information systems
Measurability	• Readily available at a reasonable cost/benefit ratio • Adequately documented and of known quality • Regularly updated with reliable procedures

Source: OECD (2003).

Comparison between countries, and even within countries, can be difficult owing to the lack of standard definitions and classifications. Hence, aggregation of data from local to national, not to mention international figures can be a fraught process. Snapshot data collection is often used to produce indicators, and the indicators themselves can be subjected to changed definitions to provide more favourable reporting. For example, the estimation of waste quantities is often based on converting vehicle volumes to weights, and anything outside an official system is not recorded.

The need for waste management indicators is ongoing. Indicators are only as good as the data that go into them. Owing to the significant variety of materials that constitute waste, sufficient data can be difficult to gather to inform meaningful indicators. While some waste data can be easily obtained (e.g., the quantity

1 United Nations Statistics Division -UNSD (2016).
2 Ibid.

and quality of water emitted from a municipal wastewater treatment plant), it is typically only the more developed countries that have widespread systems to collect the waste and analyse it.[3] Most of the data that is readily available are at the macro scale. For example, Yale University's Environmental Performance Index biennial review includes waste data under the environmental health and ecosystem vitality categories.[4] The environmental health category covers air quality (exposure to $PM_{2.5}$ and NO_2 and exceedance of $PM_{2.5}$ levels) and water and sanitation (exposure to unsafe sanitation and population lacking access to sanitation). Under ecosystem vitality, the indicator is wastewater treatment through connections to a wastewater treatment facility. There is no inclusion of solid waste management indicators.

Comparison of indicators between countries is a significant issue. The most consistent reporting scheme is that under the Basel Convention covering the transboundary movement of hazardous waste[5]. The motivation for tracking these types of wastes is three-fold: two independent jurisdictions are involved, the material being moved is known to cause harm and the international reporting means that all countries are aware of the transactions. The United Nations guidance on environmental indicators[6]considers wastes as being under the residuals component—with emissions to air, generation and management of wastewater, generation and management of waste and release of chemical substances as the four subcomponents. The data collection comes from statistical surveys, administrative records and monitoring systems.

The data categories are shown in Table 6.2.

Table 6.2 **Indicators for Emissions to the Environment**

Emissions to air	Wastewater	Solid waste	Chemical release
Greenhouse gases Ozone-depleting substances Particulate matter Heavy metals	Volume generated Pollutant content (e.g., BOD, COD, N, P, TSS) Volume collected Volume treated Urban wastewater treatment capacity Industrial wastewater treatment capacity Volume discharged after treatment Volume discharged without treatment	Quantity by source Quantity by category (e.g., chemical, municipal, food combustion) Hazardous waste generated Municipal waste collected Municipal waste treated and disposed Number of treatment and disposal facilities Hazardous waste collected Hazardous waste treated and disposed Number of hazardous waste treatment and disposal facilities Other industrial waste Quantity of recycled waste Imports and exports of hazardous waste	Quantity of fertilisers used Quantity of pesticides used Quantities of pellets, hormones, colourants and antibiotics used

Source: United Nations, Statistics Division (2016).

The challenges of creating effective indicators are three-fold:[7] data availability and accuracy, lack of standard methodologies and definitions, and data related to existing policies and incentives. The role of the informal sector in Asia means that it is difficult to obtain good data on their activities because they have no or little reporting requirements owing to the lack of formal organisation.

Standard methodologies, despite attempts to provide guidance for them, have been elusive in adoption through Asian countries. As each country requires different data to meet its policy-driven requirements, data between countries are difficult to compare. Additionally, definitions and terms vary between countries. For example, a diversion from landfills can be measured in terms of cyclical reuse rate, recycling rate, resource recovery rate and waste diversion rate, as is the case in different countries.

3 EMC Country Master Database (n.d.).
4 Yale University (2016).
5 For the text of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, visit the Secretariat of the Basel Convention's website; available from: *http://www.basel.int/TheConvention/Overview/TextoftheConvention/tabid/1275/Default.aspx* (accessed 16 January 2017).
6 UNSD (2016).
7 Kojima (2012).

Regarding indicators, what is probably most important is that the long-term effects of interventions (or otherwise) are monitored and reported and that transboundary effects are mutually reported in a consistent manner to provide national relevance and international comparison for wastes that have regional or global effects.

Recent work focusing on developing indicators benchmarking performance in Asian countries has been mainly the subject of academic research, as summarised in Table 6.3.

Table 6.3 Overview of Recent Initiatives to Develop Waste Management Indicators in Asia

Description	Reference	Origin	Applicability	Extent of Use
Monitoring progress of 3R efforts towards green economy. Discussion paper and fact sheets on performance indicators in 3Rs and resource efficiency	Hotta et al. (2014)	Asia Resource Circulation Policy Research Group	Low-, middle- and high-income countries	None
Assessment of performance of SWM collection	Huang et al. (2011)	University research	China	307 local governments
Assessment of performance of recycling, treatment and disposal as component of sustainable SWM systems	Menikpura et al. (2013)	University research	Thailand	1 municipality
Service-level benchmarks for water supply, sanitation and solid waste management in urban local bodies	Ministry of Urban Development of India (2010)	Government of India	India	Widespread
Benchmarking performance of national hazardous waste management system	Romualdo (2014)	University research	Low-, middle- and high-income countries	Proposed indicator set tested in 7 countries including 1 from Asia
'Wasteaware' ISWM benchmark indicators to compare performance of SWM in cities	Wilson et al. (2015) (also Scheinberg, Wilson, Rodic (2010); Wilson, Rodic et al. (2012); Soos and others (2013a)	International community of practice. Parts of 6-year programme funded by UN-Habitat and GIZ	Low-, middle- and high-income countries	Tested in 39 cities in 6 continents. An adaptation has been used to benchmark performance across nine countries (SweepNet 2014)

Source: UNEP (2015).

The focus in the results in Table 6.3 is on individual cities or countries. This makes them of limited use when trying to extrapolate nationally or internationally. One of the examples of a set of indicators applied across nations and continents is the "Wasteaware" integrated solid waste management benchmark indicators that built on work for UNHabitat and GIZ.[8]. The framework is set up in such a way that the outputs are easy to grasp; thus, it can raise awareness for the city's waste management decision makers. Comparisons can be made between cities of similar economic backgrounds, enabling like-for-like correlations. The indicator set combines quantitative indicators for waste generation, composition and physical components with corresponding qualitative indicators measuring service provisions and governance aspects.

8 Wilson and others (2015).

6.1.1 Indicators for Urban Local Bodies

Urban local bodies are the primary deliverers of waste management services, either by doing it themselves, contracting the services out to providers or enabling the private sector to operate on its own. Indicator sets for local governments allow their decision makers to better understand their issues and the effect of decisions the long term. It should be noted that unless dramatic changes are made that disrupt the system (e.g., a fully regulated local government collection system that was unorganised in the past), the effects of changes may only appear years after they have been introduced and embedded into the community. This is the nature of a complex system like waste management,[9] where the results of a change in on a system take time to be observed. Profile indicators for sustainable cities have been incorporated into ISO 37120:2014 - Sustainable Development of Communities – Indicators for City Services and Quality of Life.[10]

The indicators relevant for urban waste are shown in Table 6.4.

Table 6.4 **Waste Indicators at the Urban Level**

	Core Indicator	Supporting Indicator
Solid Waste	Percentage of city population with regular solid waste collection Percentage of city's solid waste recycled	Percentage of city's solid waste disposed of in incinerator Percentage of city's solid waste burned openly Percentage of city's solid waste disposed of in open dump Percentage of city's solid waste disposed of in sanitary landfill Percentage of city's solid waste disposed of by other means
Wastewater	Percentage of city population served by wastewater collection Percentage of the city's wastewater that has received no treatment	Percentage of city's wastewater receiving primary treatment Percentage of city's wastewater receiving secondary treatment Percentage of city's wastewater receiving tertiary treatment Tax collected as percentage of tax billed Own-source revenue as percentage of total revenues Capital spending as percentage of total expenditures
Finance	Debt-service ratio (debt service expenditure as a per cent of a municipality's own-source revenue)	Tax collected as percentage of tax billed Own-source revenue as a percentage of total revenues Capital spending as a percentage of total expenditures
Environment	PM_{10} concentration	Greenhouse gas emissions measured in tonnes per capita
Social Equity		

Source: Global City Indicators Facility (n.d.).

The indicators in Table 6.4 do not represent an exhaustive list of potential indicators as many others could be added (e.g., leachate escape from disposal sites or the percentage of local drains free from litter), but these would be in addition to the internationally agreed ones in the ISO standard. As shown in Table 6.4, waste indicators go beyond material production. The social and financial indicators are important drivers for waste service provision. Socially, poverty is a significant aspect hindering the provision of waste services, and one way out of poverty is to encourage micro and small businesses to engage in waste services at all levels of the waste management hierarchy. The lack of finance is a significant barrier to waste service development. A high debt- service ratio restricts the finance available to provide infrastructure like waste services.[11]

Two examples of indicator sets designed to provide service level benchmarks for local government are found in India. A national service level benchmark for monitoring water supply, sanitation, waste services and storm water drainage has been rolled out across the country by the Ministry of Urban Development. This was a part of a programme aimed at expediting critical urban reforms. By including participation in

9 Seadon (2010).
10 International Standards Organisation (2014).
11 Hicks (1989).

the programme as a criterion to gain performance grants from the Central Finance Commission, 1,400 local governments participated in 2010–2011.[12]

An important indicator is a value for money spent. An Indian locally developed tool, the Performance Assessment System, links the planning and fund allocation process to performance. The inclusion of indicators for access and coverage, equity, service levels, quality, efficiency and the financial sustainability of the participating local governments provides significant information on how initiatives develop over time. The 400 participating local governments in two Indian states provide a wealth of information that can be used to benchmark performance and assist planning, target setting and tariff determination.

An example of an output from the city of Navi Mumbai is shown in Figure 6.1.

6.1.2 Indicators at National Levels

One of the significant factors for developing countries is to set indicators that are relevant to their priorities for waste management and minimisation. The availability of statistics forms a vital part of the usefulness of an indicator.

An example of basic statistics collected by the Asian countries in this Outlook is shown in Table 6.5.[13]

Table 6.5 Statistics Availability Related to Waste Minimisation and Management

	MSW waste generation	MSW disposal to landfill	Hazardous waste generation	MSW Recycled
Bangladesh	Yes		Yes	
China	Yes	Yes	Yes	
India	Yes		Yes	
Indonesia	Yes			
Japan	Yes	Yes	Yes	Yes
Malaysia			Yes	
Maldives	Yes			
Philippines	Yes		Yes	
Republic of Korea	Yes	Yes	Yes	Yes
Singapore	Yes	Yes	Yes	Yes
Sri Lanka	Yes			
Thailand	Yes		Yes	Yes

Source: Kojima (2012).

Table 6.5 suggests that the developed countries generally have better statistics, and of the 25 countries studied, the information on total waste generated is only readily available for 44 per cent of these. Of particular note, any statistics from activities higher up the waste management hierarchy have only penetrated to four of the Asian countries, with Thailand being the only developing country. As countries become more developed, their ability to devote resources to data collection and indicator generation expands. When considering the 11 proposed indicators by the Asian Resource Circulation Policy Research Group,[14] it can be seen that the development of indicators on a national and regional basis still has a long way to go.

12 UNEP (2015).
13 EMC Country Master Database (n.d.).
14 Kojima (2012).

The development of indicators in the Asian region focuses on diversion from landfills, particularly focusing on recycling rates. One of the more comprehensive sets of indicators is from Japan.

The categories are shown in Table 6.6.

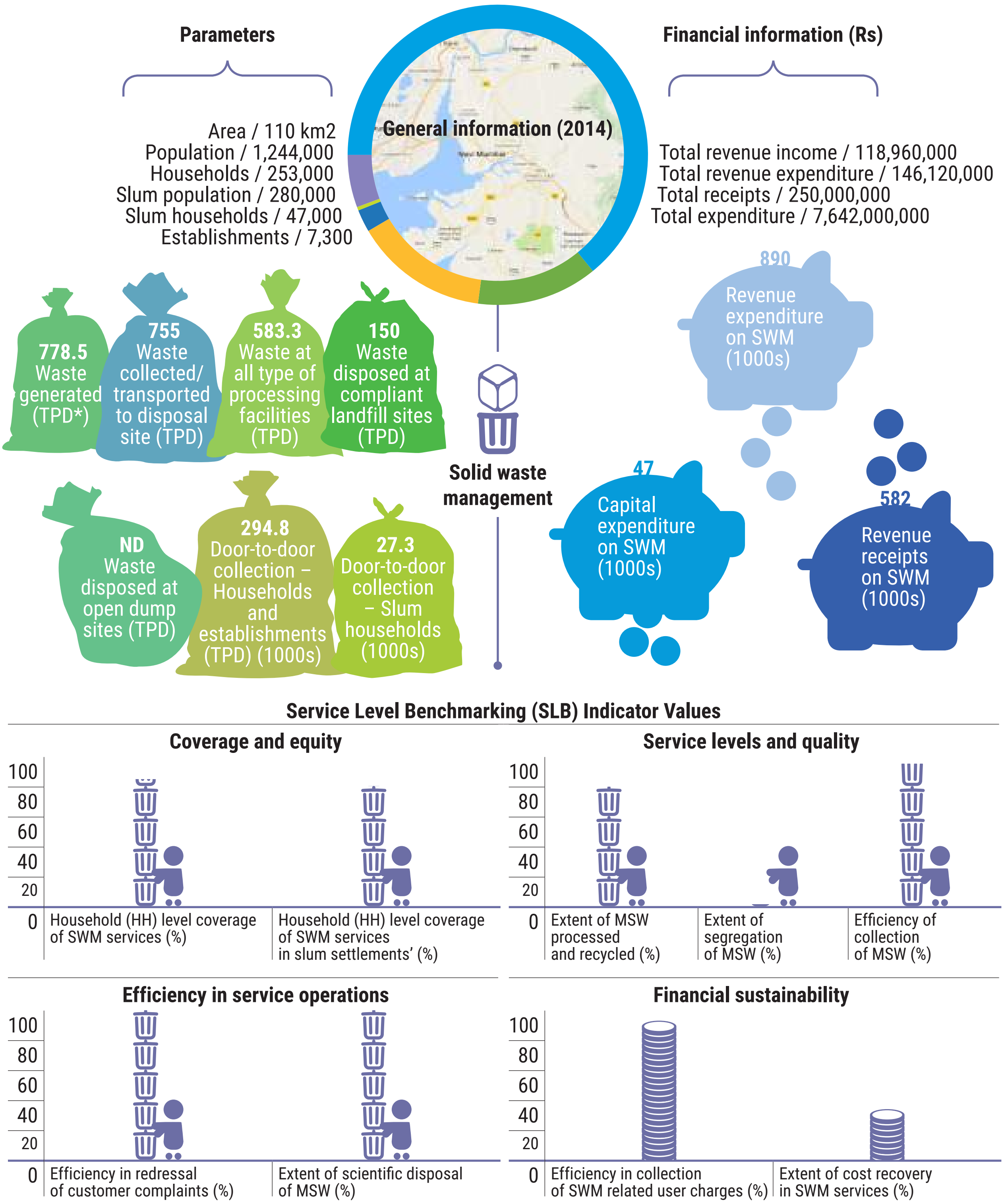


Figure 6.1 : Solid Waste Management Indicators for the City of Navi Mumbai, Maharashtra 2013–2014

Source: Kojima (2012).

Table 6.6 **Waste-related Indicators in Japan**

Description	Indicators
Economywide material flow accounting	Resource productivity Cyclical use rate Total material requirement of metal resources Final disposal amount
Municipal solid waste (MSW)	Total generation of MSW treatment Flow of MSW (national) MSW Generation per capita Status of MSW management in each local government area Type, number and size of waste management facilities (incinerators and recycling facilities) Status of establishment and capacity of waste management facilities in each local government area Remaining capacity and year of final treatment sites of MSW Status of final treatment sites in each local government area Change in operational costs of MSW management
Industrial waste	Flow of treatment of industrial waste (national) Total generation of industrial waste Generation of industrial waste in different industrial sectors Generation of different types of industrial wastes Change in amount of recycling, reduction and final treatment of industrial wastes Number of different types of industrial waste management facilities. Treatment capacity, remaining capacity and remaining years of industrial waste management facilities Number and amount of illegal dumping cases Types of illegal dumpers
Recyclables	Production and shipment of packaging Recycling rate and collection rate of packaging Ratio of packaging waste in household waste Number of used home appliances accepted at designated collection points Number of recycled used home appliances Rate of recycling of home appliances Total weight of materials and components of different targeted used home appliances Amount of recovery and destruction of chlorofluorocarbons Amount of generation of different types of construction wastes Status of recycling for each type of construction waste Generation of food waste and status of treatment Number of end-of-life vehicle take-backs Collection and recycling of small batteries and personal computers

Source: Government of Japan, Ministry of Environment (2015).

The comprehensiveness of the indicators in Table 6.5 and Table 6.6 can serve as a model for a highly industrialised society able to devote significant resources to data collection. In the move from dumpsite thinking to circular economy thinking, the emergence of 3R thinking is an early indicator. A study by Hotta et al. (2016)[15] compared seven Asian countries (China, Japan, Malaysia, the Philippines, Republic of Korea, Viet Nam and Thailand) for the adoption of 3R indicators in their environmental plans. A summary of this inclusion of 3R indicators is shown in Figure 6.2. It shows that while there is a significant activity to reduce and eliminate dumpsites, there are also signals to move further up the waste management hierarchy, with a high proportion of countries working on reducing and reusing waste materials.

15 Hotta and others (2016).

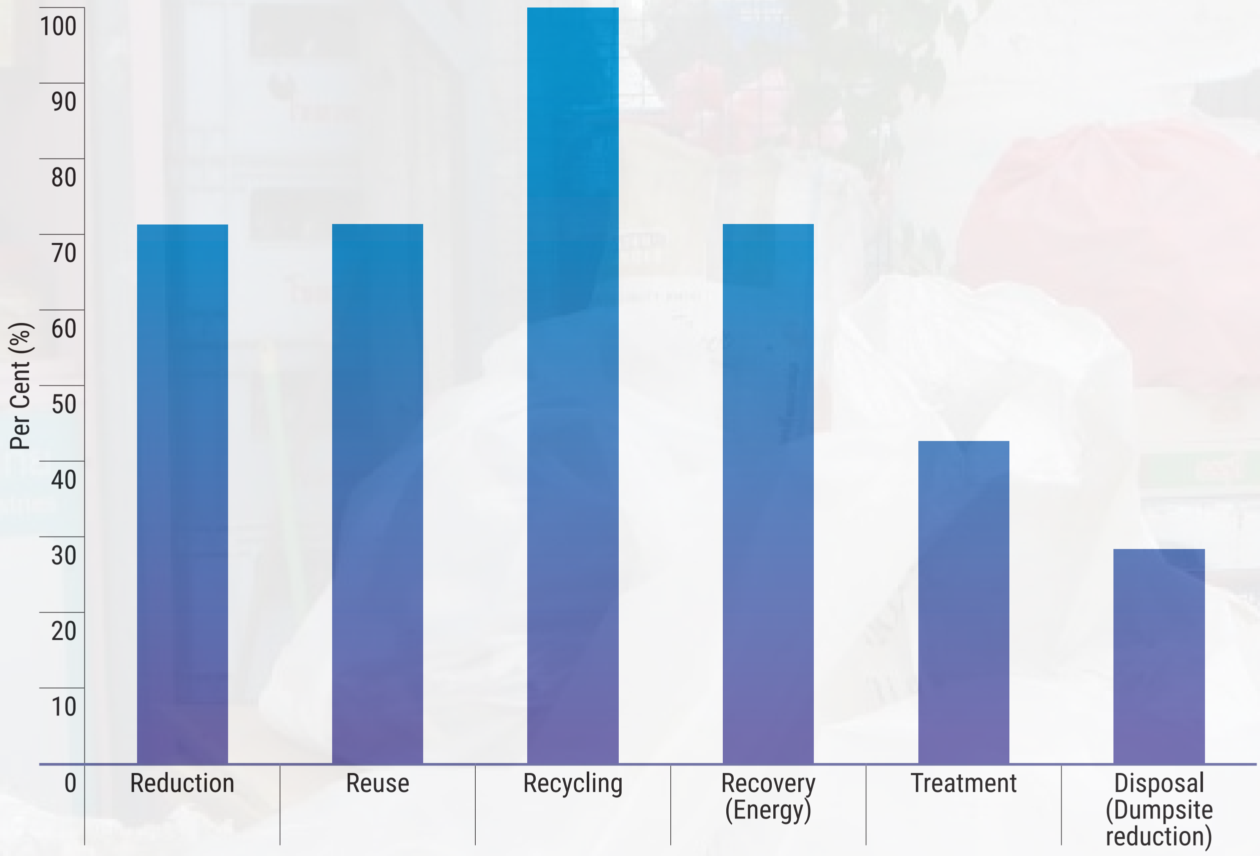


Figure 6.2 : Share of Selected Asian Countries with Waste Management Hierarchy Indicators in Environment Plans

Source: Hotta and others (2016).

Recycling waste swap-shop, Bangkok, Thailand.

6.2 Resource Management Indicators

Resource management indicators are analogous to waste management indicators and provide an opportunity to measure the efficiency of the whole industrial and agricultural sector. This sort of measurement is a useful step on the path to a circular economy. Material flow analysis has been a developing area to provide a spotlight on the usage of material flows. Calculation of materials flows in the Asian region undertaken by UN Environment and CSIRO24 shows China (60%) and India (14%) having dominated in domestic material consumption by 2008. Earlier decades show higher domestic material consumption for Japan (over 20% in the early 1970s). The report considered high-density industrial countries (Japan and the Republic of Korea) as well as the high-density developing countries (China, India, Indonesia, Malaysia, the Pakistan, Thailand and Viet Nam) in Asia and plotted three relationships: domestic material consumption(t)/capita; domestic material consumption(kg)/GDP; and physical trade balance(t)/capita. The results are summarised in Table 6.7.

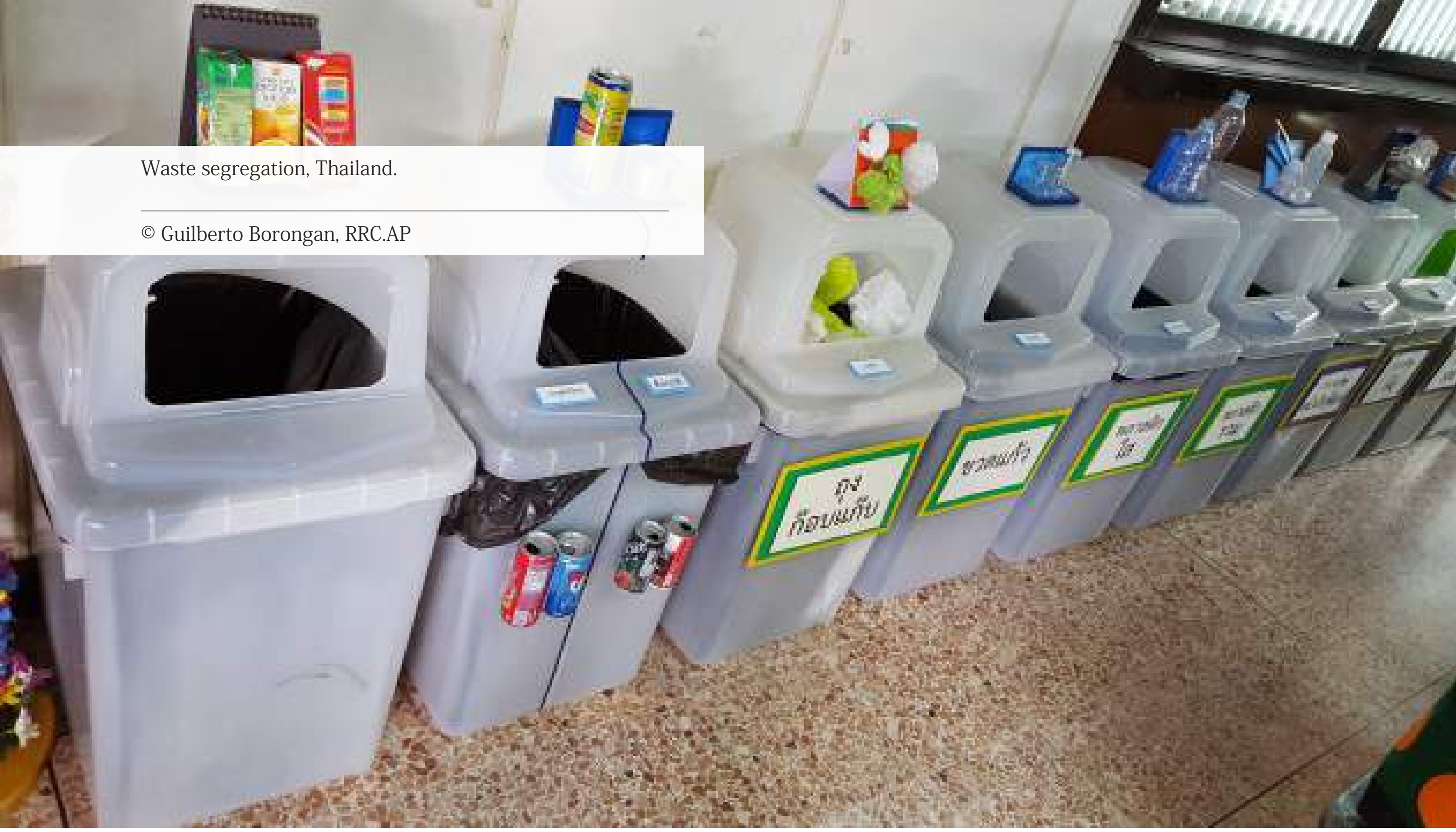
Table 6.7 **Material Flows and Resource Productivity in High-Density Industrial and Developing Asian Countries**

Country	Domestic material consumption(t)/capita	Domestic material consumption(kg)/GDP	Physical trade balance(t)/capita
China	Steady increase then accelerated growth after 1990	Significant decrease since 1975	Increasing reliance on imports for MO and FF and exports of CM
India	Steady increase since 1970	Significant decrease since 1970	Increasing reliance on imports for FF and increasing exports of MO
Indonesia	Steady increase since 1970 then flattening off in the mid-2000s	Significant decrease since 1970	Increasing reliance on imports for FF but less reliant on importing CM
Japan	Decrease since the 1970s	Steady decrease since 1970	Increasing reliance on imports for FF
Malaysia	Significant increase since the 1970s	Steady increase until 1997 then a significant decrease	Importers of MO and diminishing exporter of FF. Reduced B exports
Pakistan	Slight increase since 1970	Significant decrease since 1970	Increasing reliance on imports for FF and recent increasing exports of CM
Republic of Korea	Strong increase until 1997 then dropped and plateaued	Steady until 1992 then significant decrease	Increasing reliance on imports for FF and MO. CM sector increasing significantly
Thailand	Significant increase till 1997 then dropped sharply and is increasing	Steady drop until 1996 then significant decrease	Increasing reliance on imports of FF and exports of CM
Viet Nam	Steady until 1994 then significant increase	Significant increase after 1997	Increasing reliance on imports of MO and exports of FF

CM	FF	MO	B
Construction minerals	Fossil fuels	Metal ores and industrial minerals	Biomass

Source: UNEP and CSIRO (2013).

Table 6.7 shows that, with the exception of Japan, domestic material consumption per capita has increased. However, the material intensity (column 3) shows that all countries other than Viet Nam have increased their efficiency, demonstrating more efficient resource use at the national scale. The physical trade balance shows the vulnerability of countries to external influence on economic growth. For example, all countries except Viet Nam are vulnerable to fossil fuels as their requirements per capita increase over time.



Waste segregation, Thailand.

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6.3 Integrating Waste Management and Resource Management Indicators

A combination of waste indicators with resource management indicators provides an overall efficiency for a country. For example, a comparison of the trend for municipal solid waste generation with material intensity could provide such a measure.

6.4 Composite or Integrated Indicators at the National Level

As the move to a circular economy increases, the sophistication level of indicators to measure progress also needs to increase. Most countries focus on the lower parts of the waste management hierarchy—that is, disposal, treatment, and recycling. However, the biggest potential gains in resource efficiency are to be found in reduction and reuse, both of energy and materials. At the national level, integration of indicators can provide very useful information to policymakers.

An example of an integrated set of indicators is the circular economy evaluation indicator system is shown in Table 6.8.

Table 6.8 **Indicator System to Assess Circular Economy**

Category	Indicators
Resource output rate	Output of the main mineral resource Output of energy
Resource consumption rate	Energy consumption per unit of GDP Energy consumption per industrial value added Energy consumption per unit product in key industrial sectors Water withdrawal per unit of GDP Water withdrawal per unit industrial value added Water consumption per unit product in key industrial sectors Coefficient of irrigation water utilisation
Integrated resource utilisation rate	Recycling rate of industrial solid waste Industrial water reuse ratio Recycling rate of reclaimed municipal wastewater Safe treatment rate of domestic solid wastes Recycling rate of iron scrap Recycling rate of non-ferrous metal Recycling rate of waste paper Recycling rate of plastic Recycling rate of rubber
Waste (wastewater) discharge or final disposal	Total amount of industrial solid waste disposal Total amount of industrial wastewater discharge Total amount of SO_2 emissions Total amount of COD discharge

Source: Kojima (2012).

Although the solid and liquid phases of waste are well catered for in this set of indicators, air emissions are restricted to those resulting from solid or liquid waste discharges. Additions of indicators like greenhouse gases and particulate matter would provide a fuller picture for of a circular economy.

An example of a country moving towards a circular economy is Japan. Japan signalled in 2003 under its Fundamental Plan for Establishing a Sound Material Cycle Society that it was moving towards a circular economy.[16] The indicators for Japan's circular economy were material flow analysis-based indicators; they included resource productivity (gross domestic product (GDP)/natural resource input), cyclical use rate (cyclical use amount/(cyclical use amount plus natural resource input) and final treatment of waste. Targets were set in 2003 to be achieved by 2010 but were achieved by 2008; thus, new targets were set in the Second Fundamental Plan in 2008 (for achievement in 2015). Once again, the targets were achieved early and the Third Fundamental Plan was set 2013 for 2020.[17] It is evident from the above Japanese Plans that setting targets that are a stretch, but achievable, results in early achievement. Of particular note, the Third Fundamental Plan contains waste-based targets such as a reduction in municipal solid waste (total waste, household waste and business waste), tracking systems (coverage of industrial waste generation), citizens' awareness and behaviour regarding 3Rs and promotion activities for recycling businesses.

Box 6.1 **Circular Economy in China**

China's National Development and Reform Commission produced its first national circular economy indicators along with detailed instructions on how to calculate such indicators by factoring in local conditions. A concurrent release of industrial park indicators demonstrated that the focus in China on the circular economy is the industrial sector. The national circular economy indicators consisted of 12 indicators categorised into four groups: four indicators for resource output, four for resource consumption, two for resource integrated utilisation, and two for waste disposal and pollution emissions.

In 2013, China released its strategy and short-term action plan for the development of a circular economy. The 80 indicators in the plan covered energy conservation, water, land, resources and the recycled use of resources in industrial sectors. The targets to increase the total utilisation rate of industrial waste from 69 per cent (in 2010) to 72 per cent (in 2015) and increase the recovery rate of recyclable resources from 65 to 70 per cent over the same period, are referred to in the 12th five-year plan of China covering 2011 –2015. This shows the importance that China is now placing on moving towards a circular economy.

Source: Hotta and others (2016).

16 Government of Japan, Ministry of the Environment (2003).
17 Government of Japan, Ministry of the Environment (2003).

Key Messages

for Policymakers

+ Environmental indicators need to be relevant for policymakers, understandable by users, analytically sound and easily measurable.

+ Comparability of indicators between countries is difficult owing to differing definitions of data and the structure of indicators. There is a need to establish a common and agreed-upon set of indicators with uniform definitions of data.

+ Less than half the Asian countries have basic data on municipal waste generated, and one-sixth have data from higher up the waste management hierarchy.

+ Resource management indicators show that Asian countries have significantly increased their efficiency over the past half century, but they are particularly vulnerable to international fossil fuel policies.

+ Integrating waste management and resource management indicators can provide an overall efficiency for a country.

+ Indicators for circular economy activities will require an even greater level of sophistication and data requirements covering all three media.

The Way Forward

Chapter 7

7.1 Introduction

This chapter summarises key recommendations on action required towards making solid waste management more sustainable. They target high-level government officials, elected representatives, policy makers, business leaders and chairs of business associations, investors, researchers and technology developers and the financing institutions.

The recommendations have been drawn based on the situation analyses presented in Chapters 2 and 3. They consider the enabling frameworks elucidated in Chapters 4 and 5 that consist of policies, regulations and financing mechanisms.

The key concepts introduced in Chapter 1—namely, life cycle thinking, integrated solid waste management, 3Rs and circular economy—are threaded in the recommendations to reinforce the need for a paradigm shift from traditional waste management to resource conservation. The recommendations cover both strategic as well as operational perspectives to ensure that both "upstream" and "downstream" interventions are factored across the waste and resource management cycles.

Figure 7.1 shows a visual representation of the above key recommendations. It is hoped that these recommendations help national governments in the Asian region as a guide to achieve the goal of sustainable waste management.

7.2 Build More Reliable and Comprehensive Waste-related Statistics

Quantification of the problem is a first step towards finding solutions. In the preparation of this Outlook, country data was provided in a template format by the national governments, and the same has been annexed.

It may be observed that comprehensive, reliable data on various waste streams in the Asian region are currently missing. For better interpretation, a compilation of associated socioeconomic, health and environmental indicators is also necessary. The paucity of quality data affects system design, technology selection, estimation of investment needs and assessment of policy performance. Information on the generation of urban and non-urban wastes is dated and not very reliable. Data on new waste streams such as construction and demolition (C&D) waste, e-waste and plastic waste is scant.

Generally, some information on municipal solid waste (MSW) is available, although it is often estimated by making several assumptions. Importantly, information on material flows (especially on recycling, livelihood creation and employment) in the informal sector that dominates the Asian waste management regime has been difficult to obtain.

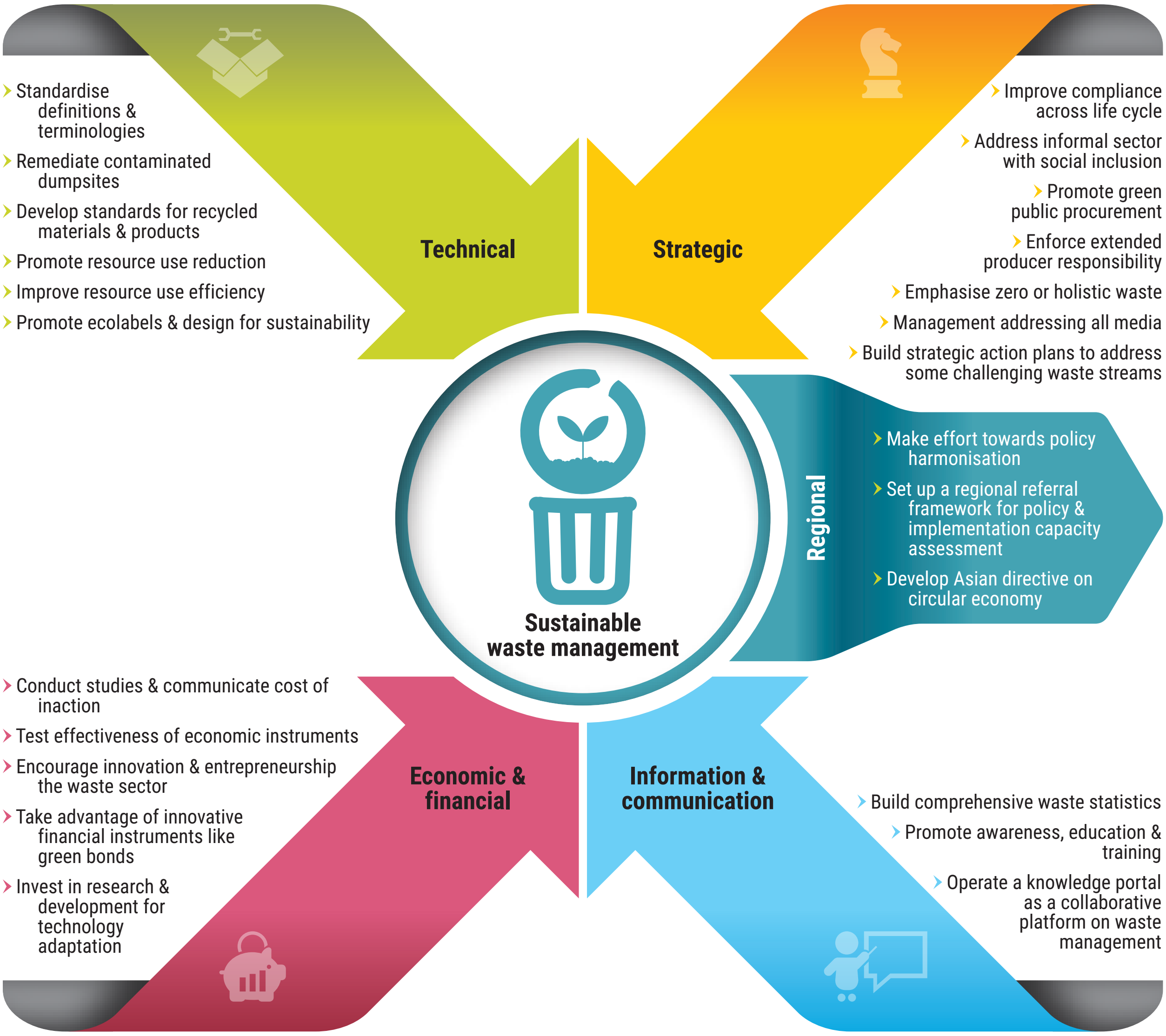


Figure 7.1 Key Recommendations

7.3 Standardise the Definitions of Waste Streams and Terminologies

To improve on waste-related statistics across the Asian region, it is important that standard and universally acceptable definitions of waste streams and related terminologies are followed. Currently, there are no such uniform or agreed definitions. This makes a comparative assessment across the counties difficult and in some cases even misleading.

Development of a uniform protocol of common definitions can, however, be challenging because many waste-related definitions are embedded in national laws and regulations. A regional consultation on how to address this challenge needs to be held on priority.

7.4 Improve Compliance on Waste-related Regulations across Product Life Cycles

Most national governments in the Asian region have policies and regulations in place. However, implementation of these policies and regulations has been rather slow and not very effective. The first step, therefore, should be to achieve compliance with the existing policies and regulations through strict enforcement and monitoring. This may be realised by focusing first on populated and non-compliant urban local bodies (ULBs).

Increasing the coverage of collection, establishing decentralised waste processing systems, proper closure of existing dumps and construction of secured sanitary landfills should be the priority tasks. All these activities should be taken up in an integrated perspective covering the entire waste-to-resource management cycle.

For implementation purposes, the private sector should be involved by offering attractive business models and by involving communities. End-of-pipe approaches alone will not be sustainable. A strategic approach that involves upstream thinking (reduction in consumption, design and promotion of eco-products, encouraging take-backs, etc.) will play a crucial complementary role. Building a robust, sustainable waste management infrastructure following the waste management hierarchy is, thus, a necessity. Compliance will then be achieved proactively on a cost-effective, sustained basis.

7.5 Conduct Studies and Communicate Costs of Inaction

It is important that administrators at the national and local level understand the "cost of inaction." Specifically, political leadership should to be sensitised to these impacts and concerns. There is hardly any data and analyses available in the Asian region on the health, environmental and social impacts of indiscriminate waste disposal in monetary terms.

It is, therefore, necessary to undertake pilot studies on the cost of inaction, damage assessment and remediation to convince decision makers to move forward on waste management. Pilot studies and projects will also provide insights on methodology, data collection protocols, analytical tools and translation of impact/risks in economic terms.

7.6 Remediate Contaminated Dumpsites and the Surrounding Environment

In most developing countries in Asia, landfills are not secured and wastes are dumped without adequate treatment. This situation leads to risks to human health, especially those living around dumpsites and to the surrounding ecosystem. These dumpsites are often not attended to owing to lack of finance, technology and political will. There is a need to develop innovative business models for landfill mining and restoration and build field experience on remediating such sites. Based on studies on the cost of inaction, the economics of remediation of dumpsites may be calculated with cost-sharing models.

Pilot projects on this basis need to be initiated where technology options could also be tested. Pilots should lead to dumpsite remediation manuals, technology options and institutional models, especially public-private partnerships. On this basis, national governments may be assisted to set up dumpsite remediation funds.

7.7 Test the Effectiveness of Economic Instruments for Effective and Sustainable Waste Management

Use of economic instruments to improve compliance as well as promote conversion of waste to resources that complement laws and regulations has hardly been attempted in Asia. Direct translation of the experience from developed countries in this arena is not going to work. There is a need to develop and adapt application of various economic instruments to promote waste-to-resource management on a pilot basis and to share experiences across the Asian region.

7.8 Promote Resource Use Reduction and Improve Resource Use Efficiency

Given the expected rise in Asia's economy, it is critical that resources available are better managed. This can be done by reducing consumption of resources to the extent possible and improve resource use efficiency. These efforts will lead to reduced waste generation at source. To achieve these objectives, the strategies discussed below may be considered.

7.7.1 Control Consumerism and Related Consumption Patterns

Consumption projections show a steep, continued increase for most Asian countries. Urbanisation is leading to more consumptive lifestyles. This has direct impact on resource availability and per capita waste generation. Countries in Asia need to promote sustainable lifestyles.

Mobile phones are an example of a product that is expected to see a very steep growth in Asia. They have a large ecological footprint (because of the use of precious metals) and relatively short life (3–4 years) owing to product obsolesce. It is critical that consumption of such products is reduced by increasing consumer awareness and developing more environmentally friendly product designs.

7.7.2 Promote Collaborative Consumption and Shared Economy

Low utilisation is seen of "assets" like cars, medical equipment and materials nearing end- of-life. These assets can be shared among stakeholders, especially with those who cannot afford assets on their own or do not have access.

Online as well as off-line platforms can be developed by public and private entities to promote the sharing of such assets. Examples of such initiatives could be recycling of food waste (generated in weddings and catering services), practicing carpooling, directing industrial co-processing of wastes and offering waste exchange services. These initiatives lead to reduced consumption of resources and waste generation.

7.7.3 Design for Sustainability

Design of products and services that have a sustainability focus is important to minimise consumption of natural resources and waste generation across the product's life cycle. Promotion of sustainable product design helps to move towards circular economy. Manufacturers of electronics and electrical equipment, furniture and automobiles for example, should design their products to minimise resource inputs and increase product longevity. Products should be designed to enable refurbishment and re-use, ensuring ease of disassembly and cost-effective recycling of product components. Such efforts need to be incentivised and awarded recognition.

E-commerce in Asia is on the rise as is the generation of packaging waste. Packaging has a very short life and creates large amounts of paper and plastic waste. Often, packaging is "overdone" in the interest of product protection during storage and transportation or to improve aesthetics and marketing. There is a need to balance functionality and the aesthetics in packaging design. Packaging should, therefore, play an important part of sustainable product design.

7.7.4 Promote Eco-labels and Practice of Environment Product Declarations

Many Asian countries have national programmes for green product certification, but their promotion and impact has remained rather weak, such as the eco-mark scheme in India.

Efforts are required to inform and educate consumers about the advantages of green products. National eco-labels should be promoted and products and companies that carry eco-labels may be incentivised. Further, businesses need to be more transparent about their product footprints and, thus, should publish environmental information about their products for the public. Elimination or substitution of hazardous and non-biodegradable chemicals in products help to achieve cleaner, safer material cycles and make reuse and recycling possible.

7.7.5 Encourage and Enforce Extended Producer's Responsibility

Manufacturers and retailers are required to extend their responsibility beyond the product's use/consumption stage. Extended producer responsibility (EPR) should be viewed as a harbinger to promoting green products. Taking feedback to the manufacturers and designers on how to design products that are easy to refurbish, re-use, disassemble and recycle would lead to process and product innovations.

While EPR is now echoed in some waste-related legislations in Asia, enforcement of EPR may be considered as a mandatory requirement focusing on key consumer products.

7.7.6 Develop Code of Practice and Quality standards for Recycled Materials

Recycled materials and products made from waste are often perceived to be of inferior quality compared to products made from virgin materials. There could also be concerns if such products carry contaminants from the waste such as hazardous substances.

To build a market of recycled products, efforts need to be made at two levels: first, to ensure that recycled products are functionally acceptable and meet essential quality criteria and, second, products that are recycled are not contaminated, which would shift the environmental burden and risks to the consumer.

7.7.7 Promote Green Public Procurement

Public bodies can lead by setting examples of green or sustainable public procurement policies. In Asian countries like Japan, Republic of Korea and Thailand, green procurement-related laws are in place to promote the purchase of green products and services that have reduced environmental impact. Initiatives like the International Green Purchasing Network and projects supported in the SWITCH-Asia Programme(highlighted in Chapter 3) should be leveraged. Technical assistance may be provided to national governments and ULBs to develop green procurement-related criteria and bid evaluation procedures. It is also important that potential local green product suppliers are consulted, their capacities are built and concessions are given to innovate, invest and promote green products. Office supplies (e.g., paper, electronics and printer cartridges) and building materials could be priority areas where green public procurement could be introduced on priority.

7.9 Informal Sector and Social Inclusion

The informal sector is an important stakeholder in waste collection and processing in Asia. Integration of the informal sector with the formal sector has led to a reduction in the cost of waste collection and an increase in recycling and recovery from waste. Several success stories have emerged where ULBs have taken efforts to form associations and cooperatives with the necessary infrastructure, such as waste sorting centres. Efforts are however required to ensure social inclusion, health and safety, dignity of labour of the informal sector and ensure sustained livelihoods.

7.10 Promote Investments in the Waste Management Sector

Governments across the world have budgets allocated for waste management but in the Asian region, budgets have been rather frugal.

Investments in sustainable waste management must increase. If not, national and the local governments will face significant costs of inaction, and public health and ecosystems will face significant risks. As elaborated in Chapter 4, the costs of remediation and rehabilitation are often found to be several times more than investments on waste management infrastructure. Gathering such evidence and data are necessary to sensitise city administrators and political leadership.

The strategies discussed below may be considered to boost investments in the waste management sector.

7.10.1 Encourage Entrepreneurship and Innovative Business Models

Traditionally, waste management is not looked at as a business but more as an essential service generally provided at no or low cost. Profitability through clever business models is seldom considered. Although there is a need to increase and effectively implement waste management-related budgets, it is important to encourage entrepreneurship and private investment flows as government resources are often limited. The current need is to turn waste management into lucrative, innovative businesses to attract entrepreneurs and both public and private investments.

Limited landfill areas, rising complexity and variability of waste streams and tightening of emission/ effluent standards have increased the challenges in the waste management business. However, at the same time, owing to the pressure on the availability of virgin resources waste-to-resource management is emerging as an attractive business incentive. Further, technological developments over the past three decades are reducing the costs of waste reuse and recycling. Projects on waste-to-energy and the production of compost from organic MSW are now gaining more momentum, given the challenges of energy use and security and the limited availability of fossil fuels in Asia. Waste-to-resource management can thus become an important "channel" for promoting entrepreneurship and investment flows in the waste management sector. Governments should create an enabling framework in this direction.

There is a dearth of cases that present the economic, environmental and social benefits of sound waste management. Such studies need to consider the life cycle perspective and follow a total resource and cost accounting approach, identify barriers and recommend policy reforms to make a business case. Examples of projects such as waste-to-compost, waste-to-energy, plastics-to-fuel, metal recycling, C&D waste recycling, battery recycling and waste oil recycling.

Entrepreneurs in Asia face many challenges including lack of access to risk capital and support systems. As discussed in Chapter 5, Asian governments and influential business powerhouses should launch waste management entrepreneurship schemes in their respective countries. Asian governments can partner with innovation and incubation centres to encourage young entrepreneurs and students to pursue waste management as a career. The support can come from public and private entities like national grants, venture capital firms, commercial banks and from mechanisms such as direct foreign investment, public-private partnerships, and socially responsible investments. .

Among the many recycling business models, Wongpanit, a Thailand-based waste buying company, is particularly outstanding. It not only invests in trading recyclables for monetary benefits but also significantly contributes to social development and environmental conservation. It works with governments to create public awareness, offers franchisees, and has a transparent pricing system for recyclables.

7.10.2 Take Advantage of Innovative Financial Instruments like Green Bonds

During the past decade, several innovative financing instruments have appeared in the market. Green bonds are now emerging as attractive financial instruments and can be issued to mobilise funds for waste-to-resources projects. The interest is to make investments as green as possible—and in particular, climate friendly.

Currently, green bonds focusing on renewable energy and sustainable transport have a major market share. Bonds raised for sustainable waste management are yet to gain momentum and, thus, present an opportunity. The waste management sector can leverage green bonds to attract public as well as private investments in setting up waste-to-energy and waste-to-compost plants.

At a global scale, although the waste management sector makes a relatively minor contribution to greenhouse gas (GHG) emissions,[1,2] a holistic approach to waste management can lead to positive consequences addressing GHG emissions across various sectors. These sectors include energy, forestry, agriculture, mining, transport and manufacturing. In these sectors, the co-benefits result from avoided landfill emissions, reduced virgin material extraction and manufacturing, reduced consumption of fossil fuels, carbon binding in soil through compost application and carbon storage owing to disposal of recalcitrant materials in landfills. There are, thus, substantial co-benefits of waste management in the context of climate change on a multisectoral basis.

Unfortunately, these co-benefits are often not quantified for better understanding and communication. Therefore, it will be useful to develop case studies that quantify the co-benefits of sustainable waste management towards GHG reduction for six key sectors such as energy, forestry, agriculture, mining, transport and manufacturing. This quantification will further help in the design and launch of green bonds.

7.11 Promote Awareness, Education and Training for Knowledge Generation and Capacity Building

7.11.1 Awareness Raising

Public awareness is needed at both the "upstream" as well as the "downstream" stages of the waste management cycle, starting with the reduction of waste generation to segregation, re-use or recycling followed by collection, transportation, treatment and disposal. Some strategies to achieve these objectives are listed below as illustration.

1 Estimated at about 3–5 per cent of total anthropogenic emissions in 2005.
2 UNEP (2010).

7.11.2 Public Campaigns

Short films, audio-visuals, exhibitions, street plays, social drives and social media campaigns to sensitise the communities need to be taken up on a massive scale and on a sustained basis. To undertake this task, governments should partner with NGOs and community based organisations (CBO's). It is important to understand the culture and social characteristics of the local communities and then, accordingly, develop awareness campaigns and programs.

The advertising community and media houses should be invited by public and private entities to communicate powerful messages to the community through photographs, videos, short films and television advertisements. Media houses can announce public competitions and awards for communities, schools or groups that demonstrate positive impacts towards waste management.

7.11.3 Education

Schoolchildren and university-age students should be the primary target to introduce waste management-related education and practice. Tools (e.g., waste-to-art workshops), creative exercises (e.g., waste-mapping) and field visits could also be used.

E-learning courses could be organised in partnership with reputed academic institutions in the region, especially in the interest of working professionals. UN Environment's International Environmental Technology Centre recently completed the development of a curriculum on holistic waste management in partnership with five academic institutions, led by the Asian Institute of Technology in Bangkok, Thailand. This work, for instance, could be used to develop e-learning courses on holistic waste management.

7.11.4 Training and Skill Development

One of the key barriers to sound waste management in Asian countries is the lack of training and capacity among key stakeholders.

A one-size-fits-all approach does not work when planning and delivering training and capacity building programs to diverse stakeholders. A training needs assessment could be conducted for each type of stakeholder to identify areas where awareness and skills need to be developed. For example, product designers need training and knowledge on recyclable materials and on the design of products for disassembly and recycling. An automobile dismantler will need training on how to safely and efficiently extract plastic and metal resources from automobiles. Training programs should employ tools like practical hands-on demonstrations, international case studies or success stories and field visits not only within the country but also to other countries, thus developing stakeholder capacities. The programme launched by the Skill Council for Green Jobs under the National Skill Development Corporation in India is an example.[3]

3 For more information, visit the About page on the Skill Council for Green Jobs website. Available from: *Available from: http://sscgj.in/* (accessed 16 January 2017).

7.12 Invest in Research and Development for Technology Adaptation

Technologies need to be pre-assessed based on the characteristics of waste. Most ULBs in Asia process waste in mixed conditions. Pilot testing and adaptations are, thus, necessary to ensure that technologies can handle high moisture content, contamination and low fuel value. These considerations are very important in the context of technologies for waste-to-energy (thermo-mechanical routes) and biomethanation.

Much experience is now available in the management of MSW and special waste streams like plastic and healthcare waste. Experience on cost-effective management of new waste streams such as e-waste (e.g., focusing on precious metal extraction), C&D waste and marine litter is relatively low. There is a need to establish more experience in managing these waste streams through research and development and technology demonstration projects. Demonstration projects need not be technology limited and could be set up to test innovative institutional and business models. To ensure the multiplier effect of these pilots, demonstration projects should be located in and around industrial clusters and townships.

There is a need to identify institutions that could undertake technology assessments and adaptation. Setting up research parks as university extensions in partnership with private sector will help.

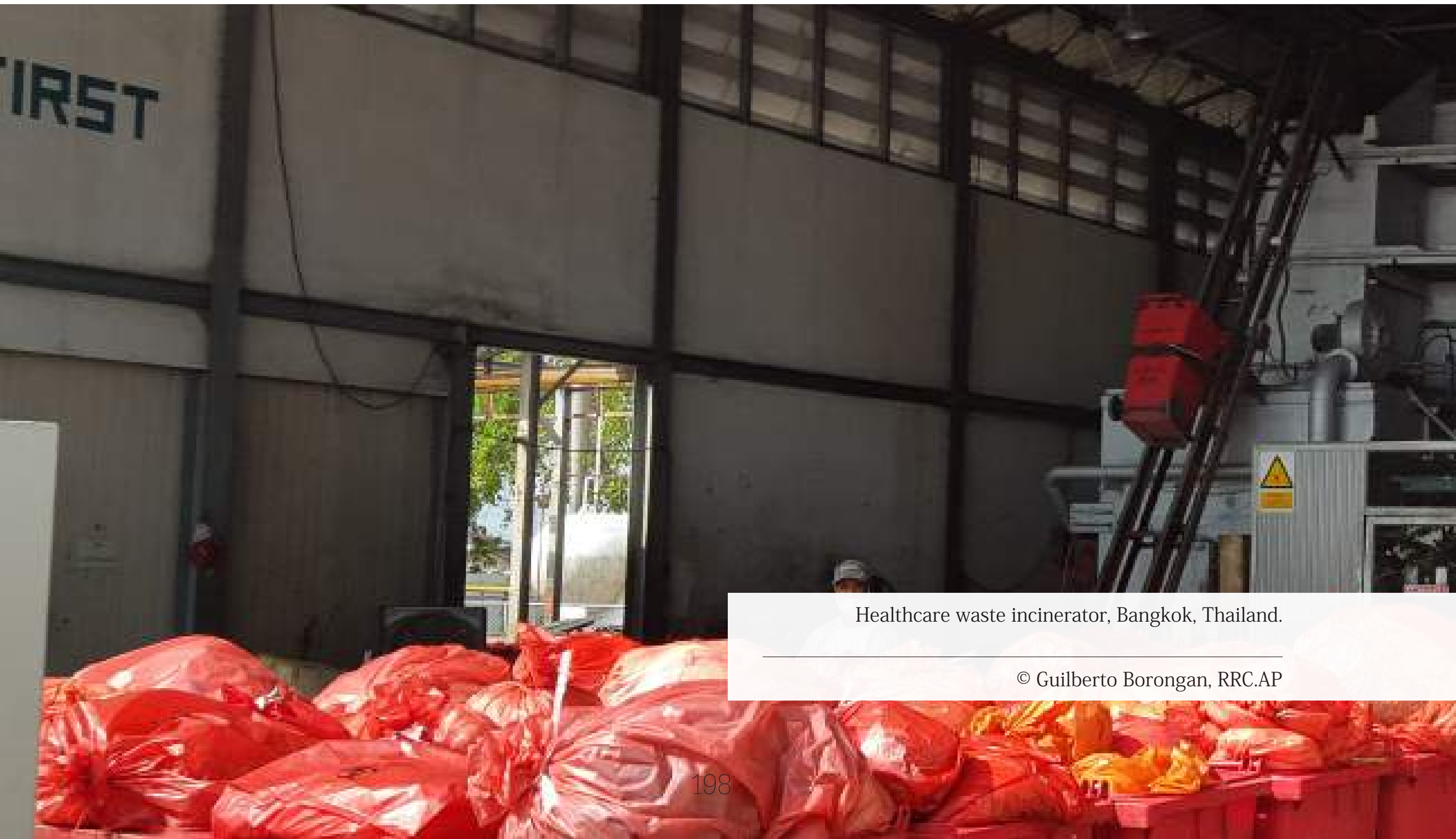
Sanitary landfill in Quezon City, Philippines.

7.13 Build Strategic Action Plans to Address Challenging Waste Streams

Marine litter, mining waste and disaster waste are important waste streams today that pose a challenge on a global basis. Relatively little experience is available on their management.

Marine litter is perhaps the most volumetric form of waste spread across the oceans—many times more than MSW. Mining waste is increasing in volume owing to increasing intensity of resource extraction. Waste generated from disasters is a recent phenomenon and of great concern. Given the reality of climate change, an occurrence of debris generated through disasters is going to increase. Not enough guidance is available yet, and responses will have to be quick.

There is a need to address all of the above waste streams by developing regional or Asia-wide strategies and preparing focused action plans.



Healthcare waste incinerator, Bangkok, Thailand.

7.14 Operate a Knowledge Portal as a Collaborative Platform on Waste Management

As explained earlier, there is a need to strengthen data, information and knowledge on waste management at the local, national and regional levels in Asia. A "knowledge portal" should be developed, operated and sustained—a portal that will also serve as a comprehensive, dynamic networking platform for countries in Asia. The platform should meet the interests of a wide range of stakeholders such as ULBs, policymakers and regulators, research and academia, financing institutions, professionals and technology providers.

This knowledge portal should provide information on key waste management-related information and statistics. Examples include national waste generation (volumes and characteristics), waste and resource management indicators, indicating status, trends and diagnostics, current management strategies (i.e., investments, policies and regulations), successful research developments on waste prevention, waste reuse, recovery and recycling. The platform should also showcase major national projects undertaken towards waste management, successful and not-so-successful stories, technologies deployed and those under development, projects under bidding, a roster of experts and the offerings on training programs.

It has been observed that developing a portal is easy. But the challenge lies in garnering data from countries on a regular basis, peering and analysing the collated data. The portal could, thus, have "national gateways" managed by a nodal office in each participating country. This will help in updating data at regular intervals as well as with quality control.

7.15 Emphasise on Integrated or Zero Waste Management by Addressing all Media

Typically, when wastes are processed, secondary waste streams like solid waste residues, wastewater, energy leakage and air emissions are released; these need to be adequately addressed and contained. For example, landfilling of solid waste produces hazardous leachate (liquid waste) that causes land pollution, and incineration of solid waste leads to generation of residues like bottom ash (solid waste) and flue gases (gaseous waste). Waste processing facilities must, thus, address all the types of media.

This concept of multimedia control needs to be expanded further whereby all forms of wastes are considered in a region. Such a holistic approach helps in developing a comprehensive, integrated strategy that aims to achieve zero (or near-zero) waste.[4]

4 The term "zero waste" is defined by Zero Waste International Alliance on their webpage, "ZW Definition" Available from: *http://zwia.org/standards/zw-definition/* (accessed 16 January 2017).

Under this strategy, concurrent investments are identified for the region that cover wastewater treatment, air emissions control and solid waste management. This coordinated approach helps reduce risks to the public and the ecosystems and ensures that the burden of pollution is not passed from one media to another.

Implementation of integrated or zero waste strategies requires innovation in technology, business models and policies and regulations to move towards a circular economy. It may be useful to undertake pilot projects in selected Asian cities and industrial clusters to start with. All these efforts would lead to the reduction in costs of waste disposal, transportation of waste and consumption of virgin resources.

7.16 Make Efforts towards Policy Harmonisation at National and Regional Levels

Typically, in most countries, management of various types of wastes and resources falls under the purview of national or local bodies that operate independently. For example, solid waste is managed by ULBs, air pollution is monitored and controlled by pollution control authorities, while resources like water, energy and raw materials are managed by line ministries such as ministries of water resources, power, and so on. To integrate management of waste and to establish circular economy, a dialogue and collaboration between various ministries and departments is key.

Again, there are disconnects as well as overlaps with line ministries. In India, for example, the Ministry of Environment and Forests and Climate Change formulates legislation of municipal waste management, whereas financing of waste management infrastructure is the responsibility of the Ministry of Urban Development. The Ministry of New and Renewable Energy promotes waste-to-energy projects, while the ministries of health and water and sanitation focus on health-related impacts. All waste-related policies of these ministries need to be aligned or harmonised to achieve minimum overlaps and conflicts towards better effectiveness. Thus, to achieve sustainable waste management, it is necessary to have policy harmonisation at the ministry level. The referral policy framework proposed in Chapter 5 may be considered in this perspective.

7.17 Develop a Referral Framework Assessment of Policy Equivalence and Implementation Capacities

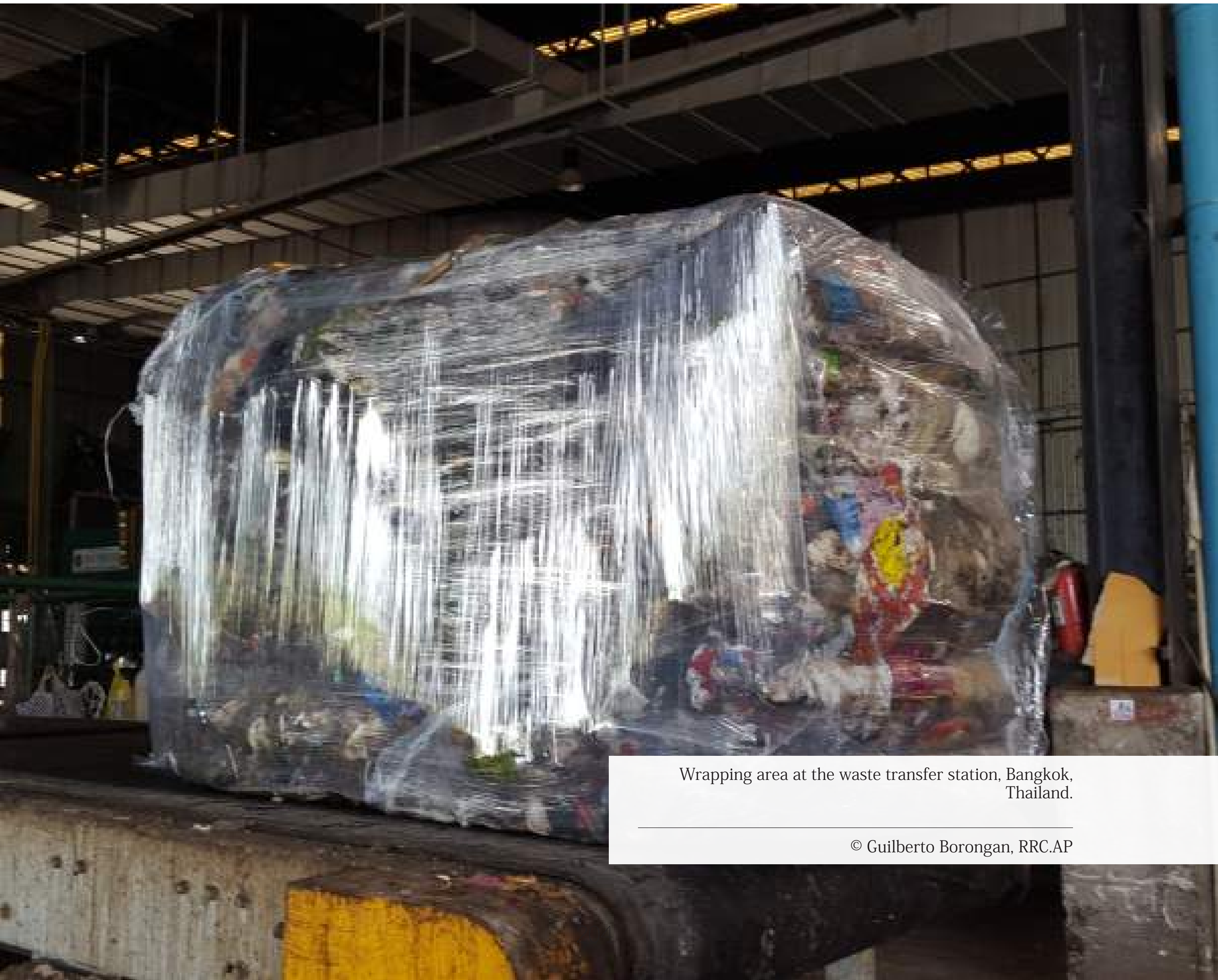
It is important to set up a referral framework across Asia on waste and resource management that will guide national governments to set targets and make continuous improvements. Frameworks for assessment of policy equivalence and implementation capacities of countries can help to guide, harmonise as well as identify gaps for auctioning.

Such frameworks could also provide national governments and development financing institutions a rationale for customised and targeted financing and for capacity development. Over the long run, the referral framework could reduce disparities and unevenness in policies and regulations, provide tracking mechanisms and a reporting system. In addition, it may help to set up country-to-country collaborations.

7.18 Consider Development of an Asian Directive on Circular Economy

Given the resource-constrained future of the Asian economy at large, policies are required that could guide industries and consumers to move from a "dispose after first use" attitude towards "'reuse" by following the principles of circular economy. National governments need to take a lead in building on the experiences of the EU and leading countries in the Asia-Pacific region such as China, Japan and Korea.

One of the fundamental steps in this direction could be the establishment of an Asian Centre of Excellence on Circular Economy. This Centre can serve as a think tank and work with national governments in the Asian region to assist in setting up a framework for a circular economy. Its mandate could be to come up with an Asian directive in line with the circular economy directive in the EU.



Wrapping area at the waste transfer station, Bangkok, Thailand.

Key Messages

for Policymakers

+ **Build more reliable, comprehensive waste-related statistics because paucity of data affects system design, technology selection, estimation of investment needs and assessment of policy performance.**

+ **Standardise definitions of waste streams and waste-related terminologies to track progress and make comparisons.**

+ **Improve compliance on waste-related regulations across product life cycles through strict enforcement and monitoring.**

+ **Conduct studies and communicate the "costs of inaction" to realise the health, environmental and social impacts of indiscriminate waste disposal.**

+ **Remediate contaminated dumpsites and the surrounding environment.**

+ **Test the effectiveness of economic instruments for effective and sustainable waste management (i.e., to improve compliance as well as promote conversion of waste to resources).**

+ **Promote reduction in resource use and improve resource use efficiency.**

  - Control consumerism and consumption patterns
  - Promote collaborative consumption and shared economy among stakeholders, especially with those who cannot afford assets on their own or do not have access
  - Design products and services with sustainability as a focus and minimise consumption of natural resources and waste generation across the product's life cycle
  - Promote eco-labels and the practice of green products
  - Encourage and enforce Extended
  - Producer Responsibility
  - Develop codes of practice and quality standards for recycled materials
  - Promote green public procurement

+ **The informal sector is an important stakeholder in waste collection and processing and integrating them with the formal sector is key.**

+ **Promote investments in the waste management sector by:**

  - Encouraging entrepreneurship and innovative business models
  - Taking advantage of innovative financial instruments like green bonds

+ **Promote awareness, education and training for knowledge generation and capacity building**

  - Raise awareness
  - Public campaigns
  - Education for school- and university-age youth
  - Training and skill development

+ **Invest in research and development for technology adaptation.**

+ **Build strategic action plans to address challenging waste streams, such as marine litter, mining and disaster waste.**

+ **Develop and operate a knowledge portal as a comprehensive dynamic collaborative platform on waste management to meet the needs of a wide range of stakeholders.**

+ **Emphasise holistic or zero waste management addressing waste in all three media (solid, liquid and air).**

+ **Make efforts towards policy harmonisation at the national and regional levels.**

+ **Develop a referral framework assessment of policy equivalence and implementation capacities to guide national governments to set targets and make continuous improvements.**

+ **Consider development of an Asian directive on circular economy to guide industries and consumers.**

Country Profiles

Afghanistan • Bangladesh • Bhutan • Brunei Darussalam • Cambodia • China • Democratic People's Republic of Korea • India • Indonesia • Iran • Japan • Lao PDR • Malaysia • Maldives • Mongolia • Myanmar • Nepal • Pakistan • Philippines • Republic of Korea • Singapore • Sri Lanka • Thailand • Timor-Leste • Viet Nam


Mongolia
China
Democratic People's Republic of Korea
Republic of Korea
Japan
Iran
Afghanistan
Pakistan
Nepal
Bhutan
Bangladesh
India
Myanmar
Viet Nam
Lao PDR
Thailand
Cambodia
Philippines
Sri Lanka
Maldives
Malaysia
Brunei Darussalam
Singapore
Indonesia
Timor-Leste

Afghanistan

Country General Information

Total population:	32,527,000 (2015)
Urban population:	26.7% (2015)
Area:	652,860 square kilometers (2015)
GNI per capita:	630 USD (Atlas method)[1]

Definition

Municipal Solid Waste[2]: Any substance or thing that the holder discards or disposes of, or intends or is required to discard or dispose of, irrespective of its value to any person, and any substance or thing discarded in a public place or on vacant land not designated for such purpose. Solid waste is mainly any garbage, refuse or rubbish that we make in our homes and other places. These include plastic, iron, glasses, food, etc. in different forms.

Hazardous Waste[3]: means clinical waste and waste containing hazardous substances

Healthcare/Clinical Waste[3]: any waste produced by hospitals, clinics, nursing homes, doctor's offices, medical laboratories, medical research facilities and veterinarians which is infectious or potentially infectious.

Solid Waste

MSW

Generation: 255,000 tonnes/year (700 tonnes/day only in Kabul city, n.d.)[4]

Solid Waste Composition[5]

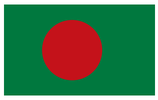
Organic waste	70%
Plastic	39.8%
Glass	2.2%
Paper and cardboard	5.5%
Textile waste	1.2%
Demolition waste	15%
Metals	1.2%

Legal Instruments

Environment Law[3]	2007
Environmental Protection Act[6]	2007
Infection Prevention and control Policy[7]	2005

1 *http://data.worldbank.org/indicator/NY.GNP.PCAP.CD?locations=AF*
2 Azad, B. W. (2015, p. 15).
3 Islamic Republic of Afghanistan, The National Assembly (2007).
4 Asian Institute of Technology (2014).
5 Forouhar, A. (2012, p. 10).
6 Islamic Republic of Afghanistan, Ministry of Public Health (2014, p. 23-24).
7 Ibid.

Bangladesh



Country General Information

Total population:	160,996,000 (2015)
Urban population:	28.4% (2015)
Area:	148,460 square kilometers (2015)
GNI per capita:	1,190 USD (Atlas method)

Solid Waste

MSW

Generation: 4,866,000 tonnes/year (13,332.89 tonnes/day; 0.41 kg/capita/day, 2005)
Hazardous Waste: 1,560,000 tonnes/year (2010)
Collection coverage: 56%
Recycled (material recovery): 15% (476 tonnes/day)[1]

Organic Waste

Generation: 65,000,000 tonnes/year (2007)[2]

Healthcare waste

Generation: 36,000 tonnes/year (2008)[3]

E-waste

Generation: 126,000 tonnes/year (2014)[4]

Solid Waste Composition[2]

Food & Vegetable	67.65%
Paper Products	9.73%
Plastic, leather, rubber	5.10%
Metals	0.26%
Glass and ceramic	1.13%
Wood, grass, leaves	4.20%
Rags, textile, Jute	2.50%
Medicine/Chemical	0.64%
Rocks, dirt & misc	8.79%

Waste Water

Municipal Waste Water

Generation: 522,000,000 tonnes (725,000 thousand cubic meter[5], 2000; Waste water density value = 0.72 tonne per cubic meter)

Industrial Waste Water

Generation: 78,818
(109,470 thousand cubic meter/year, 20083; Waste water density value = 0.72 tonne per cubic meter[6])

Legal Instruments[7]

Draft National Urban Policy	2006
National Renewable Energy Policy	2008
National Agriculture Policy	1999
National Industrial Policy	2005
National Policy for Water Supply and Sanitation	1998
Urban Management Policy Statement	1998

Acts

Fertilizer Act	2006
Bangladesh Environmental Conservation Act (ECA)	1995

1 *http://data.worldbank.org/indicator/NY.GNP.PCAP.CD?locations=BD*
2 UNCRD (2010, p. 4).
3 Asian Institute of Technology (2008, p.11).
4 Baldé and others (2015, p. 65).
5 *https://goo.gl/Bcezq0*
6 *http://www.aqua-calc.com/page/density-table/substance/sewage-coma-and-blank-sludge*
7 Bangladesh, Ministry of Environment and Forests (2010).

Rules

Biomedical Waste Management Rules	2008
Lead Acid Battery Recycling and Management Rules	2006
Draft National Solid Waste Management Handling Rules	2005
Bangladesh Environmental Conservation Rules (ECR)	1997
National Policy for Water Supply and Sanitation	1998

Strategy

National CDM Strategy	2005
Poverty Reduction Strategy Paper (PRSP)	2005
National Sanitation Strategy	2005

Action Other

Dhaka Environment Management Plan	2005
Solid Waste Management Action Plan for Eight Secondary Towns in Bangladesh	2005
National Environment Action Plan (NEMAP)	1995

Other

Circular to Promote Compost by the Ministry of Agriculture (MoA)	2008
Private Sector Infrastructure Guideline	2004
Private Sector Housing Development Guideline	2005
Dhaka Declaration on Waste Management by SAARC countries	2004

Bhutan

Country General Information

Total population:	775,000 (2015)[1]
Urban population:	38.6 (2015)
Area:	38,394 square kilometers (2015)
GNI per capita:	2,370 USD (Atlas method)

Solid Waste

MSW

Generation: 117,000 tonnes/year (329 tons/day, 2012)[2]

E-waste

Generation: 3,000 tonnes/year (2014)[3]

Healthcare Waste

Generation: 11,000 tonnes (31.75 kg/day in Thimphu[4])

Solid Waste Composition

Organic	58%
Paper	17%
Plastic	13%
Glass	4%
Metal	1%
Other	7%

Waste Water

Municipal Waste Water

Generation: 2,808,000 tonnes (3,900 thousand cubic meter[5]; Waste water density value = 0.72 tonne per cubic meter)[6]

Legal Instruments

Waste Prevention and Management Regulation, 2012[7]	2012
National Environment Protection Act, 2007[8]	2007
Waste Prevention and Management Act of Bhutan	2009
The Bhutan Municipal Act of 1999	1999
Environmental Assessment Act[9]	2000
Regulation for the Environmental Clearance of Projects[10]	2001
Regulation on Strategic Environmental Assessment[11]	2001
ECoP for Hazardous Waste Management[12]	2002
The Ministry of Trade and Industry's public notification No. MTI/VII-3/427 (April 20 1999)	1999

1 *http://databank.worldbank.org/data/reports.aspx?source=2&country=BTN*
2 Hoornweg and Perinaz Bhada-Tata (2012, p. 90, 96).
3 Baldé and others (2015, p. 65).
4 Asian Institute of Technology(2007).
5 FAO (2016).
6 *http://www.aqua-calc.com/page/density-table/substance/sewage-coma-and-blank-sludge*

7 FAOLEX (2016).
8 National Assembly of Bhutan(1999).
9 Office of the Attorney General, Bhutan (2000).
10 Ministry of Economic Affairs (2001).
11 FAO (2001).
12 Environmental Management Framework, Bhutan (2013).

Brunei Darussalam

Country General Information

Total population:	423,188 (2015)
Urban population:	76.89% (2015)
Area:	5,770 square kilometers (2015)
GNI per capita:	32,200 USD (Atlas method)[1]

Solid Waste

MSW

Generation: 210,000 tonnes/year (1.4 tonnes/day, 2014)[2]
Collection coverage: 50%-70%[3]
Disposal: 70%[3]
Compost: 2%[3]

E-waste

Generation: 1,000 tonnes/year (2014)[4]

Healthcare Waste

Generation: 195 tonnes/year (195 tonnes/year, 2001)

Solid Waste Composition

Food Waste	36%
Paper	18%
Plastic	16%
Glass	3%
Metal	4%
E-waste	1%
Innert	1%
Rubber	1%
Wood	1%
Textile	2%
Yard Waste	6%
Other	11%

1 *http://data.worldbank.org/country/brunei-darussalam*
2 Brunei Darussalam, Department of Environment, Park, and Recreation, Ministry of Environment (2016).
3 Shams, S., Juani, R.H.M., & Guo, Z. (2015).
4 Baldé and others (2015, p. 65).

Legal Instruments

Hazardous Waste (Control of export, import and transit) Order[5]	2013
Poison Act	2007

5 FAOLEX (2016).

Cambodia

Country General Information

Total population:	Total population: 15,577,899 (2015)[1]
Urban population:	20.71 (2015)[1]
Area:	181,040 square kilometers (2015)[1]
GNI per capita:	1,070 USD (Atlas method)[1]

Solid Waste

MSW
Generation: 1,089,000 tonnes/year 2014[2]
Collection coverage: 80% (urban)[2]
Recycled (material recovery): Less than 50%[2]

E-waste
Generation: 16,000/year tonnes (2014)[3]
Recycling: 80% (60% reusable, 20% recyclable, only in Phnom Pehn 2009)[4]
Disposal: 20% (Only in Phnom Pehn 2009)3

Healthcare Waste
Generation: 147 (403 kg/day)[5]

Urban Solid Waste Composition[6]

Organic	72.38%
Plastic	15.74%
Fabrics	3.6%
Paper	3.45%
Glass	1.86%
Medical	1.31%
Gypsum	0.19%
Poly-ethylene	0.68%
Metal	0.42%
Limestone	0.2%
Tyres	0.1%
Dry-batteries	0.07%

1 *http://databank.worldbank.org/data/reports.aspx?source=2&country=KHM*
2 Cambodia, General Department of Environment Protection, Ministry of Environment (2016).
3 Baldé and others (2015, p. 65).
4 Cambodia, Ministry of Environment (2006).
5 Asian Institute of Technology (2007).
6 Sothun, C. (2010).

Waste Water

Industrial Waste Water
Generation: 40,000 tonnes (2002)[7]
(Waste water density value = 0.72 tonne per cubic meter[8])

Legal Instruments

Law on Environmental Protection and Natural Resource management[9]	1996
Waste Management[10]	1999
Sub-decree on Solid Waste Management (MoE)[11]	1999
The Joint Prakas 19 on Solid Waste Management in Cities and Provinces made between the MoE and the Ministry of Interior (MoI)[12]	
National Environmental Action Plan[13]	1997
Environmental Guidelines on Solid Waste Management in Kingdom of Cambodia[14]	2006

7 UNEP and Ministry Environment (2009, p. 63).
8 *http://www.aqua-calc.com/page/density-table/substance/sewage-coma-and-blank-sludge*
9 *http://www.cambodiainvestment.gov.kh/law-on-environmental-protection-and-natural-resource-management_961242.html*
10 Asian Institute of Technology (2007).
11 Cambodia, Council of Ministers (2009).
12 Cambodia, Ministry of Environment, Phnom Penh (2010)
13 Council of Ministers (2009).
14 Cambodia, Ministry of Environment and COMPED-Cambodian Education and waste Management Organisation (2006).

China

Country General Information[1]

Total population:	1,371,220,000 (2015)
Urban population:	55.6% (2015)
Area:	9,562,911 square kilometers (2015)
GNI per capita:	7,820 USD (Atlas method)

Definition

MSW (general): refers in daily life or daily living activities providing services in solid waste generated as well as legal and administrative regulations as household waste solid waste.[2]

Organic (agricultural) waste: Means of agricultural production and construction of solid waste generated in the process, mainly from plant cultivation, animal farming and agricultural plastic film and other plastic.[3]

Construction & Demolition Waste: Refers to the construction unit, construction unit construction, reconstruction, expansion and removal of all types of buildings, structures, pipe network, as well as residents decorate houses during renovation spoil generated by discarded materials and other waste.[4]

Consumer Waste: Solid waste discharged from everyday life or from services provided to everyday life as well as the solid waste that is regarded as consumer waste under laws and administrative regulations. MSW refers in daily life or daily living activities providing services in solid waste generated as well as legal and administrative regulations as household waste solid waste.[5]

E-waste (WEEE): means waste electrical and electronic products, electrical and electronic equipment and obsolete parts, components and the State Environmental Protection Administration in conjunction with the relevant provisions in the management of e-waste items, substances. Product or device including scrap generated in industrial production, waste and scrap of semi-finished products, products or equipment maintenance, renovation, re-manufacturing process produces scrap, daily life or providing services to daily life activities of waste product or device as well as laws and regulations prohibit the production or import of products or equipment.[6]

Industrial Waste: refers to the industrial production of solid waste generated in.[7]

Hazardous **Waste**: Solid waste that is included in the national list of hazardous waste or identified to be dangerous according to the identification criteria and methods of hazardous waste as prescribed by the State.[5]

Healthcare Waste: refers to a direct or indirect infection, toxic and other hazardous waste generated by medical institutions in health care, prevention, health care and other related activities.[8]

Solid Waste

MSW[9]

Generation: 178,602,000 tonnes/year (2014)
Collection coverage: 100%
Energy recovery by incineration: 29.84% (53,299,000 tonnes/year, 2014)
Disposal/landfill: 60.16% (107,443,000 tonnes/year, 2014)
Untreated discharge/open dump: 8.21% (2014)[10]

Construction & Demolition Waste (building waste)[11]

Generation: 1,500,000,000 tonnes/year (2014)
Recycling: 45,000,000 tonnes/year

E-waste

Generation: 6,000,000 tonnes/year (2014)[12]
Recycling: 3,135,000 tonnes/year (2014)[10]

1 *http://data.worldbank.org/indicator/SP.POP.TOTL?locations=CN*
2 China, National People's Congress (2005).
3 Environmental Protection Standards (2010).
4 China, Ministry of construction (2005).
5 National People's Congress (2005).

6 China, State Environmental Protection Administration (2008).
7 Solid Waste (2015).
8 Medical Waste Management Regulations 2003.
9 National Bureau of Statistics of China (2015).
10 Mian, M.M., and others (2016).
11 China Construction Waste Resources Industrialisation (2014).
12 Baldé and others (2015, p. 65).

Industrial Waste[13]

Generation: 3,256,200,000 tonnes/year (2014)
Recycling: 63% (2,043,302,000 tonnes/year, 2014)
Disposal without energy recovery: 25% (803,875 thousand tonnes, 2014)

Solid Waste Composition[14]

Food Residue	55.86%
Wood waste	2.94%
Paper	8.52%
Textiles	3.16%
Plastics	11.15%
Rubber	0.84%
Non-combustibles	18.36%

Waste Water

Municipal Waste Water

Generation: 14,755,360,000 tonnes/year (2013)[15]
Treatment: 35,503,200,000 tonnes/year (2014)[16]
Re-use: 2,779,200,000 tonnes/year (2013)13

Industrial Waste Water

Generation: 3,630,520,000 tonnes/year (2013)[17]

Emission from Waste

GHG 241,380,000[18]

Legal Instruments

Measures for the Supervision and Administration of Safe Transport of Radioactive Materials (FAO)	2016[18]
Law of the People's Republic of China on the Prevention and Control of Environmental Pollution by Solid Waste (FAO)	2015[18]
Law of Environmental Protection of the People's Republic of China	2014
Administrative Measures for the Circulation of the Used Electrical and Electronic Products (FAO)	2013[18]
Administrative Measures on the Collection and Use of the Fund for the Disposal of Discarded Electrical and Electronic Products (FAO)	2012[18]
Administrative Measures for Registration of Hazardous Chemicals. (FAO)	2012[18]
Regulations on the Administration of Recovery and Disposal of Waste Electrical and Electronic Products (FAO)	2011[18]
Administrative regulations of Beijing Municipality on urban living garbage.	2011
Administrative Measures for the import of solid waste (FAO)	2011[18]
Public Health and Municipal Services Ordinance (Chapter 132) (FAO)	2011[18]
Waste Disposal Ordinance (FAO)	2010[18]
Provisions on the administration of urban construction garbage (FAO)	2005[18]
Water pollution control (sewerage) Regulation, Chapter 358AL (FAO)	2002
Administrative Regulations on City Appearance and Environmental Sanitation issued by the State Council in 1992 (State Council Oder No. 101)	1992

13 National Bureau of Statistics of China (2015).
14 Zhou, H., Meng, A., Long, Y., Li, Q., Zhang, Y. (2014).
15 National Bureau of Statistics of China (2014).
16 FAO (2016).
17 National Bureau of Statistics of China (2014).
18 Xiao, L., QIAN M., Jinghao, L. (2016).

19 EU-China Environmental Governance Programme (2014).

Democratic People's Republic of Korea

Country General Information[1]

Total population:	32,527,000 (2015)
Urban population:	26.7% (2015)
Area:	652,860 square kilometers (2015)
GNI per capita:	630 USD (Atlas method)

Solid Waste

MSW

Generation: 420,000 tonnes/year in Pyongyang, 2003[2]

Legal Instruments

The Environmental Law[3]	
Law on Protection of Pollution in Taedong River	2005
Regulation on Handling Toxic Chemicals	2006[4]
Law on Wastes Handling	2007[4]
Law on Public Sanitation	1998[4]

1 CIA. DPRK KOREA (2016).
2 UNEP (2003).
3 Hayes, P. (1994).
4 UNEP (2012).

India

Country General Information[1]

Total population:	32,527,000 (2015)
Urban population:	1,295,291,543 (2015)
Urban population:	32.7
Area:	3,287,260 sq. km (2015)
GNI per capita:	1,590 (GNI per capita, Atlas method, 2015))

Definition

Municipal Solid Waste: Municipal solid waste includes commercial and residential wastes generated in a municipal or notified areas in tither solid or semi-solid form excluding industrial hazardous wastes but including treated bio-medical wastes.[2]

Hazardous Waste: Any waste which by reason of characteristics such as physical, chemical, biological, reactive, toxic, flammable, explosive or corrosive, causes danger or is likely to cause danger to health or environment, whether alone or in contact with other wastes or substances, and shall include (i) waste specified under column (3) of Schedule Ⅰ, (ii) waste having equal to or more than the concentration limits specified for the constituents in class A and class B of Schedule Ⅱ or any the characteristics as specified in class C of Schedule Ⅱ, (iii) wastes specified in Part A of Schedule Ⅲ in respect of import or export of such wastes or the wastes not specified in Part A but exhibit hazardous characteristics specified in Part C of Schedule Ⅲ.[3]

E-Waste: Electrical and electronic equipment, whole or in part discarded as waste by the consumer or bulk consumer as well as rejects from manufacturing, refurbishment and repair processes.[4]

Construction and Demolition Waste: The waste comprising of building materials, debris and ruble resulting from construction, re-modeling, repair and demolition of any civil structure.[5]

Bio-medical Waste: Any waste, which is generated during the diagnosis, treatment or immunisation of human beings or animals or in research activities pertaining thereto or in the production or testing of biological or in health camps, including categories mentioned in Schedule I appended to these rules.[6]

Solid Waste

MSW[7]

Generation: 68,800,000 tonnes/year (188,500 tonnes/day only in urban, 2012)
Hazardous waste: 156 000,000 tonnes/year (2010)
Collection coverage: 70% - 90%
Disposal: 91%

Organic (Agricultural) Waste

560,000,000 tonnes/year (1997)[7]

Construction & Demolition Waste (building waste)[8]

Generation: 50,000,000 tonnes/year (2013)

E-waste

Generation: 1,641 (2014)[9]

Healthcare Waste

Generation: 330,000 tonnes/year (2001)[10]

Solid Waste Composition[11]

Biodegradables	42.51%
Paper	9.63%
Plastic/rubber	10.11%
Metal	0.63%
Glass	0.96%
Inert	17%

Waste Water

1 *http://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?locations=IN*
2 India, Ministry of Environment & Forests (2000, p. 3).
3 India, Ministry of Environment & Forests (2016a, p. 3).
4 India, Ministry of Environment & Forests (2016b, p. 3).
5 India, Ministry of Environment & Forests (2016c, p. 2)
6 India, Ministry of Environment & Forests (2016d, p. 3).
7 UNESCAP (2012).
8 Centre for Science and Environment (2013).
9 Baldé and others (2015, p. 65).
10 Asian Institute of Technology (2008, p. 54).
11 Joshi, R. & Ahmed, S. (2015, p. 5).

Municipal Waste Water

Generation: 11,124,000,000 (15,450,000 thousand cubic meter, 2011;[12] wastewater density value = 0.72[13])

Treatment: 3,179,520,000 (4,416,000 thousand cubic meter, 2011).

Legal Instruments

Biomedical Wastes Management & Handling Rules[14]	1998
National Environmental Policy[15]	2006
Municipal Solid Wastes (Management & Handling) Rules[16]	2000
Plastic Manufacture & Use Rules, 2003[17] The Plastic Waste (Management and Handling) Rules	2011
E-Waste Rules[18]	2011
Batteries (Management and Handling) Rules[19]	2001
The Environment (Protection) Act[20]	1986
EPA - Rule and Implementation Information for Standards of Performance For Municipal Waste Landfills[21]	
The Public Liability Insurance Act[22]	1991
The National Environment Tribunal Act[23]	1995
The National Environment Appellate Authority Act[24]	1997

12 FAO (2016).
13 *http://www.aqua-calc.com/page/density-table/substance/sewage-coma-and-blank-sludge*
14 *http://envfor.nic.in/legis/hsm/biomed.html*
15 OPENEI (2006).
16 Report (2010, p. 13).
17 Ibid., p. 17.
18 Delhi, Central Pollution Control Board (2011, p. 3).
19 *http://envfor.nic.in/legis/hsm/biomed.html*
20 *http://envfor.nic.in/legis/env/env1.html*
21 United States Environmental Protection Agency (1999, p. 1).
22 *http://envfor.nic.in/legis/public/public1.html*
23 *http://envfor.nic.in/legis/others/tribunal.html*
24 *http://envfor.nic.in/legis/others/envapp97.html*

Indonesia

Country General Information

Total population:	255,993,674 (2015 est.)[1]
Urban population:	53.7[1]
Area:	1,910,930[1]
GNI per capita:	3,440 (GNI per capita, atlas method)[1]

Definition

MSW (general): Remnant of human daily activities and/or natural processed in the solid form.[2]

Household Waste: Derives from household daily activities, excluded feces and specific waste.[3]

Household-like Waste: Derives from commercial area, industrial areas, special areas, social facilities, public facilities, and/or other facilities.[3]

Specific Waste: The waste in which its types, concentration, and/or volume required to be managed specifically.[3]

Hazardous and toxic waste: Abbreviated B3 waste, shall mean any waste containing dangerous and/or toxic material, which due to its characteristics and/or concentration and/or amount, either directly or indirectly, may damage and/or pollute the living environment and/or endanger human health.[4]

Solid Waste

MSW

Generation: 38,500,000 tonnes/year (2008[5]
Hazardous: 23,000,000 tonnes/year (2010)[6]
Collection: 56% in urban; 5% in rural[3]
Recycling: 7% (compost and recycled)[7]
Disposal: 84% (69% landfilled, 5% burned, 10% buried, 2012)

Organic (agricultural) waste

Generation: 122,000,000 tonnes/year (1997)[4]

E-waste

Generation: 745,000 tonnes/year (2014)[8]

MSW Composition[3]

Organics	65%
Plastics	11%
Paper	13%
Fabric	1%
Glass	1%
Metal	1%
Other	8%

Waste Water

Municipal Waste Water

Generation: 11,124,000 tonnes/year (10,288,800 thousand cubic meter, 2011;[9] wastewater density value = 0.72[10])

Legal Instruments

Government regulation of the Republic of Indonesia, No. 18 of 1999 on the management of the waste of hazardous and toxic materials[11]	1999
Waste Management Law No. 18/2008[12]	2008
Regulation of the Minister of Public Works No. 03/PRT/M/2013 on the Implementation of Infrastructure and Facilities in Domestic Waste Disposal. (FAOLEX)	2013

1 *http://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?locations=ID*
2 Pariatamby and Tanaka (2014).
3 Indonesia, President (2008, pp. 2-3).
4 Indonesia, President (1994, p. 1).
5 Ocean Conservancy and Trash Free Seas Alliance (2017, p. 69).
6 UNESCAP (2012, pp. 173-174).
7 Indonesia, Ministry of Environment (2015).
8 Baldé and others (2015, p. 65).
9 FAO, Aquastat (2016).
10 *http://www.aqua-calc.com/page/density-table/substance/sewage-coma-and-blank-sludge*
11 Indonesia, Regulation (1999).
12 Indonesia (2008).

Regulation of the Minister of Trade RI No. 23/M-DAG/PER/9/2011 concerning amendment to Regulation of the Minister of Trade No. 44/M-DAG/PER/9/2009 concerning procurement, distribution and supervision of hazardous material. (FAOLEX)	2011
Regulation of the State Minister for Environmental Affairs No. 2/2010 regarding the application of electronic registration system of hazardous and toxic substances in the framework of Indonesia National Single Window in the Ministry of Environmental Affairs. (FAOLEX)	2010
Decree of the Trade Minister No. 1215/M-DAG/Kep/9/2009 on the appointment of surveyor to conduct technical verification or trace of non-hazardous and toxic (Non B3) waste imports. (FAOLEX)	2009
Regulation of the Trade Minister No. 44/M-DAG/PER/9/2009 on the procurement, distribution and control of hazardous materials. (FAOLEX)	2009
Law No. 18/2008 regarding Rubbish Management. (FAOLEX)	2008
Regulation of the State Minister of Living Environment Affairs No. 13/2007 concerning requirements and procedures in the management of waste water of natural oil, gas and geothermal upstream businesses and/or activities by injection method. (FAOLEX)	2007
Regulation of the State Minister for Environmental Affairs No. 8/2007 on quality standard of waste water of business and/or activities of upstream petrochemical industry. (FAOLEX)	2007
Regulation of the Minister of Agriculture No. 42/Permentan/SR.140/5/2007 on pesticide monitoring. (FAOLEX)	2007
Regulation of the Minister of Public Works No. 21/PRT/M/2006 on National Policy and Strategy of Rubbish Management System Development (KSNP-SPP). (FAOLEX)	2006
Regulation of the Minister of Energy and Mineral Resources No. 045/2006 on treatment of drill mud, mud waste and drill cutting in oil and gas drilling activities. (FAOLEX)	2006
Decree of the Minister of Agriculture No. 818/Kpts/RC.220/10/98 RE Reports on Monitoring of liquid waste generated by agricultural activities/businesses and or industry. (FAOLEX)	1998
Decree of the State Minister of Environmental Affairs (No. 51 of 1995). (FAOLEX)	1995
Decree No. KEP-01 of 1990 on the Organisation and Work Procedures of the Agency for Environmental Impact Control. (FAOLEX)[13]	1990
Law No. 32/2009: Environmental Protection and Management[14]	2009

13 FAOLEX (2016).
14 Asia Network (2016).

Iran

Country General Information

Total population:	79.11 million (2015)[1]
Urban population:	69.1[1]
Area:	1,648,195 sq km[2]
GNI per capita:	6,550 (GNI per capita, Atlas method, 2014)

Definition

Municipal Solid Waste[3]: solid waste generated by households, offices, shops and hotels

Organic (agricultural) waste: Any wastes resulted from productive activities in the agricultural section including animal refuse, animal corps (cattle, poultry, and aquatic animals), decayed or unusable agricultural products.

Industrial Waste[3]: Any wastes resulted from mine and industrial operations and gas, oil, petrochemistry refinery and power stations wastes and the likes, such as filings, slag and industrial sludge.

Healthcare Waste[3]: means any infectious and harmful wastes generated by hospitals, health and treatment facilities, medical laboratories and other similar facilities. Other harmless hospital wastes are not included.

Solid Waste

MSW[4]

Generation: 10,371,000 tonnes/year (0.64 kg/capita/day, 2008)
Recycling: 16% (6% was recycled, 10% composted,2008)
Disposal: 84% (2008)
Organic (agricultural) waste[5]
Generation: 16.049,000 tonnes/year (2005)

Construction & Demolition Waste (building waste)

Generation: 2,626,519 tonnes/year (2005)[5]

E-waste

Generation: 581,000 tonnes/year (2014)[6]

Healthcare Waste

Generation: 27,198 tonnes/year (2005)[5]

Household Waste Composition (in Tehran)[5]

Stale bread	42.6%
Plastic	10.5%
Paper and cardboard	22.3%
Metal	9%
Glass	1.6%
PET	0.9%
Others	13%

Waste Water

Municipal Waste Water[7]

Generation: 2,554,560,000 tonnes/year (3,548,000 thousand cubic meter, 2010)
Treatment: 637,200,000 tonnes/year (885,000 thousand cubic meter, 2012)

Legal Instruments

Memorandum of Understanding between the Ministry of Environment of the Republic of Turkey and the Department of Environment of the Islamic Republic of Iran.	1996
Regulation on Sanitary Monitoring and Supervision of Toxins and Chemicals.	2007
Waste Management Law[3]	2004
Executive Regulation of the Law on Waste Management.[8]	2005

1 *http://data.worldbank.org/indicator/NY.GNP.PCAP.CD?locations=IR*
2 CIA Factbook (2016).
3 Haddad-e-Adel (n.d.).
4 Nabizadeh and Hassanvand (2008).
5 Damghani and others (2008).
6 Baldé and others (2015, p. 65).
7 FAO, Aquastat (2016).
8 FAOLEX (2016).

Japan

Country General Information

Total population:	126,820,000 (2015)[1]
Urban population:	93.5[1]
Area:	377,962 sq km (2015)[1]
GNI per capita:	36,700 (GNI per capita, atlas method, 2015)[1]

Definition

MSW (general)[2]: Waste other than industrial waste is defined as "municipal solid waste", which the law stipulates must be treated by municipal governments. Municipal solid waste includes waste not classified as industrial waste that is generated through business activities, and this is referred to as "commercial municipal solid waste". While this waste is also treated by municipal governments, the responsibility for treatment remains with the business operators who generated the waste, and thus they must assume the costs of treatment.

Industrial Waste[3]: Twenty types of waste that are generated through business activities and have the potential to cause environmental pollution are designated as "industrial waste". These are ash, sludge, waste oil, waste acid, waste alkali, waste plastics, waste rubber, metal scraps, waste glass and ceramics, animal and plant residue, paper scraps, wood chips, waste textiles, slag, debris, livestock excreta, livestock carcasses, dust, discarded solid matter derived from animals, and matter resulting from the treatment of the above-mentioned industrial waste before disposal. Industrial waste is subject to the polluter pays principle (PPP), under which the entity generating the waste has responsibility for treating it. The law stipulates that the business operators must either treat the waste themselves or outsource treatment to industrial waste treatment businesses licensed by the prefectural governor.

1 *http://data.worldbank.org/indicator/NY.GNP.PCAP.CD?locations=IR*
2 UNEP (2013).
3 Ibid.

Solid Waste

MSW[4]

Generation: 44,320,000 tonnes/year (2014)
Recycling: 20.6% (9,130 thousand tonnes, 2014)
Disposal: 1.2% (4,300 thousand tonnes, 2014)

Organic (agricultural) waste

Generation: 35,109,000 tonnes/year (2010)[5]

Construction & Demolition Waste (building waste)

Generation: 115,813,000 tonnes/year (2010)[5]

E-waste

Generation: 2,200,000 tonnes/year (2014)[6]

Industrial Waste[6]

Generation: 381,210,000 tonnes/year (2011)[7]
Directly recycled: 22% (83,186 thousand tonnes, 2011)
Intermediate treatment: 77% (292,286 thousand tonnes, 2011)
Directly disposed: 2% (5,734 thousand tonnes, 2011)

Healthcare Waste

15,307 thousand tonnes (2010)[8]

Household Waste/MSW Composition[6]

Waste other than containers and wrapping	75.7%
Plastic (Incl. PET)	8.9%
Paper	9.1%
Metal	2.1%
Glass	4%
Other	0.2%

4 Japan, Ministry of the Environment (2014, p. 1).
5 OECD Stat (2010).
6 Yolin (2015, pp. 36, 39).
7 Japan, Ministry of the Environment (2014).
8 Organisation for Economic Cooperation and Development (2010).

Incinerations

Waste Incineration Plants[9]

- Number of plants: 1,162 (down 0.9% from 1,172 in previous year)
- Capacity: 183,511 tons/day (182,683 tons/day in previous year)
- Capacity per plant: 158 tons/day (156 tons/day in previous year)
- Number of plants using residual heat: 764 (778 in previous year)
- Number of plants with power generation facilities: 338 (328 in previous year) (29.1% of total)
- Total power generating capacity: 1,907,000 kilowatts (up 7.7% from 1,770,000 kilowatts in previous year)

Waste Water[10]

Municipal Waste Water

Generation: 12,189,600,000 tonnes/year (16,930,000 thousand cubic meter, 2011)
Treatment: 8,323,200,000 tonnes/year (11,560,000 thousand cubic meter, 2011)
Re-use: 140,400,000 tonnes/year (2011)

Emission

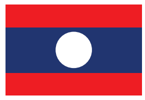
Waste emission[9]: 44,320,000 tonnes/year (947 grams/person/day, 2014)

Legal Instruments[11]

Management and Public Cleansing Act	1970
Act on the Promotion of Effective Utilisation of Resources	1973
Containers and Packaging Recycling Act (enacted in 1995)	1995
Home Appliance Recycling Act (enacted in 1998)	1998
Food Recycling Act (enacted in 2000)	2000
Construction Recycling Act (enacted in 2000)	2000
Automobile Recycling of End-of-Life Vehicles (enacted in 2002)	2002
Small Home Appliance Recycling Act (enacted 2012)	2012
Effective Resource Utilisation Promotion Act	1991
Green Purchasing Act	2000

9 Japan, Ministry of Environment (2014).
10 FAO Aquastat (2011).
11 FAOLEX (2016).

Lao PDR



Country General Information

Total population:	6,802,023 (2015)[1]
Urban population:	38.6% (2015)[1]
Area:	236,800 sq. km (2015)[1]
GNI per capita:	1,730 (GNI per capita, atlas method, 2015)[1]

Solid Waste

MSW

Generation: 77,000 tonnes (0.69 kg/capita/day, 2014)[2]
Collection coverage: 40%-70%[3]
Recycled:9%, only in Vientiane, 2011[4]
Disposal: 91%, only in Vientiane, 20114

E-waste

Generation: 8,000 tonnes (2014)[5]

Healthcare Waste

Generation: 255,500 (700 kg/day maximum, 2005)[6]

Solid Waste Composition[7]

Organic	46%
Paper	6%
Plastic	10%
Glass	8%
Metal	12%
Others	21%

Waste Water

Municipal Waste Water

Generation: 600,192 thousand tonnes (833,600 thousand cubic meter, 2008)[8]

Legal Instruments

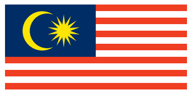
Industrial Waste Discharge[9]	1994
Environmental Protection Law[10]	1999
Law on Hygiene Disease Prevention and Health Promotion[11]	2001
Industrial Law[12]	1999
Regulation on the Monitoring and Control of Wastewater Discharge (No.1122/STENO of 1998)[13]	1998

910 11 12 13

1 World Bank (2015).
2 Lao PDR, Pollution Control Department (2016).
3 AIT RRC.AP (2015).
4 JICA (2011).
5 Lao PDR, Pollution Control Department (2016).
6 Asian Institute of Technology (2008, p. 46).
7 Hoornweg and Bhada-Tata (2012).

8 FAO (2016).
9 Lao PDR, Ministry of Industry-Handicrafts (1994).
10 Viyakhet (1999).
11 Viyakhet (2001).
12 World Bank (2005, p. 47).
13 Baetings and O'Leary (2010, p. 69).

Malaysia



Country General Information[1]

Total population:	30,331,007 (2015)
Urban population:	74.7%
Area:	330,800 sq. km (2015)
GNI per capita:	10,600 (GNI per capita, atlas method, 2015)

Definition

Solid Waste: (a) any scrap material or other unwanted surplus substance or rejected products arising from the application of any process. (b) any substance required to be disposed of as being broken, worn out, contaminated or otherwise spoiled. (c) any other material that according to this Act or any other written law is required by the authority to be disposed of, but does not include scheduled wastes as prescribed under the Environmental Quality Act 1974 (Act 127), sewage as defined in the Water Services Industry Act 2006 (Act 655) or radioactive waste as defined in the Atomic Energy Licensing Act 1984 (Act 304).[2]

Industrial Solid Waste: Any solid waste generated from any industrial activity.[3]

Healthcare Waste: Solid and liquid waste arising from healthcare (including collected gaseous waste).

Solid Waste

MSW

Generation: 10,680,000 tonnes/year (2015)[4]
Recycling: 5%[2]
Incineration with energy recovery: 42% (2013)[5]
Incineration without energy recovery: 56% (2013)[3]

Organic Waste (Agricultural)

Generation: 42,000,000 tonnes/year (1997)[6]

E-waste

Generation: 78,278 tonnes/year (2012)[7]

MSW Waste Composition[6]

Organic	46%
Paper	14%
Plastic	15%
Rubber	3%
Textile	3%
Metal	3%
Glass	3%
Wood	7%
Others	6%

Waste Water

Municipal Waste Water

Generation: 3,043,440,000 tonnes/year (4,227,000 thousand cubic meter, 2009)[9]
Treatment: 1,874,160,000 tonnes/year (2,603,000 thousand cubic meter, 2009)[6]

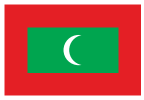
Legal Instruments[10]

Local Government Act, 1976 (Act No. 171)	1976
Atomic Energy Licensing Act 1984, No. 304	1984
Environmental Quality (Prescribed Premises) (Scheduled Wastes Treatment and Disposal Facilities) Order 1989.	1989
Environmental Quality (Prescribed Premises) (Scheduled Wastes Treatment and Disposal Facilities) Regulations, 1989.	1989

1 World Bank (2015).
2 Percetakan National Malaysia Berhad (2007).
3 Malaysia, Department of Environment (2009).
4 Clean Malaysia (2015).
5 Anwar, Z (2013).
6 UNESCAP (2012).
7 Ibrahim (2013).
8 Premakumara and Hengesbaugh (2014, p. 199).
9 FAO (2016).
10 FAOLEX (2016).

Sewerage Services (Charges) (Amendment) Regulations, 2004.	2004
Environmental Quality (Scheduled Wastes) Regulations 2005, PU(A) 294/2005.	2005
Environmental Quality (Prescribed Conveyance) (Scheduled Wastes) Order, 2005.	2005
Environmental Quality (Prescribed Premises) (Scheduled Wastes Treatment and Disposal Facilities) (Amendment) Regulations, 2006.	2006
Solid Waste and Public Cleansing Management Act	2007
Solid Waste and Public Cleansing Management Corporation Act, 2007 (Act No. 673).	2007
Environmental Quality (Scheduled Wastes) (Amendment) Regulations 2007	2007
Guidelines for the Classification of Used Electrical and Electronic Equipment in Malaysia	2008
Environmental Quality (Control of Pollution from Solid Waste Transfer Station and Landfill) Regulations, 2009 – Corrigendum	2009
Environmental Quality (Industrial Effluent) Regulations, 2009	2009
Solid Waste and Public Cleansing Management (Compounding of Offences) Regulations	2011
Solid Waste and Public Cleansing Management (Prescribed Solid Waste Management Facilities and Approval for the Construction, Alteration and Closure of Facilities) Regulations, 2011 (PU(A) 302/2011).	2011
Solid Waste and Public Cleansing Management (Licensing) (Management or Operation of Prescribed Solid Waste Management Facilities) Regulations, 2011 (PU(A) 304/2011)	2011
Solid Waste and Public Cleansing Management (Licensing) (Undertaking or Provision of Transportation Services by Long Haulage) Regulations, 2011 (PU(A) 305/2011	2011
Solid Waste and Public Cleansing Management (Licensing) (Undertaking or Provision of Public Cleansing Management Services) Regulations, 2011 (PU(A) 306/2011)	2011
Solid Waste and Public Cleansing Management (Scheme for Household Solid Waste and Solid Waste Similar to Household Solid Waste) Regulations, 2011 (PU(A) 307/2011).	2011
Solid Waste and Public Cleansing Management (Manner of Appeal) Regulations, 2011.	2011
Atomic Energy Licensing (Radioactive Waste Management) Regulations, 2011	2011

Maldives



Country General Information

Total population:	409,163 (2015)[1]
Urban population:	45.5 (2015)[1]
Area:	300 sq km (2015)[1]
GNI per capita:	6,670 (GNI per capita, atlas method, 2015)[1]

Definition

Industrial Waste: Waste produced or arising from manufacturing or industrial activities or processes[2]

Solid Waste

MSW

Generation: 324,000 tonnes/year (890 MT/day, 2012)[3]
Hazardous waste: 1%[4]
Recycling: 6% (3% from Island, 5%from resort, and 9% from safari vessels, 2012)[4]

Construction & Demolition Waste (building waste)

Generation: 29,000 tonnes/year (9% of MSW, 2012)[4]

E-waste

Generation: 2,000 tonnes/year (6.1 kg/capita/year, 2014)[5]

MSW Composition[4]

Food, garden/yard wastes, and paper products	72.3%[6]
Metals and Plastics	5.7%[6]
Residuals (C&D, wood, paper, concrete, glass, textiles, leather, rubber, batteries)	22%[6]

Waste Water

Municipal Waste Water

Generation: 2,664,000 tonnes/year (3,700 thousand cubic meter, 2000)[7]
(Waste water density value = 0.72)[8]

Legal Instruments

Environmental Protection and Preservation Act of Maldives Law No: 4/93[9]	1993
Maldives Tourism Act Law No. 2/99[10]	1999
Regulation on the Protection and Conservation of Environment in the Tourism Industry.[11]	2006
The National Solid Waste Management Policy for the Republic of the Maldives[12]	2007

1 World Bank (2015).
2 Saleem and others (2008).
3 World Bank (2015).
4 Peterson (2015, pp. 9, 26, 28).
5 UNU (2014).
6 The average percent of Island communities, resorts and safari vessels.
7 FAO (2016).
8 *http://www.aqua-calc.com/page/density-table/substance/sewage-coma-and-blank-sludge*
9 UNESCO (1998).
10 Peterson (2015).
11 FAOLEX (2016).
12 Maldives (2013).

Mongolia

Country General Information[1]

Total population:	3,057,800 (2015)
Urban population:	68.5%
Area:	1,564,120 (2015)
Monthly average income per household:	419 USD

Definition

Municipal Solid Waste[2]: It is domestic and industrial solid waste from materials produced during the process of consumption, production and services, including unwanted waste.

Household and Industrial Waste[3]: Any objects and substance that are created through and from consumption and industrial and service activities and that are not further re-usable for the same purposes.

Hazardous Waste[3]: Waste containing explosive, toxic, flammable, infectious, or actively reactive substances infectious or harmful to humans, livestock, animals or plants, and having potential adverse impact on progeny of humans, livestock, animals or plants and disrupting environmental balance.

Solid Waste

MSW[1]

Generation: 2,452,600 tonnes/year
Collection: 3,300 tonnes/year
Disposal without energy recovery: 2,344,600 tonnes/year

Construction & Demolition Waste (building waste)[1]

Disposal: 126,300 tonnes/year

Industrial Waste[1]

Disposal: 81,400 tonnes/year

Healthcare Waste[1]

935 tonnes/year (only in Ulaanbaatar city)

MSW Composition (only in Ulaanbaatar)[4]

Kitchen	74.3%
Pet Bottles	1.6%
Glass	3.5%
Cans	0.1%
Plastics	1.8%
Paper	3.4%
Other	15.2%

Waste Water[1]

Municipal Waste Water

Generation: 43,766,640 tonnes/year (60,787,000 cubic meter/year, 2015)
(Waste water density value = 0.72)[5]

Legal Instruments[1]

Law on waste	2012
Government resolution No 264	2015
Government resolution No 288	2015
Ministral order No A-116	2014
Government resolution No 263	2015
Ministral order No A-115	2014

1 Jargalsaikhan (2016).
2 RRC.AP, UNEP (2010).
3 Byambadorj (2004, p. 1).

4 Delgermaa and Matsumoto (2016, p. 370).
5 *http://www.aqua-calc.com/page/density-table/substance/sewage-coma-and-blank-sludge*

Myanmar

Country General Information

Total population:	53,897,154 (2015)[1]
Urban population:	34.1%[1]
Area:	676,590 sq.km (2015)[1]
GNI per capita:	1,280 (GNI per capita, atlas method, 2014)[1]

Definition

MSW (general): Non-gaseous and non-liquid waste" that results from the daily activities of community's residential and commercial sector within a given administrative urban area[2]

Solid Waste

MSW

Generation: 1,130,040 tonnes/year (3096 tonnes/day in total in Yangon, Mandalay, Nay Pyi Taw, 2016)[2]

Collection coverage: 92% (in Yangon and Mandalay, 2016)[3]

Recycling: 5% (86 tonnes/day in 2014, only in Yangon city)[3]

Disposal: 92% (1550 tonnes/day in 2014, only in Yangon city)[3]

E-waste

Generation: 29,000 tonnes/year (2014)[4]

Industrial Waste

Generation: 54,750 tonnes/year (150 tonnes/day in Yangon, 2016)[2]

Healthcare Waste

Generation: 985.5 tonnes/year (2.0 and 0.7 tonnes/day in Mandalay and Yangon, 2016)[2]

Solid Waste Composition (only in Yangon)[2]

Food Waste	69%
Plastic	8%
Paper	3%
Green leaves	8%
Textiles	2%
Glasses	1%
Metal	1%
Glue	3%
Others	5%

Waste Water

Municipal Waste Water

Generation: 10,800 tonnes/year (15,000 cubic meter/year, 2016)[2]

Industrial Waste Water

Generation: 3,942,000 to 5,254,000 tonnes/ year (15,000 – 20,000 cubic meter/day, in Mandalay, 2016)[2]

Emission from Waste

2GHG

GHG emissions from waste collection/transport

- 7.51 kg of CO_2eq/tonnes

GHG emissions from open dumping (emissions of CH_4 from open dumping

- 22.88 kg of CH_4/tonnes, direct GHG emission from mixed waste open dumping
- 480.48 kg of CO_2eq/tonnes

1 World Bank (2015).
2 Premakumara and Hengesbaugh (2016, pp. 3, 14-17).
3 IGES (n.d.).
4 Baldé and others (2015, p. 65).

Legal Instruments

The Oilfields Act[5]	1918
The Factories Act[5]	1951
The National Food Law[5]	1997
The Private Industrial Enterprise Law[5]	1990
The Myanmar Mines Law[5]	1994
The Myanmar Pearl Law[5]	1995
The Myanmar Gemstone Law[5]	1995
The Ports Act[5]	1908
Myanmar Foreign Investment Law[5]	2012
The Forest Law[5]	1992
The Protection of Wild Life and Wild Plants and Conservation of Natural Areas Law[5]	1994
The Canal Act[5]	1905
The Pesticide Law[5]	1990
The Fertilizer Law[5]	2002
The Development Committees Law[5]	1993
The City of Yangon Municipal Act, 1922 (The Law Amending the City of Yangon Municipal Act)[5]	1991
The City of Yangon Development Law[5]	
1990 (Amended in 1995 and 1996)	
The Yangon Water-works Act[5]	1885
The Water Power Act[5]	1927
The Underground Water Act[2]	1930
The Yangon Civil Development Law[2]	2013
The Mandalay City Development Law[5]	1992
MCDC Environmental Conservation and Cleansing bylaws[2]	2015
NDC Pollution control and Cleansing Department bylaws[2]	
NDC Water and Sanitation Department Bylaws[2]	
The National Environment Policy of Myanmar[6]	1994
The Environmental Conservation Law No. 9/2012[7]	2012

5 Kyaw (2014).
6 San Oo (2015).
7 Thein Sein (2012).

Nepal

Country General Information

Total population:	28,513,700 (2015)[1]
Urban population:	42%[1]
Area:	147,180 sq. km (2015)[1]
GNI per capita:	730 (GNI per capita, atlas method, 2015)[1]

Definition

Solid Waste[2]: means domestic waste, industrial waste, chemical waste, health institution related waste or harmful waste and this word shall also mean the materials which cannot be used presently, thrown away or in rotten stage or in solid, liquid, gaseous, thick liquid, smoke, or dust form emitted out damaging the environment or materials and equipments used for electrical or information technology or any other materials of such nature or posters, pamphlets posted unauthorised at public places or other substances prescribed as solid waste through publication of notice in the Nepal Gazette by the Government of Nepal from time to time.

Industrial Waste[2]: Harmful and polluted waste discharged from the Industrial Enterprises

Healthcare Waste[2]: Harmful waste produced and discharged from hospital, clinic, pharmacy, medicine shop, blood bank, pathological laboratory, animal health related body or health research centre etc.

Solid Waste

MSW

Generation: 408,000 tonnes/year (1,119.3 tonnes/day[3])[4]

E-waste

Generation: 15,000 tonnes/year (2014)[5]

Solid Waste Composition[6]

Organic	56%
Plastics	16%
Paper and Paper products	16%
Glass	3%
Metal	2%
Textiles	2%
Rubber and leather	1%
Others	4%

Waste Water

Municipal Waste Water

Treatment: 432,000 thousand tonnes/year (600,000 thousand cubic meter 2006)[7]
(Waste Water Density = 0.72)[8]

1 World Bank (2015).
2 Constituent Assembly (2011).

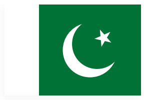
3 Total weight of 58 municipalities in Nepal per day.
4 Central Bureau of Statistics (2013, p. 113).
5 Baldé and others (2015, p. 65).
6 ADB (2013, p. 12).
7 FAO (2016).
8 *http://www.aqua-calc.com/page/density-table/substance/sewage-coma-and-blank-sludge*
9 Pokharel (n.d.).

Legal Instruments

The Constitution of Kingdom of Nepal	1990
The Environment Protection Act[9]	1996
Solid Waste Management and Resource Mobilisation Act[8]	1986
The Labor Act[8]	1991
Industrial Enterprise Act[8]	1992
Acts Relevant Provisions Local Self-Governance Act[8]	1998
Forest Acts[8]	1992
Water Resources Act[8]	1992
Electricity Act[8]	1992
Vehicle and Transport Management Act[8]	1992
Industrial Enterprises Act[8]	1992
Pesticide Act[8]	1991
Labour Act[8]	1991
Soil and Water Conservation Act[8]	1982
Tourism Act[8]	1978
National Parks and Wildlife Conservation Act[8]	1973
National Health Care Waste Management Guidelines[10]	2002
Health Care Waste Management[8]	2002
Solid Waste Management Act[11]	2011

10 Nepal, National Health Research Council (2002).
11 Constituent Assembly (2011).

Pakistan



Country General Information

Total population:	188,924,874 (2015)[1]
Urban population:	38.8[1]
Area:	796,100[1]
GNI per capita:	1,440 (GNI per capita, atlas method, 2015)[1]

Solid Waste

MSW

Generation: 18,410,000 tonnes/year (50,438 tons/day
0.84 kg/capita/day, 2009)[2]
Recycling: 13.6%-23.55% (2005)[3]

E-waste

Generation: 266,000 tonnes/year (1.4 kg/capita/year, 2014)[4]

Solid Waste Composition[5]

Food Waste	30%
Leather	1%
Paper	6%
Plastic	9%
Rubber	1%
Metals	4%
Wood	2%
Yard Wastes	14%
Ash, Bricks & Dirt	18%
Glass	6%
Textile	2%
Cardboard	7%

Waste Water

Municipal Waste Water

Generation: 906,480,000 tonnes/year (1,259,000 thousand cubic meter, 2011)[6]
(waste water density = 0.72)[7]

Legal Instruments

Cantonment Act 1924 (section 132)[8]	1924
Islamabad Capital Territory Bye Laws[9]	1968
Lahore Development Authority Act, 1975 (Pb. Act No. XXX of 1975).[10]	1975
Sind Fisheries Ordinance, 1980 (Sind Ordinance No. III of 1980)Part I.[9]	1980
Pakistan Environmental Protection Act (section 11)[9]	1997
Punjab Environmental Protection Act, 1997 (No. XXXIV of 1997)[9]	2004
Hazardous Substances Rules[11]	2003
New Murree Development Authority Act, 2004 (Pb. Act No. I of 2004)[9]	2004
Hospital Waste Management Rules[12]	2005

1 World Bank (2015).
2 Hoornweg and Bhada-Tata (2012, p. 82).
3 Pakistan Environmental Protection Agency (2005, p. 11).
4 Baldé and others (2015, p. 65).
5 Mahar (n.d., p. 11).

6 FAO (2016).
7 *http://www.aqua-calc.com/page/density-table/substance/sewage-coma-and-blank-sludge*
8 *http://bdlaws.minlaw.gov.bd/sections_detail.php?id=133&sections_id=8176*
9 Rahman (2013, p. 4).
10 FAOLEX (2016).
11 FAO (2003).
12 Ibid.

Philippines

Country General Information

Total population:	100,998,376 (2015 est.)[1]
Urban population:	44.4% (2015)[1]
Area:	300,000 (2015)[1]
GNI per capita:	3,540 (GNI per capita, Atlas method)

Definition

Municipal Solid Waste: It is produced from activities within local government units including a combination of domestic, commercial, institutional, industrial wastes and street litters

Solid Waste

MSW

Generation[2]: 14,400,000 tonnes/year
Collection Coverage: 90%/80%[2]
Recycling: 28% (of MSW)[3]

MSW Composition by Waste Streams[4]

Residential	56.7%
Commercial	27.1%
Industrial	4.1%
Institutional	12.1%

E-waste

Generation: 127,000 tonnes/year (2014)[5]

Solid Waste Composition[2]

Biodegradable waste	52.31%
Paper and cardboard	8.7%
Plastics	10.55%
Metals	4.22%
Glass	2.34%
Textile, Leather, and Rubber	1.97%
Residual Waste	17.98%
Special Waste	1.93%
Total	100%

Waste Water

Municipal Waste Water

Generation: 906,480,000 tonnes/year (1,259,000 thousand cubic meter, 2011)[6]
Wastewater density value = 0.72[7]

Emission from Waste

GHG

Legal Instruments[8]

Sewer Use Regulations (Resolution No. 51-1971).	1971
Philippine Environment Code.	1988
Toxic Substances and Hazardous and Nuclear Wastes Control Act No. 6969 of 1990.	1990
DENR Administrative Order No. 29 implementing Rules and Regulations of the Republic Act No. 6969.	
Date of text: 1992	1992
Ecological Solid Waste Management Act No. 9003 of 2000.	2000
Implementing Rules and Regulations of the Philippine Ecological Solid Waste Management Act of 2000.	2001

1 World Bank (2015).
2 Ocean Conservancy and Trash Free Seas Alliance (2017, p. 69).
3 http://goo.gl/8fLQl5
4 National Solid Waste Management Commission (2015, p. 6)
5 Baldé and others (2015, p. 65).
6 FAO (2016).
7 *http://www.aqua-calc.com/page/density-table/substance/sewage-coma-and-blank-sludge*
8 FAOLEX (2016).

DENR Administrative Order No. 24 of 2013 on the Chemical Control Order (CCO) for Lead and Lead Compounds.	2013
Administrative Order No. 47 of 2015 creating an Inter-Agency Task Force on Arsenic Risk Reduction and Management.	2015
DENR Administrative Order No. 19 on Rules and Procedures for the Implementation of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS).	2015

Republic of Korea

Country General Information

Total population:	50,617,045 (2015)[1]
Urban population:	82.5[1]
Area:	100,266 sq. km (2015)[1]
GNI per capita:	27,400 (GNI per capita, atlas method, 2015)

Solid Waste

MSW[2]

Generation: 143,996,000 tonnes/year (construction: 186,629 tonne/day, general: 146,390 tonne/day, residential: 48,990 tonne/day, designated waste: 12,501 tonne/day, 2012)

Construction and Demolition Waste[2]

Generation: 68,119,600 tonnes/year (186,629 tonnes/day, 2012)
Recycling: 27.2%
Incineration with energy recovery: 0.5%
Disposal: 2.2%

E-Waste

Generation: 804,000 tonnes/year (2014)[3]

Solid Waste Composition[4]

Food	8.1%
Paper	35.1%
Wood	1.6%
Plastics	21.4%
Fabric Rubber Leather	1.7%
Miscellaneous Combustibles	25.1%
Incombustibles	7%

Waste Water

Municipal Waste Water[5]

Generation: 5,643,360,000 tonnes/year (7,838,000 thousand cubic meter, 2011)
Treatment: 4,739,760,000 tonnes/year (6,583,000 thousand cubic meter, 2011)

Legal Instruments[6]

Enforcement Decree of the Act on the Disposal of Sewage, Excreta and Livestock Wastewater	2004*
Act on the Disposal of Sewage, Excreta and Livestock Wastewater.	2005*
Promotion of Installation of Waste Disposal Facilities and Assistance, etc. to Adjacent Areas Act.	2005*
Wastes Control Act.	2007*
Enforcement Decree of the Wastes Control Act.	2008*
Toxic Chemicals Control Act.	2008*
Act on the Control of Transboundary Movements of Hazardous Wastes and their Disposal.	2008*
Enforcement Decree of the Act on the Control of Transboundary Movement of Hazardous Wastes and their Disposal.	2008*
Enforcement Decree of the Toxic Chemicals Control Act.	2009*
Enforcement Decree of the Marine Environment Management Act (Presidential Decree No. 20544 of 2008).	2010*
Marine Environment Management Act.	2010*
Act on the Management and Use of Livestock Excreta.	2011*
Act on the Promotion of Saving and Recycling Resources.	2011*

1 World Bank (2015).
2 Korea, Ministry of Environment (2012).
3 Baldé and others (2015, p. 64).
4 Ryu (2010, p. 170).

5 FAO (2016).
6 FAOLEX (2016).
* reprint

Enforcement Decree of the Wastes Control Act (No. 24119).	2012*
Act on Registration, Evaluation etc. of Chemicals.	2013
Act on the Management and Use of Livestock Excreta.	2013*

Singapore

Country General Information

Total population:	5,540,000 (2015)
Urban population:	100% (2015)
Area:	717 square kilometers (2015)
GNI per capita:	52,100 USD (Atlas method)[1]

Solid Waste

MSW[2]

Generation: 7,670,000 tonnes/year (2015)
Recycled (material recovery): 61% (2015)
Incineration with energy recovery: 37% (2015)
Incineration/disposal without energy recovery: 2% (2015)

Organic Waste[2]

Generation: 1,520,000 tonnes/year (2015)
Recycled (material recovery): 41% (2015)
Incineration with energy recovery: 59% (2015)
Incineration/disposal without energy recovery: 0% (2015)

Construction and Demolition Waste[2]

Generation: 1,411,000 tonnes/year (2015)
Recycled: 99% (2015)
Incineration with energy recovery: 0% (2015)
Incineration without energy recovery: 1% (2015)

Biohazardous Waste

Generation: 5,770 tonnes/year (33,940 cubic meter, 2015)[3]
Density value (hospital general waste garbage bags-medium) = 170kg per cubic meter[4]

Healthcare Waste

Generation: 985.5 tonnes/year (2.0 and 0.7 tonnes/day in Mandalay and Yangon, 2016)[2]

Solid Waste Composition[5]

Construction Debris	18%
Used slag	5%
Ferrous metal	18%
Scrap tyres	0%
Non-Ferrous metals	2%
Wood	5%
Horticultural Waste	5%
Paper/Cardboard	16%
Glass	1%
Ash & Sludge	3%
Food	10%
Textile/Leather	2%
Plastics	11%
Others (stones, ceramic, rubber, etc.)	5%

Waste Water

Municipal Waste Water

Generation: 367, 920,000 tonnes/year (511,000 thousand cubic meter, 2013[6]; Waste water density value = 0.72 tonne per cubic meter[7])

Treatment: 100% (2013)[8]

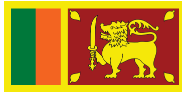
Legal Instruments[9]

Environmental Public Health (Public Cleansing) Regulations.	1970
Environmental Public Health (General Waste Collection) Regulations.	1989
Hazardous Waste (Control of Export, Import and Transit) Regulations.	2000
Environmental Public Health Act (Public Cleansing) (Amendment) Regulations 2001.	2001
Hazardous Waste (Control of Export, Import and Transit) Act (Chapter 122a).	2003*

1 World Bank (2015).
2 Singapore, National Environment Agency (2016).
3 Singapore, National Environment Agency (2015).
4 EPA (2016).
5 Singapore, National Environment Agency (2015).
6 FAO (2016).
7 *http://www.aqua-calc.com/page/density-table/substance/sewage-coma-and-blank-sludge*
8 FAO (2016).
9 FAOLEX (2016).
* reprint

Biological Agents and Toxins (Transportation) Regulations, 2005 (No. 875/2005).	2007*
Biological Agents and Toxins (Proficiency Testing) Regulations, 2008 (No. S 82).	2008
Biological Agents and Toxins Act (Amendment of First and Second Schedules) Order, 2009.	2009
Biological Agents and Toxins (Exemption) Regulations, 2009.	2009
Environmental Public Health (Toxic Industrial Waste) Regulations.	2009
Environmental Protection and Management (Trade Effluent) Regulations (No. S 160/1999).	2011*
Environmental Protection and Management (Hazardous Substances) Regulations (No. S 159/1999).	2011*
Environmental Protection and Management Act (Chapter 94A).	2014*
Protection Act, 2007 (Act No. 27 of 2007).	2014*
Environmental Public Health Act (Chapter 95) 1987.	2014*
Biological Agents and Toxins Act (Chapter 24A of 2005).	2015*

Sri Lanka



Country General Information

Total population:	21,000,000[1]
Urban population:	18.4%[1]
Area:	65,610 sq km[1]
GNI per capita:	3,800 (GNI per capita, atlas method, 2015)

Definition

Solid Waste[2]: The discarded materials, substances or objects which originate (or refuse) from domestic, business and industrial sources, including household wastes which are typically disposed of in municipal type landfills, but not including industrial hazardous or 'special wastes'.

Organic (agricultural) Waste[2]: Agricultural wastes are of two types, namely farm sector wastes and agricultural process wastes. Farm sector wastes are generated post harvest in the farm such as cotton stems, cereal straw etc; Process wastes are generated in the processing of agricultural produce such as bagasse from sugar mills, rice husk from rice mills, saw dust from saw mills, cotton fibre process waste from cotton fibre mills etc.

Hazardous Waste: Industrial hazardous waste shall consist of waste exhibiting one or more hazardous characteristics, such as being flammable, oxidizing, poisonous, infectious, corrosive, ecotoxic or radioactive and includes health care, clinical and related wastes.[3]

Special Wastes: Wastes (not hazardous) that require handling considerations during disposal.[3]

1 World Bank (2015).
2 Sri Lanka Standards Institution (2003).
3 Sri Lanka, Hazardous Waste Management Unit (n.d.).

Solid Waste

MSW

Generation: 5,499,000 tonnes/year (15,068 tonnes/day, 2003)[4]
Collection: 60% in the Western Province; 43% in Colombo District; 25% collected within Colombo Municipal limits

E-waste

Generation: 87,000 tonnes/year (2014)[5]

Solid Waste Composition[6]

Biodegradable	62%
Paper	7%
Polythene & Plastic	6%
Wooden	6%
Glass	2%
Others	17%

Waste Water

Municipal Waste Water

Generation: 85,032,000 tonnes/year (118,100 thousand cubic meter, 2009)[7]

4 Hoornweg and Perinaz Bhada-Tata (2012).
5 Baldé and others (2015).
6 Central Environmental Authority (n.d.).
7 FAO (2016).

Legal Instruments

Urban Council Ordinance – No 61 of 1939 – Sections 118, 119, 120[8]	1939
Municipal Councils ordinance – No. 16 of 1947 – Sections 129, 130, 131[9]	1947
National Environmental Act No. 47 1980[10]	1980
Pradeshiya Sabha Act - No 15 of 1987 - Sections 93, 94, 95[11]	1987
The Sri Lanka Standard 1246: 2003 (UDC 628.477.4) Specification for Compost from Municipal Solid Waste Management and Agricultural Waste, Sri Lanka Standard Institution[12]	2003
Policy Statements and Strategies[13]	2007
National Environmental (Protection and Quality) Regulations, No. 1 of 2008.[14]	2008

8 Laws of Sri Lanka (n.d.).
9 Fernanco and others (2014).
10 Central Environmental Authority (1980).
11 Sri Lanka Consolidated Acts (1987).
12 Sri Lanka Standards Institution (2003).
13 Wel and Post (2007).
14 FAOLEX (2016).

Thailand

Country General Information

Total population:	67,959,259 (2015)[1]
Urban population:	50.37[1]
Area:	513,120 sq.km (2015)[1]
GNI per capita:	5,260 (GNI per capita, atlas method, 2015)

Solid Waste

MSW[2]

Generation: 26,850,000 tonnes/year (from service area: 10.47 million tonnes- 76.23%; from no-service area: 6.38 million tonnes - 23.77%, 2015)
Hazardous: 576,000 tonnes/year (2015)

From Service Area
Collection Coverage: 57.69% (15.49 million tonnes/year, 2015)
Reused: 17.65% (4.74 million tonnes/year, 2015)
Utilised: 0.15% (0.04 million tonnes/year, 2015)
Landfilled: 25.66% (6.89 million tonnes/year, 2015)
Composted: 1.82% (0.49 million tonnes/year, 2015)
Incinerated: 1.52% (0.41 million tonnes/year, 20145)
Others: 1.90% (0.51 million tonnes/year, 2015)
Incorrectly disposed: 26.63% (7.15 million tonnes/year, 2015)

From No-Service Area
Reused: 0.6% (0.16 million tonnes/year, 2015)
Incorrectly disposed: 23.17% (6.22 million tonnes/year, 2015)

Organic (agricultural) waste[2]

Generation: 82,230,000 tonnes/year (2004)

E-waste

Generation: 591,000 tonnes/year (2015)
Hazardous: 7.5% (2015)

Industrial Waste

Generation: 2,800,000 tonnes/year (2015)

Healthcare Waste

Generation: 53,868 tonnes/year (2014)

Incineration with energy recovery: 65%

Solid Waste Composition

Glass	11.6%
Paper	18.5%
Plastics	8.7%
Steel/Metal	7.3%
Aluminum	2.8%
Rubber	1.8%
Others	49.3%

Waste Water

Municipal Waste Water[2]

Generation: 2,520,348,000 tonnes/year (9,590,367 cubic meter/day, 2015)
Treatment: 26.9% (678,188 thousand tonnes/year; 2,580,625 cubic meter/day, 2015)
(Waste water density = 0.72)[3]

Legal Instruments

Public Health Act[4]	
National Solid Waste Management Policy[5]	2007
Code of Penalty[5]	
BMA Ordinance: Disposal of Garbage, Refuse and Unclean Thing[5]	1978
Industrial Estate Act[5]	1979
Construction Building Control Act[5]	1979
BMA Ordinance: Control of Water Sewage System[5]	1991
Enhancement and Conservation of National Environmental Quality Act 1992 (NEQA)[5]	1992
Factory Act[5]	1992
The Enhancement and Conservation of National Environmental Quality Act (NEQA)[5]	1992

1 World Bank (2015).
2 Thailand, Pollution Control Department (2015, p. 6, 78,178).
3 *http://www.aqua-calc.com/page/density-table/substance/sewage-coma-and-blank-sludge*
4 Thailand, Bangkok Metropolitan Area (2009, p. 4, 12, 20, 23).
5 FAOLEX (2016).

Public Cleanliness and Orderliness Act (PCOA)[5]	1992
Hazardous Substance Act (B.E. 2535)[5]	1992
Ministerial Regulation (B.E. 2537) carrying into effect the Hazardous Substance Act B.E. 2535. [5]	1994
BMA Ordinance: Specifying Requirements for Construction of Building and Public Utilities[6]	1996
BMA Ordinance: Control of Waste Collection, Haulage, or Elimination Business which is made for Consideration as Service Fee [7]	1998
Hazardous Substance Act 1992 and 2001[7]	2001
The Constitution of the Kingdom of Thailand B.E.2550[7]	2007
Atomic Energy for Peace Act 1961 Amended in 2008[7]	2008

6 Bangkok Metropolitan Area (2009).
7 Jiaranaikhajorn, T. (n.d., p. 11).

Timor-Leste

Country General Information

Total population:	1,245,015 (2015)[1]
Urban population:	32.8[1]
Area:	14,870 (2015)[1]
GNI per capita:	1,920 (GNI per capita, atlas method, 2015)[1]

Solid Waste

MSW

Generation: 768,000 tonnes/year (18,564[2] cubic meters/day: 768,370[3] tonnes/year)

E-Waste

Generation: 5,000 tonnes/year (2014)[4]

Legal Instruments

Regulation on Hazardous and Toxic Waste Management[5]	1994
Environmental Management Act[6]	1997

1 World Bank (2015).
2 ADB (2014).
3 *https://goo.gl/hpA6iV; http://www.metric-conversions.org/weight/tonnes-to-pounds.htm*
4 Baldé and others (2015, p. 65).
5 The President of the Republic of Indonesia (1994).
6 ECOLEX (1997).

Viet Nam

Country General Information

Total population:	91,700,000 (2015)[1]
Urban population:	33.6 (2015)[1]
Area:	330,972 sq km (2015)[1]
GNI per capita:	1,980 (GNI per capita, atlas method, 2015)[1]

Definition

Municipal Solid Waste[2]: Means waste in a solid form, discharged from production, business, service, daily life or other activities. Solid waste includes ordinary solid waste and hazardous solid waste. Solid waste generated in daily-life activities of individuals, households, or at public places is collectively referred to as daily-life solid waste. Solid waste generated in industrial production, craft villages, business and service activities or other activities is collectively referred to as industrial solid waste.

Construction and Demolition (Building) Waste[2]: The waste arising from construction and demolition activities.

Industrial Waste[2]: The wastes arising from processing and non-processing industries and utilities.

Solid Waste

MSW

Generation[3]: 12,800,000 tonnes/year
Collection: 72% (2014)[2]

Organic Waste

Generation[4]: 75,000,000 tonnes/year (2010)

E-waste

Generation[4]: 116,000 tonnes/year (2014)[2]

1 World Bank (2015).
2 Pariatamby and Tanaka (2014).
3 Ocean Conservancy and Trash Free Seas Alliance (2017, p. 69).
4 Viet Nam, Department of Pollution Control (2016).

Industrial Waste

Generation[4]: 9,600,000 tonnes/year (2015)[2]
Hazardous: 20% (of Industrial wastes)[2]

Healthcare Waste

Generation[4]: 200,000 tonnes/year (2015)[2]
Hazardous[3]: 16-21% (2011)3
Incineration with energy recovery[3]: 37%

MSW Composition[3]

Food Waste	41.9%
Plastics	15.6%
Paper	1.9%
Metal	6%
Glass	7.2%
Other	27.4%
Total	100%

Waste Water

Municipal Waste Water

Generation: 141840 (197,000 thousand cubic meter, 2012)[5]
Treatment: 141,840 (197,000 thousand cubic meter, 2012)4

Legal Instruments

Decision no. 155/1999QD-TTg: Promulgating the regulation on management of hazardous wastes[6]	1999
Ordinance No. 38/2001/PL-UBTVQH dated August 28, 2001[7]	2001
Inter-Ministerial Circular No. 01/2001/TTLT-BKHCNMT-BXD dated January 18, 2001	2001
Direction 01/2001/TTLT-BKHCNMT-BXD	2001
Circular No. 63/2002/TT-BTC dated July 24, 2002	2002

5 FAO (2016).

Decision 03/2004/QD-BTNMT	2004
Ordinance against dumping of imported goods into Viet Nam	2004
MONRE Decision No.23/2006/QD-BTNMT[8]	2006
MONRE Circular No.12/2006/TT-BTNMT[9]	2006
Decree No.12/2006/ND-CP	2006
Circular No. 45/2006/TT-BTC dated May 25, 200610[11]	2006
MOIT and MONRE Inter-ministerial circular 02/2007/TTLT-BCT-BTNM[12]	2007
Circular No.121/2008/TT-BTC dated 12 December 2008[13]	2008
Decree 121/2008/TT-BTC dated 12/12/2008	2008
Decision No. 798/QD-TTg dated 25 May 2011[14]	2011
The National Environmental Protection Strategy towards 2020 with a vision to 2030[15]	2012
Decision No. 5737/QD-BCT[16]	2012
The National Strategy of 2009 on Waste Management towards 2025 with a vision to 2050[17]	2013
Law on Environmental Protection (no. 55/2014/qh13) – revised in 2014[18]	2004
Decree 38/2015/ND-CP on waste and scrap management (dated 22 April 2015)[19]	2015

6 Viet Nam, The President (2006).
7 Minh Khue Law Firm (2001).
8 Viet Nam, MONRE (2006).
9 Viet Nam, Ministry of Trade (2006).
10 Ibid.
11 Minh Khue law Firm (2002).
12 Viet Nam, MOI, MOT, and MONRE (2005).
13 Viet Nam, Ministry of Finance (2008).
14 Minh Khue Law Firm (2015).
15 Viet Nam, The Prime Minister (2012).
16 Ministry of industry and Trade (2012).
17 MONRE (2013).
18 The President (2014).
19 Viet Nam, Ministry of Finance (2008).

Office e-waste, Thailand.

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City Profiles

Beijing • Colombo City • Hanoi • Jakarta • Kathmandu • Kuala Lumpur • New Delhi • Tokyo • Ulaanbaataar

Beijing

General Information

Total population: 21,710,000[1]
Urban Population: 86.5 %[1]
Peri-urban informal Population:13.5%[1]
Area: 16,411 sq. km[1]

Municipal Solid Waste (Consumption Waste)

Generation

7,903,000 (2015)[2]

Organic (biodegradable)

66.98% (2010)[3]

Treatment

26 factories for waste treatment
14 landfills, 6 incinerators, and other 6

Treatment rate of MSW

78.8%

Treatment Capacity

23,821 tonnes/day (landfill- 8,621 tonnes/day, incinerate 10,400 tonnes/day; other 4,800 tonnes/day)[2]

Disposal

62,240,000 tonnes/year (landfill – 32,580,000 tonnes/year; incinerate – 20,940,000 tonnes/year; others-873,000 tonnes/year)[2]

1 National Bureau of Statistics of China (2016a).
2 National Bureau of Statistics of china (2016b).
3 Wang, Hao and Chunmei Wang (2013, p. 69).

Colombo City

General Information

Area: 38 sq.km[1]
Total population: 506,720[1]

MSW

Generation

428,000 tonnes/year[1]

Collection

Solid waste collection by Colombo Municipal Council covered 84%.[1]

Organic (biodegradable)

56.57%[2]

Treatment

Only 3% of solid waste generated were recycled.[1]

Disposal

Colombo has 3 landfills
Meethotamulla, Bloemendhale and Madampitiya.[3]

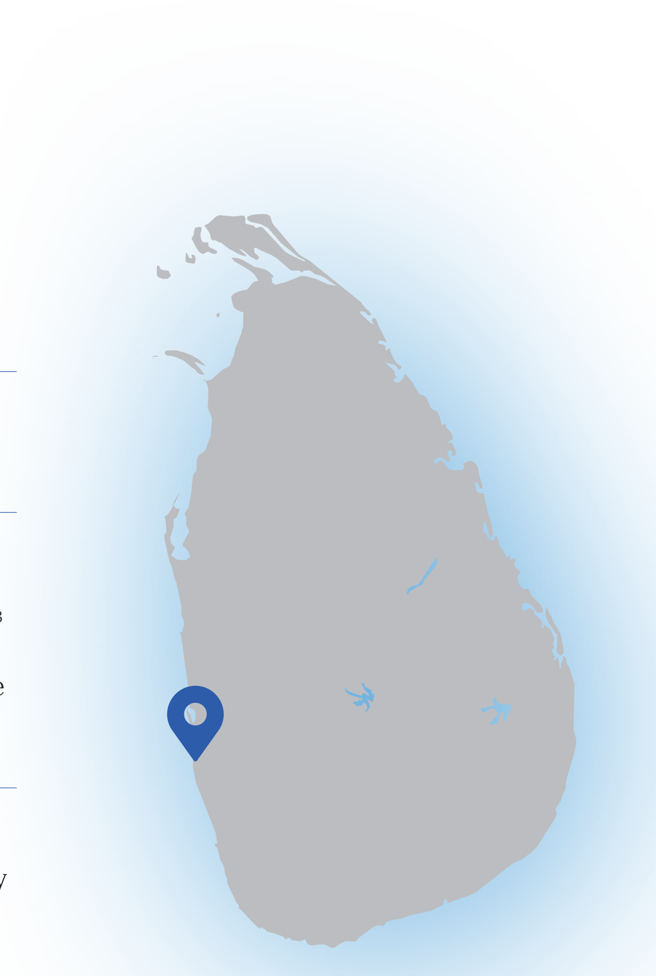
80.7% of the total solid waste was disposed to the landfill.[1]

Budget for Waste Management

113.5 million USD was spent by Central Authority for solid waste management.[1]

Projects

Pilisaru Waste Management Project has been taken up an national level to promote decentralised waste management measures to make Sri Lanka "waste-free" by 2018.[4]



1 Tool for Rapid Assessment of City Energy (2014, pp. 14, 32).
2 Premachandra (2006, p. 5).
3 Kularatne (2015).
4 Central environmental authority (2008).

Hanoi

General Information

Area: 3,324.5 sq.km[1]
Total population: 7,087,700[1]

Projects

Eco-bag campaign, segregation at source, recycling of organic waste.[4]

MSW

Generation
2,390,750 tonnes/year[2]

Collection
85% of total solid waste in Hanoi was collected[3]

Organic
41.98% of MSW[4]

Treatment

There is one composting plant in Cau Dien which received 50 tonnes per day produced 8 tonnes of organic fertilizer daily. Other two composting plants are Kieu Ki and Seraphin.[2]

Composting
2% of MSW

Recycling
8.2% of MSW[3]

Disposal

There are currently five landfill sites: Nam Son treatment complex, Nam Son treatment factory, Kieu Ky, Nui Thong, and Viet Hung.[2]

Incineration
5.4% of MSW

Disposal
84.4% of MSW[3]

1 General Statistics Office (2014, p. 17).
2 Schoebit and others (2014, pp.13-17).
3 Hanoi Urban Environment Company (2011).
4 Thanh and others (2015, p. 187).

Jakarta

General Information

Area: 660 sq.km[1]
Total population: 10,660,000[2]

Disposal

Bantar Gebang landfill site in Bekasi, West Java received 69% of total MSW every day[5]

MSW

Generation

7,500 tonnes/day, 2015[3]

Collection

70%[4]

Organic

Waste: 55.37%[1]

Composition of MSW by Sources
Residential: 52.97% of MSW2
Industrial Waste: 8.97% of MSW[1]
Institutional Waste (schools, offices, markets): 36.67% of MSW[1]
Others : 1.4% of MSW[1]

Waste to Energy

Though the supreme court did not support, the government accelerated the application of WTE in seven cities (Jakarta, Tangerang, Bandung, Surabaya, Surakarta, Makassar and Semarang)[5].

Projects

Solid waste bank: household inorganic waste collecting activities to raise public awareness and increase the economic value of waste.

Exercising EPR for polystyrene: the actors are communities, local government, NGOs, retailers, schools, offices and polystyrene producers[1].

Treatment

Recycling: 7.5%[5]

1 World Population Review (2016).
2 Environment Management Board (2012, pp. 3-5).
3 Mecca (February 2017).
4 Yeny and Trihadiningrum (2012, p. 331).
5 Jong (2015).

Kathmandu

General Information

Area: 50.67 sq.km[1]
Total population: 1,266,000[2]

MSW

Generation

166,805 tonnes/year (466.14 tonnes/day, 2013)[3]

Collection

86.9% (405 tones/day, 2013)[4]

Organic

43.48%

Treatment

The household waste composition survey revealed that more than 25% of household waste and a much higher proportion of institutional and commercial waste could be either reused or recycled, excluding organic waste. Currently, there is one compost plant in Kathmandu.[3]

Transfer Station

One transfer state in Teku with a capacity of 10,000 tonnes.[5]

Disposal

Sisdol sanitary landfill was constructed by the support of the government of Japan and there is a plan to allocate a new landfill site in the near future. 37% of total solid waste was disposed of.[3]

Budget for Solid Waste Management

2.16 USD per capita[3]

Waste to Energy

Though the supreme court did not support, the government accelerated the application of WTE in seven cities (Jakarta, Tangerang, Bandung, Surabaya, Surakarta, Makassar and Semarang).[5]

1 *http://worldpopulationreview.com/world-cities/kathmandu-population/*
2 Kathmandu Metropolitan City office (n.d.).
3 ADB (2013, pp. 15-16, 38, 41, 43, 45, 54).
4 Regmi (2013, p. 2).
5 Environmental Audit Report (2015, pp. 330, 331).

Kuala Lumpur

General Information

Area: 243 sq.km[1]
Population: 1,790,000[1]

MSW

Generation

1,600,000 tonnes/year (4,383 tonnes/day, 2016)[2]

Collection

80%[3]

Organic

47.5% of the total MWS2[2]

Treatment

The recycling rate in Kuala Lumpur is 3- 5% of total waste.[3]

Waste To Energy

There incineration plant in Selangor (40.8km from city center) run by Core Competencies Sdn Bhd (CCSB) Company had the capacity of 1000 tonnes/day or 8.9 MW of electricity generation, while operating 70% of the actual capacity and generating 5 MW electricity.[2]

Disposal

90% of landfill sites in Malaysia are non-sanitary.[4]

95% of MSW is transported to transfer location in Taman Beringin before they are finally disposed of into Bukit Tagar landfill in Hulu Selangor.[3]

1 Department of Statistics (2016).
2 Fazeli and others (2016, p.1010, 1012, 1014).
3 Osmi and others (n.d., pp. 26-27)

4 Johari and others (2014, p. 41).

New Delhi

General Information

Area: 1,483 sq.km[1]
Population: 18,686,902[2]

MSW

Generation

7,310 tonnes/day[3]

Organic (biodegradable)

38.6%[4]

Treatment

Composting Plant

MCD Plant at Bhalaswa sanitary landfill site with capacity 500 tonnes/day. 7% (480 tonnes/day) of MSW was composed[3] and 500 tonnes per day[5] was recycled.

C&D Waste Processing Plant

M/s IL & FS had installed a processing plant at Jahangirpuri which can process 2000 tonnes per day. Another processing plant of IL & FS with 500 MTD capacity had been commissioned. IL & FS will install 3 more processing plants.[6]

Waste to Energy Plants[7]

Name	Plant Capacity (MTD)	Electricity Generated (MW)
1. Timarpur-Okhla	1950	16
2. Ghazipur	1300	12
3. Narela	3000	24

Disposal

Landfill Sites

Three major landfill sites in New Delhi are Ghazipur (70 acres), Okhla (56 acres), and Bhalswa (40 acres). Jaitpur (26 acres) and Bawana (150 acreas) are being proposed.[3]

MSW disposal

85% (6,230 tonnes/day)[6]

1 *http://www.indiaonlinepages.com/population/delhi-population.html*
2 National Capital Territory-Delhi (n.d.).
3 *https://www.dpcc.delhigovt.nic.in/waste-msw.html*
4 Talyan (2008).
5 Delhi Pollution Control Committee (n.d.)
6 India, Department of Environment (2017).
7 Ghose (2016).

Tokyo

General Information

Area: 2,191 sq.km[1]
Population: 13,491,000[1]

MSW

Generation

4,618,000 tonnes/year, 2013[2]

Collection

68.11% (2013)[2]

Industrial Waste

Generation

23,600,000 tonnes/year (2012) (Sewage Sludge: 13.2 million tonnes; construction and demolition: 8.2 million tonnes).[2]

Treatment

Recycled

About 16.31% of General Waste[2]

Incineration Plant
3,431,484 tonnes combustible waste are treated in 56 places of Incineration plant in 2014.[3]

Pulverisation Processing Plant
153,595 tonnes large-sized waste are treated in 23 place of Pulverisation plant in 2014.[3]

Recycle Plant
314,354 tonnes waste are recycled in 25 place of Recycle Plant in 2014.[3]

Disposal of General Waste

Landfill site
Tokyo Bay[2]

Disposed
355,000 tonnes/year (2013)[2]

Incinerated
76% of General Waste[2]

Disposal of Industrial Waste

Disposed
3.7% of total industrial waste (877,000 tonnes, 2012)[2]

1 Tokyo Metropolitan Government (2015a).
2 Tokyo Metropolitan Government (2015b, pp. 16, 32).
3 Japan, Ministry of the Environment (2014).

Ulaanbaatataar

General Information

Area: 1,359 sq.km[1]
Population: 1,310,000[2]

MSW

Generation

1.1 million tonnes/year

Organic (biodegradable)

(Food): 36% (summer); 23% (winter)[3]

Household

50%[4]

Industry

30%[4]

Streets and public areas cleansing

20%[4]

Treatment

Sorting and recycling is carried out by private sector and a significant proportion of the waste is recycled by small businesses and the remaining items are exported to China for recycling. A programme called 'turning garbage into gold' is currently operated in three outer districts which include 20 production groups.[3]

Small and medium scale recycling plants in operation[4]

- Waste metal recycling plants - 6
- Aluminium and alloy recycling plants - 3
- Plastic bag and plastic material recycling plants - 5
- Waste tire and used oil processing plants -2
- Waste paper recycling plants -5
- Powder compact fuel processing plant -1
- Glass processing plant -1

Disposal

Three Centralised Landfill Sites are Narangiin Enger, Tsagaan Davaa, and Moringiin Davaa . Two of them are not sanitary.

Disposal

2,500-3,000 tonnes/day

Landfill Site	Disposed Quantity Per Day
Narangiin Enger	1124 tonnes (43%)
Tsagaan Davaa	934 tonnes (36%0
Moringiin Davaa	534 tonnes (21%)

1 *http://www.themongolist.com/blog/society/89-rethinking-ulaanbaatar-s-population.html*
2 Altantuya and others (2012).
3 Ulaanbaatar Mayor's Office (2015, p. 8).
4 AIT RRC.AP (2017, p. 18, 20).

Summary of the Benefits of the Economic Instruments

Waste Levy
Tax Breaks
Subsidies
Container Deposits
Material Bans
Material Controls

Waste Levy			
Definition[1]	Levies are financial contributions often imposed by national or local government on waste disposal to provide funding for waste minimisation programmes or to deter disposal. The levy is often charged on a weight or volume basis. Levies can be applied to solid, liquid and gaseous wastes.		
Precondition for success	Levies are typically imposed either locally or nationally. A national levy provides consistency for all participants. Local levies can result in pressures from local, national and international companies who can negotiate with different jurisdictions to get the most favourable conditions. The pressure on local government to provide employment opportunities can be so great that they bow to business demands and lower or remove a levy. Efficient and easy collection is also preconditions for success. A staged process is advised, starting small so that the collection infrastructure can cope with the new requirements before moving to more ambitious collection regimes.		
Stakeholders	National government Local government	Waste collectors Disposal site operators	Informal sector
Impact	The size of the levy can determine its impact. Where the levy is small in comparison to the cost of disposal, it will have very little impact on the quantities disposed of. However, a small levy, if kept separate from general funding, can provide significant finance to fund projects to improve waste management. A large levy can provide impetus to divert waste from disposal but can encourage illegal dumping.		
Benefits	• If properly managed can provide sustainable funding for waste minimisation activities. • A move towards polluter pays through full cost accounting for waste. • Can be structured so that waste minimisation funding is not subject to changeable government priorities. • Can help to provide funding for local projects to move towards urban equilibrium and sustainable cities. • Provides accurate data on waste quantities and diversion rates.		
Challenges	• Managing illegal dumping, particularly in the initial stages of imposing a levy. • Ensuring the levy funds are used for waste management activities. • Convincing business that a levy would only be a small impedance and would provide significant societal good. • Managing exemptions so that the system is easy to manage and avoids corrupting the system.		

1 Seadon, J. (2015).

Tax Breaks

Definition[2]	Taxes and charges can be imposed on goods linked to polluting activities where the pollutants are solids, liquid or gases. A tax break provides for avoidance of those taxes and includes tax exemptions, deductions or credits. Tax breaks can be applied at either national or local government level to encourage producers and consumers to choose inputs and goods that have desirable environmental aspects.
Precondition for success	The tax break must be easy to administer and clear on what is within its scope. The tax break also needs to be broad based (e.g. should cover all industries and entities engaged in an activity such as reuse or recycling).
Stakeholders	National government Local government Affected sector Informal sector
Impact	The size of the break can indicate the level of driver that a tax break will provide. For example, tax breaks are often used for purchase of equipment that will reduce pollution in waste management services and facilities[3]. This equipment can be quite expensive and, as tax is normally calculated as a percentage of the cost, the break can be quite significant. These instruments are often combined with performance obligations that reduce the risk for an enterprise to make the process viable.
Benefits	• Incentivises industry to adopt practices that are less polluting. • Enables the producer to provide a price difference for an environmental good. • Can be a driver to better practice in markets where environmental performance is a significant factor. • Can provide new employment opportunities
Challenges	• Ensuring the activities that get the breaks actually do what they claim. • Monitoring and auditing performance criteria. • Ensuring it is economic over the expected life of any equipment the break was applied to.

2 Ibid.
3 UNEP (2015). GWMO, p. 157.

Subsidies	
Definition[4]	Subsidies can be given to goods linked to non-polluting activities. Subsidies can be applied at either national or local level to encourage producers and consumers to choose inputs and goods that have desirable environmental aspects.
Precondition for success	The subsidies must be easy to administer and be clear on what is within scope. They also need to be broad based (e.g. industries and entities engaged in an activity like reuse or recycling).
Stakeholders	National government Local government Affected sector Informal sector
Impact	The size of the subsidy can indicate the level of driver that a subsidy will provide. For example, subsidies are often used to introduce new services or to assist those that are uneconomic to carry on but have identifiable economic, social and/or environmental benefits. These instruments are often combined with performance obligations that reduce the risk for an enterprise to make the process viable.
Benefits	• Incentivises industry to adopt practices that are less polluting. • Enables the producer to provide a price difference for an environmental good. • Can be a driver to better practice in markets where environmental performance is a significant factor. • Can provide new employment opportunities
Challenges	• Ensuring the activities that get the subsidy actually do what they claim. • Monitoring and auditing the performance criteria. • Ensuring it is economic over the expected life of any equipment the subsidy was applied to.

4 Seadon, J. (2015).

Container Deposits	
Definition[5]	Container deposits institute a monetary deposit on containers (often beverage containers) when sold. Return of the container to an authorised centre, or, dependent on the jurisdiction, to the original seller, releases the deposit (sometimes minus a service charge) to the redeemer. More sophisticated operations can include reverse vending machine where people can insert their container into a machine that then returns the deposit.
Precondition for success	An efficient collection and storage system is needed so that the location is secure from vermin and criminals. An efficient accounting system is also needed that connects those selling the container and those collecting containers with an agency that oversees the programme.
Stakeholders	National government Local government Container retailers Container collectors Recyclers Informal sector
Impact	Countries that institute deposit systems can achieve high return rates of those containers and people get rewarded for doing an environmental good.
Benefits	• Encourages recycling • Can complement kerbside recycling schemes • Provides employment in both the formal and informal sectors • Assists with litter reduction • Reduces material going to landfill • Can provide revenue for community organisations through cleaning up litter and returning the containers for refund of the deposit. • Unredeemed deposits can offset the cost of the scheme or even be used to fund environmental programmes
Challenges	• Increases the initial purchase price for beverages • Can undermine current recycling systems (e.g. kerbside) that depend on the payback achieved from the materials to offset the costs of collection (by people not putting out their containers or scavengers picking them up before the official collectors come through). • Must be easy to engage with. • Litter is still a problem because not all of it can be exchanged for money (e.g. cigarette butts and food scraps)

5 Seadon, J. (2015).

Material Bans			
Definition[6]	Regulations to ban the disposal of specified materials or products to landfill		
Precondition for success	Before such a ban is put in place an alternative system that is easy for consumers to engage with must be available.		
Stakeholders	National government Local government	Manufacturers Retailers	Recyclers Informal sector
Impact	Material bans are normally put in place to assist recyclers to generate a viable market for a product that often would take up a lot of space in a landfill (e.g. polystyrene or tyres).		
Benefits	• Lengthens the life of landfills. • Assists the recycling or reuse market.		
Challenges	• Initially there is often an increase in dumping of the banned material. • Making the diversion mechanism easy to engage with.		

6 Seadon, J. (2015).

Material Controls

Definition[7]	Controlled wastes are wastes that are regulated due to their toxicity, hazardous nature or their capability to do harm to human health or the environment.		
Precondition for success	A suitable enforcement system so that the controls are obeyed.		
Stakeholders	National government Local government Manufacturers	Retailers Recyclers	Waste collectors Informal sector
Impact	The removal of controlled wastes from the waste stream provide positive impacts for the health of people who would be exposed to the waste, had it not been controlled. In addition, removing the waste from the environment will reduce degradation of the environment.		
Benefits	• Reduction in health impacts • Reduction in environmental impacts • Reduction in the cost to treat people or the environment.		
Challenges	• Ensuring compliance • Providing effective alternative pathways for the wastes to be neutralised • Ensuring the chain of responsibility is adequately maintained to avoid the cheaper option of dumping		

7 Seadon, J. (2015).

Recycled tyres.

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List of 226 Legislative Tools found on the ECOLEX

Country	Title	Year
Afghanistan	Environmental Law	2007
	Mining Regulations	2010
Bangladesh	Bangladesh Water Act, 2013	2013
	Rule for the Conservation of the Environment	1997
	Bangladesh Environment Conservation Act, 1995	1995
	Mines and Mineral Resources (Control and Development) Act No.39, 1992	1992
Bhutan	Water Act of Bhutan, 2011	2011
	National Environment Protection Act, 2007	2007
	Pesticides Act of Bhutan, 2000	2007
	Disposal of dead animals 1981	1981
	Regulation for the Environmental Clearance of Projects	2001
	Mines and Minerals Management Act, 1995	1995
	Waste Prevention and Management Act of Bhutan, 2009	2009
	Waste Prevention and Management Regulation, 2012	2012
Brunei Darussalam	Hazardous Waste (Control of Export, Import and Transit) Order, 2013.	2013
Cambodia	Law on the Management of Pesticides and Fertilizers	2012
	Law on Water Resources Management of the Kingdom of Cambodia	2007
	Instructive Circular No. 345 implementing Sub-Decree No. 96 ANK-BK on Standards and Management of Agricultural Materials.	2002
	Sub-Decree On Solid Waste Management	1999
	Sub-decree on air pollution	1999
	Law on Environmental Protection and Natural Resource Management	1996
China	Requirements of the Industry Standards for the Comprehensive Utilisation of Waste Power Storage Batteries of New Energy Vehicles	2016
	Administrative measures of comprehensive utilisation of coal gangues	2014
	Provisions on the safety management of dangerous goods in ports	2012
	Administrative Measures for Registration of Hazardous Chemicals	2012
	Administrative Measures for the import of solid waste	2011
	Administrative Measures for eligibility license for disposal of waste and discarded electrical and electronic products	2010
	Announcement No. 39 of 2009 of Ministry of Environmental Protection of the People's Republic of China laying down the Farmland Environmental Quality Evaluation Standards for Livestock and Poultry Production (National Environmental Protection Standard HJ 568-2010).	2010
	Announcement No. 61 of 2009 of Ministry of Environmental Protection of the People's Republic of China laying down cleaner production standard for waste lead-acid battery recycling (National Environmental Protection Standard HJ 510-2009).	2009
	Announcement No. 26 of 2008 of the Ministry of Environmental Protection of the People's Republic of China promulgating discharge standards of water pollutants for sugar industry(National Standard GB 21909-2008).	2009
	Announcement No. 63 of 2008 of Ministry of Environmental Protection promulgating the cleaner production standard for wine industry	2008
	Circular Economy Promotion Law of the People's Republic of China	2008
	Announcement No. 26 of 2008 of the Ministry of Environmental Protection of the People's Republic of China promulgating Effluent Standards of Pollutants for Heterocyclic Pesticides Industry (National Standard GB 21523—2008)	2008
	Decree No. 47 of the Ministry of Environmental Protection promulgating the Administrative Measures for the Approval of Exporting Hazardous Wastes.	2008
	Regulation on national general survey of pollution sources	2007
	Administrative Measures for the prevention and control of environmental pollution by electronic waste	2007
	Administrative Measures for the Comprehensive Utilisation of Coal Fly Ash	
	Law of the People's Republic of China on Prevention and Control of Water Pollution	2008
	Interim Measures on the Management of Water Pollutants Discharge Permit	1988
	Measures on the Supervision of Sewage Treatment Facilities for Environmental Protection	1988

Country	Title	Year
	Rules for implementation of the Law of the People's Republic of China on the prevention and control of water pollution (2000).	2000
	Rules for implementation of the Law of the People's Republic of China on the prevention and control of water pollution.	1989
	Environmental Protection Law of the People's Republic of China	1989
	Measures on Supervision of Exhaust Pollution from Automobiles	1990
	Enforcement Regulations for Law on Prevention of Air Pollution of the People's Republic of China	1991
	Waste disposal (livestock waste) Regulations	1988
	Waste Disposal (Chemical Waste) (General) Regulation	1992
	Provisions on the Administration of Report and Registration of Pollutants Discharge	1992
	Water pollution control (sewerage) Regulation	1994
	Interim Provisions on the Administration of Environmental Protection of Waste Imports.	1996
	Law on Prevention of Environmental Pollution Caused by Solid Waste	1996
	Decision of the State Council on several issues concerning environmental protection	1996
	Regulation on Strengthening Control Over Shipment of Import Wastes	1996
	Integrated wastewater discharge standard	1996
	Measures on Administrative Penalty for Environmental Protection	1999
	Measures on the Management of Hazardous Waste Manifests (Decree of the State Environmental Protection Administration No. 5).	1999
	Measures on the Administration of Pollution Sources Monitoring	1999
	Technical Policies for the Municipal Refuse Disposal and the Prevention and Control of Pollution	2000
	Law on the Prevention and Control of Air Pollution	2000
	Classified Directory for Environmental Protection Management of Construction Projects	2001
	Cleaner Production Promotion Law	2002
	Discharge standard of pollutants for municipal wastewater treatment plant	2002
	Measures for the Administration of Permit for Operation of Dangerous Wastes	2004
	Measures for the license administration of qualification for operation of environmental pollution control facilities	2004
	Interim Measures on clean production checks	2004
	Measures for the supervision and control of sewage outlets on rivers	2004
	Law of the People's Republic of China on the prevention and control of environmental pollution by solid wastes	2004
	Measures for the prevention and control of environmental pollution by discarded dangerous chemicals	2005
	Measures for the Administration of Automatic Monitoring of Pollution Sources	2005
	Guiding Rules for Identifying Solid Wastes	2006
	Administrative Measures for the Recovery of Renewable Resources	2007
	Administrative Measures for urban living garbage	2007
India	Batteries (Management and Handling) Rules, 2001	2001
	Chemical Accidents (Emergency Planning, Preparedness, and Response) Rules, 1996	1996
	Environment (Protection) Act, 1986 (No. 29 of 1986).	1986
	Environment (Protection) Rules, 1986	1986
	E-waste (Management and Handling) Rules 2011	2011
	Hazardous Waste (Management, Handling and Transboundary Movement) Rules, 2008	2008
	Hazardous Wastes (Management and Handling) Rules, 1989	1989
	Hazardous Wastes (Management, Handling and Transboundary Movement) Second Amendment Rules, 2009	2009
	Municipal Solid Wastes (Management and Handling) Rules, 2000	2000
	Recycled Plastics Manufacture and usage Amendment Rules, 2002	2002
	Recycled Plastics Manufacture and usage Amendment Rules, 2003	2003
	Recycled Plastics Manufacture and Usage Rules, 1999.	1999
	Solid Wastes (Management and Handling) Rules, 2000	2000
	The Mines and Minerals (Development and Regulation) amendment Act, 2015 (No. 10 of 2015).	2015

Country	Title	Year
Indonesia	Decree of the State Minister for Environment No. 133/2004 on the standard quality of emission for activities of the fertilizer industry.	2004
	Decree of the State Minister for Environmental affairs No. 110/2003 on the Guidelines on stipulation of accommodating capacity of load of water pollution in water sources.	2003
	Decree of the Trade Minister No. 1215/M-DAG/Kep/9/2009 on the appointment of surveyor to conduct technical verification or trace of non-hazardous and toxic (Non B3) waste imports.	2009
	Government Regulation No. 82/2001 on management of water quality and control over water pollution.	2001
	Law No. 18/2008 regarding Rubbish Management.	2008
	Law No. 32/2009 on Environmental Protection and Management	2009
	Regional Regulation of the Province of Jakarta Capital Special Region No. 2/2005 on control over air pollution.	2005
	Regulation of the Governor of Jakarta, the Special Capital Region, No. 25/2011 concerning the formation of the organisation and management of the Environmental and Ground Water Waste Management Unit.	2011
	Regulation of the Minister of Energy and Mineral Resources No. 045/2006 on treatment of drill mud, mud waste and drill cutting in oil and gas drilling activities.	2006
	Regulation of the Minister of Living Environment No. 18/2009 on the procedure for permits for the management of hazardous and toxic waste.	2009
	Regulation of the Minister of Public Works No. 03/PRT/M/2013 on the Implementation of Infrastructure and Facilities in Domestic Waste Disposal.	2013
	Regulation of the Minister of Public Works No. 21/PRT/M/2006 on National Policy and Strategy of Rubbish Management System Development (KSNP-SPP).	2006
	Regulation of the Minister of Trade No. 04/M-DAG/PER/2/2006 on Distribution and Monitoring of Hazardous Materials.	2006
	Regulation of the Minister of Trade No. 39/M-DAG/PER/9/2009 concerning provision on the import of non-hazardous and toxic waste (non B3 waste).	2009
	Regulation of the Minister of Trade of the Republic of Indonesia No. 58/M-DAG/PER/12/2008 on Import Regulation of Non Poisonous and Dangerous Wastes (Non B3).	2008
	Regulation of the State Minister of Living Environment Affairs No. 13/2007 concerning requirements and procedures in the management of waste water of natural oil, gas and geothermal upstream businesses and/or activities by injection method.	2007
	Regulation of the State Minister of Living Environment No. 1/2010 on water pollution control system	2010
	Regulation of the State Minister of Living Environment No. 30/2009 concerning the system of permits and supervision on management of hazardous waste material and supervision on recovery from the result of pollution by hazardous and toxic waste material by Regional Government	2009
	Regulation of the Trade Minister No. 26/M-DAG/PER/6/2009 on amendment to Regulation of the Trade Minister No. 58/M-DAG/PER/12/2008 on the import of non hazardous and toxic (NON-B3) wastes.	2009
Iran	Environmental Protection Law	1974
	Law on sewerage development projects and reconstruction of water delivery systems	1998
Japan	Act on the Promotion of Effective Utilisation of Resources (Act No. 48 of 1991).	1991
	Act on the Promotion of Sorted Collection and Recycling of Containers and Packaging (Act No. 112 of 1995).	1995
	Basic Act for Establishing a Sound Material-Cycle Society	2000
	Basic Environmental Law (Law No. 91 of 1993).	1993
	Environmental Impact Assessment Law No. 81 of 1997.	1997
	Law for the Control of Export, Import, etc. of Specified Hazardous Wastes and other Wastes, 1992 (Law No. 108 of 1992).	1992
	Water Pollution Control Law Enforcement Regulations (Order No. 2 of June 1971 amended by Order No. 41 of 1971, No. 69 of 1974, No. 2 of 1976, No. 30 of 1979, No. 29 of 1985 and No. 67 of 1986).	1971
Laos	Environmental Protection Law	1999
	Environmental Protection Law, 2013	2013
	Law on Minerals No. 02	2011
	Provisions on Discharge of Waste Water from Factories	1994

Country	Title	Year
	Regulation on industrial waste discharge	1994
	Water and Water Resource Law	1996
Malaysia	Environmental Quality (Control of Pollution from Solid Waste Transfer Station and Landfill) Regulations, 2009.	2009
	Environmental Quality (Industrial Effluent) Regulations, 2009	2009
	Environmental Quality Act 1974 (No. 127 of 1974).	1974
	Solid Waste and Public Cleansing Management (Compounding of Offences) Regulations, 2011.	2011
	Solid Waste and Public Cleansing Management (Licensing) (Management or Operation of Prescribed Solid Waste Management Facilities) Regulations, 2011 (PU(A) 304/2011).	2011
	Solid Waste and Public Cleansing Management (Licensing) (Undertaking or Provision of Collection Services for Household Solid Waste, Public Solid Waste, Public Institutional Solid Waste and Solid Waste Similar to Household Solid Waste) Regulations, 2011 (PU(A) 303/2011).	2011
	Solid Waste and Public Cleansing Management (Licensing) (Undertaking or Provision of Public Cleansing Management Services) Regulations, 2011 (PU(A) 306/2011).	2011
	Solid Waste and Public Cleansing Management (Licensing) (Undertaking or Provision of Transportation Services by Long Haulage) Regulations, 2011 (PU(A) 305/2011).	2011
	Solid Waste and Public Cleansing Management (Prescribed Solid Waste Management Facilities and Approval for the Construction, Alteration and Closure of Facilities) Regulations, 2011 (PU(A) 302/2011)	2011
	Solid Waste and Public Cleansing Management (Scheme for Household Solid Waste and Solid Waste Similar to Household Solid Waste) Regulations, 2011 (PU(A) 307/2011).	2011
	Solid Waste and Public Cleansing Management Act, 2007.	2007
	Water Services Industry Act, 2006 (Act No. 655).	2006
	Waters Act 1920	1920
Maldives	Environmental Protection and Preservation Act of Maldives (Law No. 4/93).	1993
Mongolia	Law on land.	2002
	Water Law.	1995
Myanmar	Environmental Conservation Law (Pyidaungsu Hluttaw Law No. 9/2012).	2012
Nepal	Environment Protection Rules, 2054 (1997).	1997
	Solid Waste (Management and Resource Mobilisation) Act, 2044 (1987).	1987
	Solid Waste Management Act, 2068 (2011).	2011
Pakistan	Hazardous Substances Rules, 2003.	2003
	Pakistan Environmental Protection Act, 1997 (Act No. XXXIV of 1997).	1997
Philippines	Administrative Order No. 2 of 2015 on the harmonisation of the Philippine Environmental Impact System and the Philippine Mining Act of 1995 in relation to Mining Projects.	2015
	DENR Administrative Order No. 15 of 2013 on the Guidelines on the Operationalisation of the Area Water Quality Management Fund (AWQMF) under Republic Act No. 9275.	2013
	DENR Administrative Order No. 81 containing implementing rules and regulations of the Philippine Clean Air Act of 1999.	1999
	Ecological Solid Waste Management Act No. 9003 of 2000.	2000
	Executive Order No. 533 adopting Integrated Coastal Management as a national strategy to ensure the sustainable development of the country's coastal and marine environment and resources and establishing supporting mechanisms for its implementation	2006
	Implementing Rules and Regulations of the Philippine Ecological Solid Waste Management Act of 2000.	2000
	Philippine Clean Air Act of 1999, Republic Act No. 8749.	1999
	Philippine Clean Water Act of 2004 (Republic Act No. 9275).	2004
	Philippine Environment Code.	1988
	Philippine Mining Act of 1995. (Republic Act No. 7942).	1995
	Republic Act No. 3931 creating the National Water and Air Pollution Control Commission.	1964
	Republic Act No. 9512 on National Environmental Awareness and Education Act, 2008.	2008
	Sewer Use Regulations (Resolution No. 51-1971).	1971
	Toxic Substances and Hazardous and Nuclear Wastes Control Act No. 6969 of 1990.	1990
	Water Code of the Philippines, Implementing Rules and Regulations, 1979.	1979

Country	Title	Year
DPR Korea	Decree No. 202 Establishing the Rules on the standards of product packaging materials and methods	2006
	Rivers Law	2002
	Law of the Democratic People's Republic of Korea on the Protection of the Environment	1986
Republic of Korea	Act on Encouragement of Purchase of Environment-Friendly Products	2004
	Act on Special Measures for the Control of Environmental Offences	1999
	Act on the Control of Transboundary Movements of Hazardous Wastes and their Disposal	1992
	Act on the Disposal of Sewage, Excreta and Livestock Wastewater	1991
	Act on the Management and Use of Livestock Excreta (Act No. 11998 of 2013).	2013
	Clean Air Conservation Act	1990
	Enforcement Decree of the Act on the Control of Transboundary Movement of Hazardous Wastes and their Disposal	1994
	Enforcement Decree of the Act on the Disposal of Sewage, Excreta and Livestock Wastewater	1997
	Enforcement Decree of the Clean Air Conservation Act	1996
	Enforcement Decree of the Clean Air Conservation Act (Presidential Decree No. 20383 of 2007).	2007
	Enforcement Decree of the Groundwater Act	1997
	Enforcement Decree of the Wastes Control Act	1991
	Enforcement Decree of the Wastes Control Act	2007
	Enforcement Decree of the Water Quality Conservation Act	1996
	Promotion of Installation of Waste Disposal Facilities and Assistance, etc. to Adjacent Areas Act	1995
	Public Waters Management Act	1999
	Public Waters Management and Reclamation Act	2010
	Sewerage Act	1966
	Special Act on the Assistance to the Development of Abandoned Mine Areas	1995
	Wastes Control Act	1991
	Water Quality and Ecosystem Conservation Act	2005
	Water Quality Conservation Act	1990
Singapore	Environmental Protection and Management Act (Chapter 94A).	1999
	Environmental Public Health (Public Cleansing) Regulations.	1970
	Environmental Public Health (Toxic Industrial Waste) Regulations	1988
	Environmental Public Health Act (Chapter 95) 1987.	1987
	Hazardous Waste (Control of Export, Import and Transit) Regulations.	1998
	National Environment Agency Act 2002 (Act No. 4 of 2002, Chapter 195).	2002
	Sand and Granite Quarries Act 44 of 1970 (Chapter 284).	1970
	Sewerage and Drainage Act 10 of 1999 (Chapter 294).	1999
Sri Lanka	National Environmental Act of 1980	1980
	National Environmental (Protection and Quality) (Amendment) Regulations, 1996.	1996
	National Environmental (Protection and Quality) Regulations (No. 1 of 1990).	1990
	National Environmental (Protection and Quality) Regulations (No. 1 of 2008).	2008
	National Water Supply and Drainage Board Law (No. 2 of 1974).	1974
Thailand	Enhancement and Conservation of National Environmental Quality Act, B.E. 2535.	1992
	Notification Of The Ministry Of Industry No. 6, Disposal Of Wastes Or Unusable Materials	1997
Timor-Leste	Regulation No. 1/2014 on quality standards and specifications related to fuels, biofuel and lubricants	2014
	Decree-Law No. 26/2012 establishing the Environmental Basic Legislation	2012
	Decree-Law No. 5/2011 on the Environmental Licensing System	2011
	Decree-Law No. 36/2012 regulating import/export of any substance damaging ozone layer	2012
	Government Resolution No. 8/2012 approving the National Policy on Basic Sanitation	2012

Country	Title	Year
Viet Nam	Circular No. 02/2001/TT-BKHCNMT guiding criteria of high-tech industrial projects, projects on production of new materials, rare and precious materials; application of new biotechnologies, new technologies for the production of communication and telecommunications equipment; treatment of environmental pollution or waste treatment and processing which are classified as projects of special investment encouragement; matters related to environmental impact assessment reports; import of used machinery; applicable to foreign-invested enterprises in Viet Nam.	2001
	Circular No. 08/2009/TT-BTNMT providing for the environmental management and protection of economic zones, hi-tech parks, industrial parks and industrial complexes.	2009
	Circular No. 12/2006/TT-BTNMT guiding the practice conditions, procedures for compilation of dossiers, registration and licensing of practice and hazardous waste management identification numbers.	2006
	Circular No. 121/2008/TT-BTC guiding incentive mechanisms and financial supports for investment in solid waste management.	2008
	Circular No. 2/2005/TT-BTNMT guiding the implementation of the Government's Decree No. 149/2004/ND-CP on the issuance of permits for water resource exploration, exploitation and use, or for discharge of wastewater into water sources.	2005
	Decision No. 1930/QD-TTg approving orientations for development of water drainage in Vietnamese urban centres and industrial parks up to 2025 and a vision towards 2050.	2009
	Decision No. 2149/QD-TTg approving the national strategy for integrated management of solid waste up to 2025, with a vision to 2050.	2009
	Decision No. 328/2005/QD-TTg approving the state plan on environmental pollution control until 2010	2005
	Decree No. 121/2004/ND-CP on sanctioning of administrative violations in the field of environmental protection	2004
	Decree No. 149/2004/ND-CP on the issuing of permits for water resource exploration, exploitation and use, or for discharge of wastewater into water sources.	2004
	Decree No. 59/2007/ND-CP on Solid Waste Management.	2007
	Decree No. 67/2003/ND-CP on environmental protection charges for waste water.	2003
	Decree No. 68/2005/ND-CP on chemical safety.	2005
	Decree No. 80/2006/ND-CP detailing and guiding the implementation of a number of articles of the Law on environmental Protection.	2006
	Decree No. 81/2006/ND-CP on sanctioning of administrative violations in the domain of environmental protection	2006
	Decree on Sanctions against Administrative Violations in Environmental Protection (No. 26-Cp).	1996
	Directive No. 23/2005/CT-TTg on enhancing the management of solid wastes in urban centres and industrial parks.	2005
	Environment Protection Act of the Socialist Republic of Viet Nam.	1993
	Government Decree on providing Guidance for the Implementation of the Law on Environmental Protection	1994
	Joint Circular No. 01/2001/TTLT-BKHCNMT-BXD guiding the Regulations on Environmental Protection for the Selection of Location for, the Construction and Operation of, Solid Waste Burial Sites.	2001
	Law on Environmental Protection.	2006

A little girl disposing of waste in Tedim Township, Myanmar.

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Abbreviations & Acronyms

ABS	Acrylonitrile Butadiene Styrene
AC	Air Conditioning
AD	Anno Domini
ADB	Asian Development Bank
AFR	Alternate Fuel and Raw Materials
AHPs	Absorbent Hygiene Products
AIC	Australia – India Council
AIT	Asian Institute of Technology
AP	Asia Pacific
APEC	Asia-Pacific Economic Cooperation
APO	Asian Productivity Organisation
ARCS or AWCS	Automated Refuse/Waste Collection Systems
ARF	Advanced Recycling Fees
ASR	Automobile Shredding Residues
AWMO	Asia Waste Management Outlook
BOD	Biochemical Oxygen Demand
CATARC	China Automotive Technology and Research Center
CDM	Clean Development Mechanism
CE	Circular Economy
CESET	Cebu Environmental Sanitation and Enforcement Team
CII	Confederation of Indian Industry
CITENCO	Ho Chi Minh Environmental Company
CIUD	Centre for Integrated Urban Development
COD	Chemical Oxygen Demand
CP	Cleaner Production
CRT	Cathode-Ray Tube
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSR	Corporate Social Responsibility
DBFOM	Design-Build-Finance-Operate-Maintain
DFAT	Department of Foreign Affairs and Trade
DOST	Department of Science and Technology
DSW	Disposed Solid Waste
ECOLEX	The Gateway to Environmental Law
EEE	Electronics and electrical

EFTA	European Free Trade Association
EIA	Environmental Impact Assessment
EIP	Eco-industrial Parks
ELV	End-of-life Vehicles
EMC	Environmental Management Centre, India
EPIF	Eco-Product International Fair
EPR	Extended Producer Responsibility
EU	European Union
E-WaRDD & CO	Electronic & Electrical Waste Recycling, Dismantling & Disposal
FLW	Food Loss and Waste
FY	Fiscal Year
GARC	Global Automotive Research Centre
GCIF	Global City Indicators Facility
GFC	Green Finance Committee
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (German Society for International Cooperation)
GJ	Giga Joule
GNI	Gross National Income)
GNP	Gross National Product
GPCB	Gujarat Pollution Control Board
HDPE	High-density Polyethlene
HFA	Hyogo Framework for Action
IBRD	International Bank for Reconstruction and Development
ICC	International Coastal Cleanup
ICCM	International Conference on Chemicals Management
IEC	Information, Education, and Communication
IEISL	IL & FS Environmental Infrastructure & Services Ltd.
IFIs	International Financial Institutions
IGES	Institute of Global Environmental Strategies
IGPN	International Green Purchasing Network
IMO	International Monetary Organisation
INCD	Intended Nationally Determined Contribution
INR	India Rupee

IPLA	International Partnership for Expanding Waste Management Service of Local Authorities
IPR	Individual Producer Responsibility
IRRC	Integrated Resource Recovery Center
IRRI	International Rice Research Institute
ISO	International Organisation for Standardisation
ISWM	Integrated Solid Waste Management
IT	Information Technology
ISO	International Standards Organisation
ISPONRE	Institute of Strategy and Policy on Natural Resources and Environment
ISWM	International Solid Waste Management
IWR	Integrated Waste Resources
JICA	Japan International Corporation Agency
JTC	Jurong Town Corporation, Singapore
KMC	Kathmandu Municipality City
KZWMN	Korea Zero Waste Movement Network
LCA	Life Cycle Assessment
LCD	Liquid Crystal Display
LCT	Life Cycle Thinking
LDT/LTD	Light Ton Displacement
LFMR	Landfill Mining and Reclamation
MBT	Mechanical Biological Treatment
MNC	Multinational Corporation or Company
MNRE	Ministry of New and Renewable Energy
MONRE	Ministry of National Resources and Environment
MRF	Material Recovery Facility
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management
MT	Metric Tonnes
N	Nitrogen
NATRiP	National Automotive Testing and R & D Infrastructure Project
NEA	National Environment Agency
NEREPA	Nepal Recycle Producer Association
NGO	Non-government Organisation
NRREGA	Nepal Reuse and Recyclable Goods Entrepreneur Associations

NSDC	National Skill Development Corporation
NSWM	National Solid Waste Management
ODA	Official Development Assistance
OECD	Organisation for Economic Cooperation and Development
P	Phosphorus
PAYT	Pay-as-you-throw
PET	Polyethylene Terephthalate
PMC	Pune Municipal Corporation
PP	Polypropylene
PPC	Portland Pozzolana Cement
PPP	Public-Private Partnership
PRISM	Poverty Reduction of Informal Workers in Solid Waste Management
PRO	Producer Responsibility Organisation
PS	Product Stewardship
PSP	Private Sector Participation
PV	Photovoltaic
RDF	Refuse Derived Fuel
RE	Resource Efficiency
RMB	Yuan Renminbi
RPF	Referral Policy Framework
RPF	Refuse Paper and Plastic Fuel
RRC.AP	Regional Resource Centre for Asia and the Pacific
RVM	Reverse Vending Machine
SAICM	Strategic Approach to International Chemicals Management
SCP	Sustainable Consumption and Production
SCS	Scientific Certification System
SD	Sustainable Development
SIA	Sustainable Industrial Areas
SIDS	Small Island Developing States
SRM	Secondary Resource Management
SWMRMC	Solid Waste Management and Resource Management Centre
TSR	Total Substitution Rate
TSS	Total Suspended Solids
UDC	Urban Development Committee

ULB	Urban Local Bodies
UN Habitat	United Nations Human Settlements Programme
UNCRD	United Nations Centre for Regional Development
UNDP	United Nations Development Programme
UN Environment	United Nations Environment
UNEP	United Nations Environment Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations Office for Disaster Risk Reduction
US EPA	United States Environmental Protection Agency
WEEE	Waste Electrical and Electronic Equipment
WEP	Waste Eco Park
WM	Waste Management
WMA	Waste Management Authority
WND	Wuzi New District
WRI	World Resources Institute
WTE	Waste to Energy
YA	Year of Assessment
ZW	Zero Waste

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