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GREEN economy

Waste

Investing in energy and resource efficiency

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Acknowledgements

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Key messages

1. The increasing volume and complexity of waste associated with economic growth are posing serious risks to ecosystems and human health. Every year, an estimated 11.2 billion tonnes of solid waste are collected worldwide and decay of the organic proportion of solid waste is contributing to about 5 per cent of global Greenhouse Gas (GHG) emissions. Of all the waste streams, waste from electrical and electronic equipment containing new and complex hazardous substances presents the fastest-growing challenge in both developed and developing countries.

2. The growth of the waste market, increasing resource scarcity and the availability of new technologies are offering opportunities for greening the waste sector. The global waste market, from collection to recycling, is estimated at US$410 billion a year, not including the sizable informal segment in developing countries. Recycling is likely to grow steadily and form a vital component of greener waste management systems, which will provide decent employment.

3. There is no one-size-fits-all when it comes to greening the waste sector, but there are commonalities. Most of the standards are national or local. However, as a common feature, greening the waste sector includes, in the first place, the minimisation of waste. Where waste cannot be avoided, recovery of materials and energy from waste as well as remanufacturing and recycling waste into usable products should be the second option. The overall vision is to establish a global circular economy in which material use and waste generation are minimised, any unavoidable waste recycled or remanufactured, and any remaining waste treated in a manner least harmful to the environment and human health or even generating new value such as energy recovered from waste.

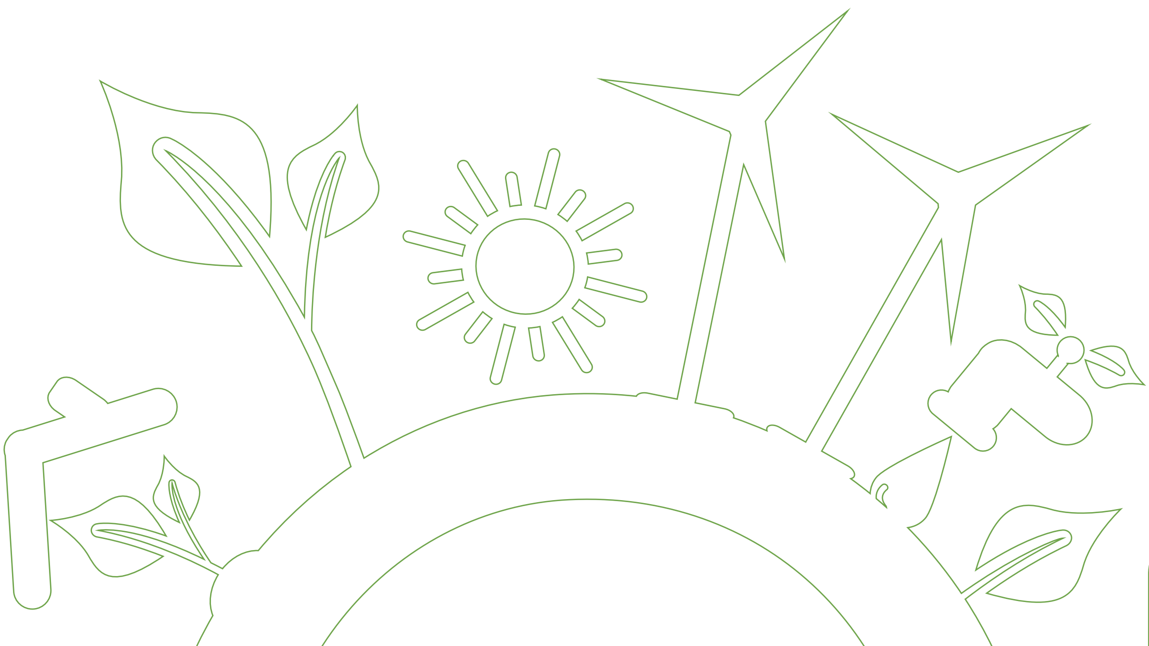
4. Investing in greening the waste sector can generate multiple economic benefits. Recycling leads to substantial resource savings. For example, for every tonne of paper recycled, 17 trees and 50 per cent of water can be saved. Recycling each tonne of aluminium, the following resource savings could be accrued: 1.3 tonne of bauxite residues, 15 m^3 of cooling water, 0.86 m^3 of process water, and 37 barrels of oil. These are in addition to the avoidance of 2 tonnes of CO_2 and 11 kg of SO_2. In terms of new products, compost production contributes to organic agricultural development benefiting small farmers and rural ecosystems and the Waste to Energy (WtE) market was already estimated at US$19.9

billion in 2008 and projected to grow by 30 per cent by 2014. Agricultural residue amounting to 140 billion tonnes globally may have an energy potential equivalent to 50 billion tonnes of oil. In terms of climate benefits, between 20–30 per cent of projected landfill methane emissions for 2030 can be reduced at negative cost and 30–50 per cent at costs of less than US$ 20/tCO_2-eq/yr.

5. Recycling creates more jobs than it replaces. Recycling in all its forms employs 12 million people in the three countries - Brazil, China and United States. Sorting and processing recyclables alone sustain ten times more jobs than land filling or incineration on a per tonne basis. Estimations made in the context of this Report suggest that if an average of US$ 143 billion were invested in waste management over the period 2011-2050, a total employment of 25-26 million could be created in the waste sector by 2050, which represents 2-2.8 million jobs, more than the 23 million projected under a business as usual scenario. While greater efficiency may imply loss of employment elsewhere in the economy, the overall net employment appears to be positive.

6. Improving labour conditions in the waste sector is imperative. The activities of collection, processing and redistribution of recyclables are usually done by workers with few possibilities outside the sector. Thus, despite the potentially significant contribution to employment creation, not all of the recycling and waste management related jobs can be considered green jobs. To be green jobs they also need to match the requirements of decent work, including the aspects of child labour, occupational health and safety, social protection and freedom of association.

7. Greening of the waste sector requires financing, economic incentives, policy and regulatory measures, and institutional arrangements. Cost recovery from improved waste management and avoided environmental and health costs can help reduce the financial pressure on governments. Private sector participation can also significantly reduce the costs as well as enhance service delivery. Micro-financing, other innovative financing mechanisms and international development assistance may in addition be tapped to support operational costs for waste treatment. Finally, a range of economic instruments can serve as incentives to green the sector and their use could be combined with regulations to set minimum safety standards that protect labour.



1 Introduction

This chapter seeks to make an economic case for investing in "greening" the waste sector and it aims to provide policy-makers with guidance on how to mobilise such investment. It demonstrates how green investment in the waste sector can create jobs and contribute to economic growth, while addressing environmental issues, in a pro-poor and equitable manner.

The environmental and social (including health-related) benefits from greening the waste sector have been stressed already for a long time. The impact of this has, however, been limited, as environmental and social concerns are often seen as competing with economic imperatives. Environmental and social aspects of greening the waste sector are discussed, but the emphasis is on making an economic case based on the available data.

The chapter starts with an explanation of the scope of the waste sector and what is meant by the greening of the waste sector, followed by a discussion of the challenges and opportunities facing the sector. It then discusses the goals for greening the sector and the potential economic implications of additional green investment, including the results from a modelling exercise. Finally, the chapter presents conditions that are important for enabling the greening of the waste sector.

1.1 Scope of the waste sector

The waste sector has traditionally referred to municipal solid waste (MSW) and excludes "wastewater", which tends to be categorised under the water or industry sectors. The scope of this chapter is therefore limited to management of MSW and special waste streams such as used electrical and electronic equipment as well as vehicles and vehicle parts, construction and demolition waste, health-care waste, and biomass waste or agricultural residues.

1.2 "Greening" the waste sector

Greening the waste sector refers to a shift from less-preferred waste treatment and disposal methods such as incineration (without energy recovery) and different forms of landfilling towards the "three Rs": Reduce, Reuse and Recycle. The strategy is to move upstream in the waste management hierarchy, based on the internationally recognised approach of Integrated Solid Waste Management or ISWM (see Figure 1).

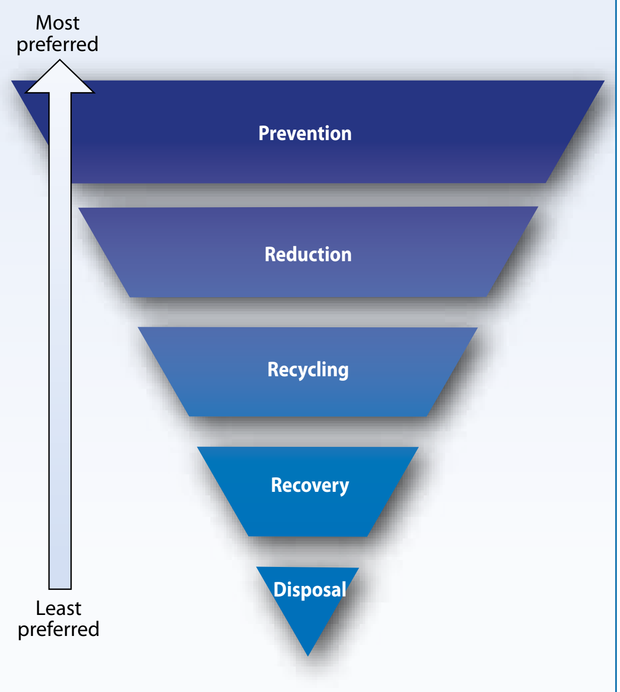


Figure 1. The waste management hierarchy

The ISWM is a strategic approach to managing all sources of waste; prioritising waste avoidance and minimisation, practicing segregation, promoting 3Rs, implementing safe waste transportation, treatment, and disposal in an integrated manner, with an emphasis on maximising resource-use efficiency. This marks a departure from the usual approach where wastes are managed mainly from a compliance point of view characterised by "end-of-pipe" treatment such as incineration (without energy recovery) and landfilling.

Under ISWM, activities of greening the sector can include:

- Resource conservation, which avoids excessive resource consumption;
- Waste reduction through resource use optimisation that minimises resource wastage;
- Waste collection and segregation, ensuring appropriate waste treatment;
- Waste reuse, which circulates waste and avoids the use of virgin resources;
- Waste recycling, which converts waste into useful products;

- Energy recovery, which harnesses residual energy from waste;

- Landfill avoidance, which conserves land and avoids risks of contamination; and

- Construction and maintenance of infrastructure for waste collection, recovery of materials from waste streams (collection and segregation) and application of 3R technologies and associated activities.

Indicators to measure the progress of greening the sector can include:

- Resource consumption rate (material use in kg per capita);

- Waste generation rates (kg per capita/year, overall and by economic sector);

- Proportion of waste being collected and segregated;

- Proportion of materials in waste streams being reused or recycled;

- Proportion of virgin material displacement in production;

- Proportion of waste used for energy recovery;

- Proportion of materials in waste streams diverted from landfill;

- Reduction in GHG emissions due to avoided landfilling;

- Proportion of total waste disposed in landfill; and

- Extent of capture, recovery and/or treatment of polluting emissions such as leachate and landfill gas.

In relation to an overall green economy, indicators of greening the waste sector can include the value of – and jobs related to – the goods generated through the greening of the waste sector such as remanufactured products, recovered energy, and the services in terms of waste collection, segregation, and processing. Economic and social benefits in terms of health, property values, tourism as well as direct and indirect job creation should also be included. Not all of these indicators may, however, be readily available. Proxies are used where possible in this chapter to gauge and estimate the economic significance of greening the sector.

1.3 A vision for the waste sector

The long-term vision for the waste sector is to establish a circular global economy in which the use of materials and generation of waste are minimised, any unavoidable waste recycled or remanufactured, and any remaining waste treated in a way that causes least damage to the environment and human health or even creating additional value such as by recovering energy from waste. To achieve this vision, radical changes to supply-chain management, especially to the product and industrial design part of the supply chain, are needed. Specifically, the 3Rs need to guide industrial design – with implications for materials at all stages – and be overlaid on the entire supply chain. This requirement is, in turn, expected to motivate innovation.

2 Challenges and opportunities in the waste sector

2.1 Challenges

The waste sector is facing four sets of challenges: 1) increasing growth in the quantity and complexity of waste streams associated with rising incomes and economic growth; 2) increasing risk of damage to human health and ecosystems; 3) the economic unattractiveness of the 3Rs; and 4) the sector's contribution to climate change.

The growing volume and complexity of waste

The exploitation of the earth's resources continues apace; material use increased eight-fold in the last century (Krausmann et al. 2009). According to the Wuppertal Institute, an average European consumes about 50 tonnes of resources a year, around three times the amount consumed per capita by emerging economies. Furthermore, on average, Europeans dispose twice as much as citizens from emerging economies (Bleischwitz 2009). Per-capita resource use in emerging economies is also increasing considerably while the world's Least Developed Countries (LDC) are now beginning the transition towards an industrial type of societal metabolism, as incomes rise and purchasing power is deployed in consumer spending.

Currently, 3.4-4 billion tonnes of municipal and industrial waste are produced every year, of which non-hazardous industrial waste accounts for 1.2 billion tonnes (Chalmin and Gaillochet 2009). A major share of the waste generated is MSW originating from urban settlements (1.7-1.9 billion tonnes, or 46 per cent of the total waste generated) with 0.77 billion tonnes of this being produced by 25 OECD countries alone (UNEP 2010).

As a country develops and becomes wealthier, the composition of its waste stream typically becomes more varied and complex. Figure 2 illustrates the high proportion of organic-rich MSW in middle and lower income countries with a gross national income per capita of less than US$12,196, while the high-income countries' MSW streams contain a large proportion of paper and plastics.

Apart from MSW, other major types of waste streams are listed below:

■ Construction and Demolition (C&D) waste represents 10-15 per cent of total waste generated in developed countries (Bournay 2006) and some countries have reported a much higher proportions. For example, OECD (2008a) estimated that Germany generates 178.5 million tonnes of C&D waste, which is about 55 per cent of the total waste reported. C&D waste can be classified as high-volume waste with relatively low impact compared with other types of waste.

■ End-of-life Vehicles (EoLV) account for 8-9 million tonnes of waste in the European Union (EU) with Germany, UK, France, Spain and Italy responsible for approximately 75 per cent of EU-25 vehicles de-

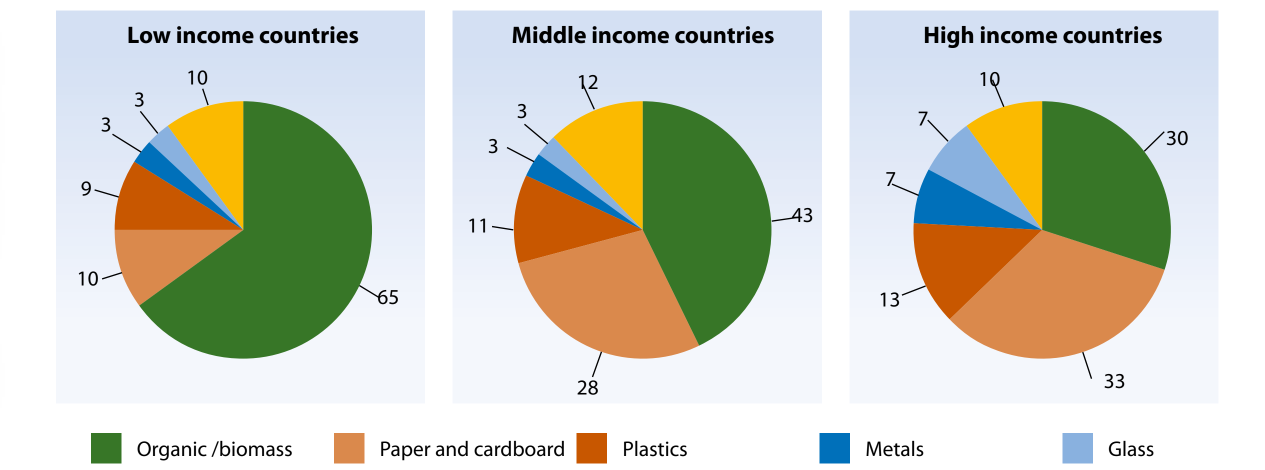
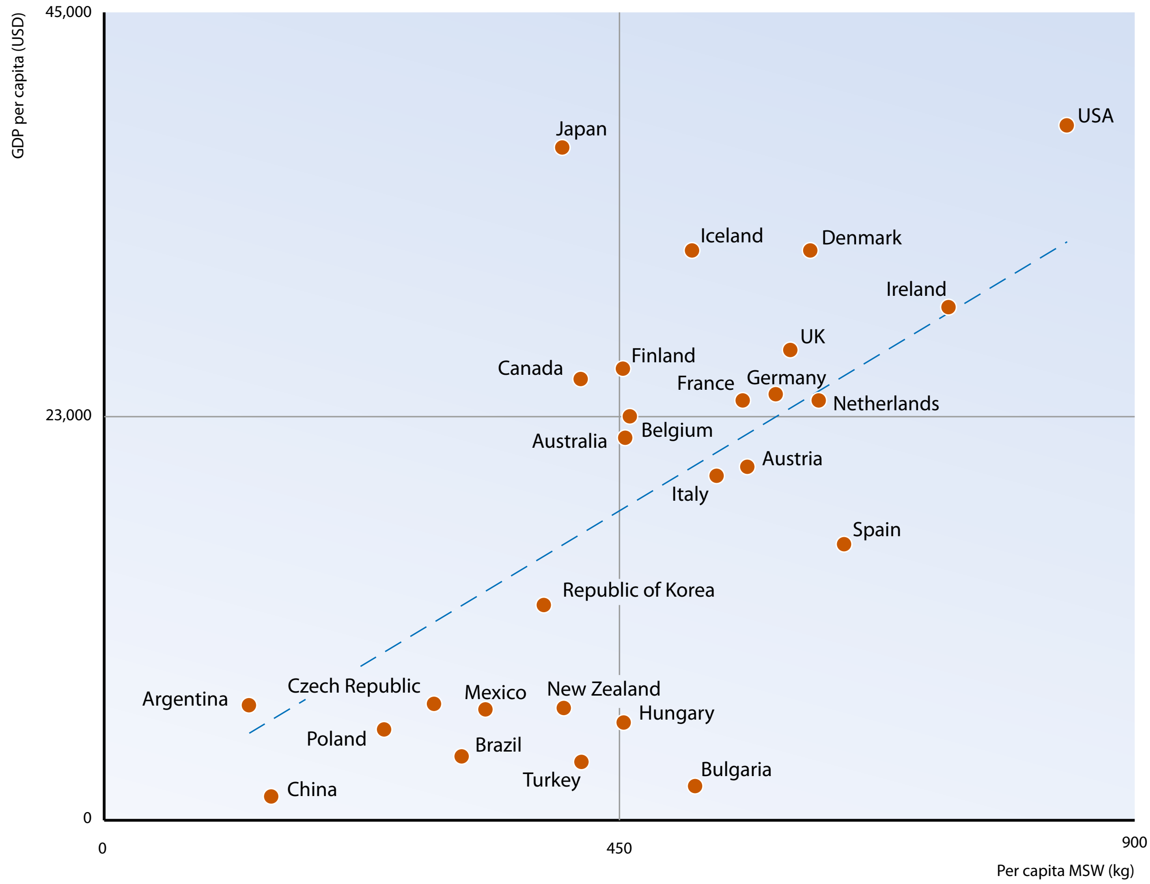


Figure 2: Composition of MSW by national income

Source: Data sourced from Chalmin and Gaillochet (2009) and averaged



Quadrant	Economic status and waste generation	Country and year of data	
Q1	GDP: More than US$23,000 Waste: More than 450 kg per capita	USA: United States of America[a] (2006) IRL: Ireland (2004) DNK: Denmark (2005) ISL: Iceland (2004) GBR: United Kingdom (2004)	NLD: Netherlands (2004) DEU: Germany (2004) FRA: France (2004) BEL: Belgium (2002)
Q2	GDP: More than US$23,000 Waste: Less than 450 kg per capita	FIN: Finland (2004) CAN: Canada (2004)	JPN: Japan[e] (2007)
Q3	GDP: Less than US$23,000 Waste: Less than 450 kg per capita	BRA: Brazil[b] (2002) ARG: Argentina[c](2002) CHN: China[d] (2004) POL: Poland (2005)	CZE: Czech Republic (2005) MEX: Mexico (2006) KOR: Republic of Korea (2002) NZL: New Zealand (1999) TUR: Turkey (2004)
Q4	GDP: Less than US$23,000 Waste: More than 450 kg per capita	AUS: Australia (2002) HUN: Hungary (2004) BGR: Bulgaria[f] (2003)	ITA: Italy (2004) AUT: Austria (2004) ESP: Spain (2004)

Note: US$23,000 represents the median point in the GDP data.

Figure 3: GDP per capita vs. MSW per capita[1]
Sources: MSW Data sourced from [a] EPA (2007), [b] Borzino (2002), [c] Methanetomarkets (2005), [d] World Bank (2005), OECD 2008a and [e] Yatsu (2010) and [f] GHK (2006). Population data sourced from http://esa.un.org/unpp/ and GDP data sourced from World Bank.

registrations (Eurostat 2010a). Japan generates about 0.7 million tonnes of Automobile Shredder Residues (ASR) every year – materials such as plastic, rubber, foam, paper, fabric, glass, etc. that remain to be recycled after the reusable parts of the automobile are removed from shredded EoLV (Kiyotaka and Itaru 2002). In the United States of America, ASR amount to 5 million tonnes annually (EPA 2010).

■ Biomass waste includes agricultural and forestry waste. It is estimated that globally 140 billion tonnes of agricultural residue is generated every year (Nakamura

1. This figure was generated by using latest available data from 27 countries including developed and developing countries from specified sources (using the GDP and population data for the year for which the latest waste data is available).

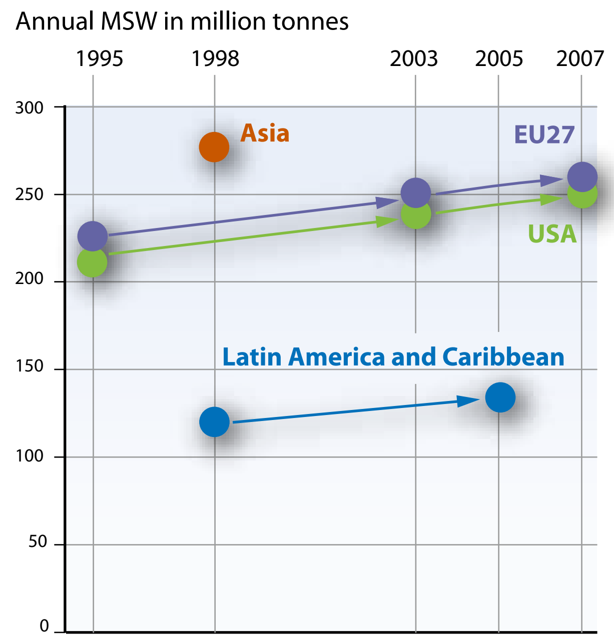


Figure 4: Estimated generation of MSW across regions of the world

Source: Data sourced Acurio et al. (1998), World Bank (1999), EPA (1999) and (2009), Hoornweg and Giannelli (2007) and Eurostat (2010b)

2009). Like C&D, biomass waste is a high-volume waste with a relatively low impact.

■ Health-care waste is sometimes classified as a subcategory of hazardous waste. No global estimates are available. On average, however, low-income countries have been observed to generate between 0.5 kg and 3 kg of health-care waste per capita per year, which includes both hazardous and non-hazardous components. High-income countries have been reported to generate up to 6 kg of hazardous waste per person per year from health-care activities (WHO 2010).

■ Electronic waste (e-waste) continues to increase dramatically amid growing global demand for electronic and electrical goods. It is estimated that in 2004 alone, 315 million Personal Computers (PC) became obsolete globally and 130 million mobile phones were estimated to have reached their "end of life" in 2005 (UNEP 2005). The USA produces most electronic scrap, reportedly 3.16 million tonnes in 2008 (EPA 2009). The total e-waste generated worldwide rose from 6 million tonnes in 1998 to 20-50 million tonnes in 2005 (UNEP 2005). Jinglei Yu et al. (2010) predict that obsolete PCs in developing regions will exceed those of developed regions by 2016-2018 and that by 2030 they could amount to 400-700 million units (compared with 200-300 million units in developed countries).

■ Hazardous waste requires special handling and treatment even in low quantities. They may also mix up with the stream of waste generated in the municipal or agricultural sector, for e.g. used batteries, spent paints and residual chemical pesticides as well as Ozone Depleting Substances (ODS) such as refrigerators, air-conditioners, fire extinguishers, cleaning products, electronic equipments and agricultural fumigants. Reports submitted to the Basel Convention suggest that at least 8.5 million tonnes of hazardous waste have been crossing international boundaries every year (Baker et al. 2004).

■ Packaging waste and its management has become a major issue in high-income countries. For example, EU15 recorded an increase in packaging waste from 160 kg per capita in 1997 to 179 kg per capita in 2004. According to the European Environmental Agency (EEA 2009), an increase in packaging waste has been observed in both older and newer EU member states.

■ Marine litter consists of material discarded directly or indirectly from recreational/shoreline, ocean/waterway, smoking-related, dumping and medical and personal-hygiene-related activities and sources (UNEP 2009a). The

Countries	Assessment Date	PCs	Printers	Mobile phones	TVs	Refrigerators	Total
South Africa	2007	19,400	4,300	850	23,700	11,400	59,650
Kenya	2007	2,500	500	150	2,800	1,400	7,350
Uganda	2007	1,300	250	40	1,900	900	4,390
Morocco	2007	13,500	2,700	1,700	15,100	5,200	38,200
Senegal	2007	900	180	100	1,900	650	3,730
Peru	2006	6,000	1,200	220	11,500	5,500	24,420
Colombia	2006	6,500	1,300	1,200	18,300	8,800	36,100
Mexico	2006	47,500	9,500	1,100	166,500	44,700	269,300
Brazil	2005	96,800	17,200	2,200	137,000	115,100	368,300
India	2007	56,300	4,700	1,700	275,000	101,300	439,000
China	2007	300,000	60,000	7,000	1,350,000	495,000	2,212,000

Table 1: Estimates of e-waste generation (tonnes per year)

Source: Adapted from UNEP and UNU (2009)

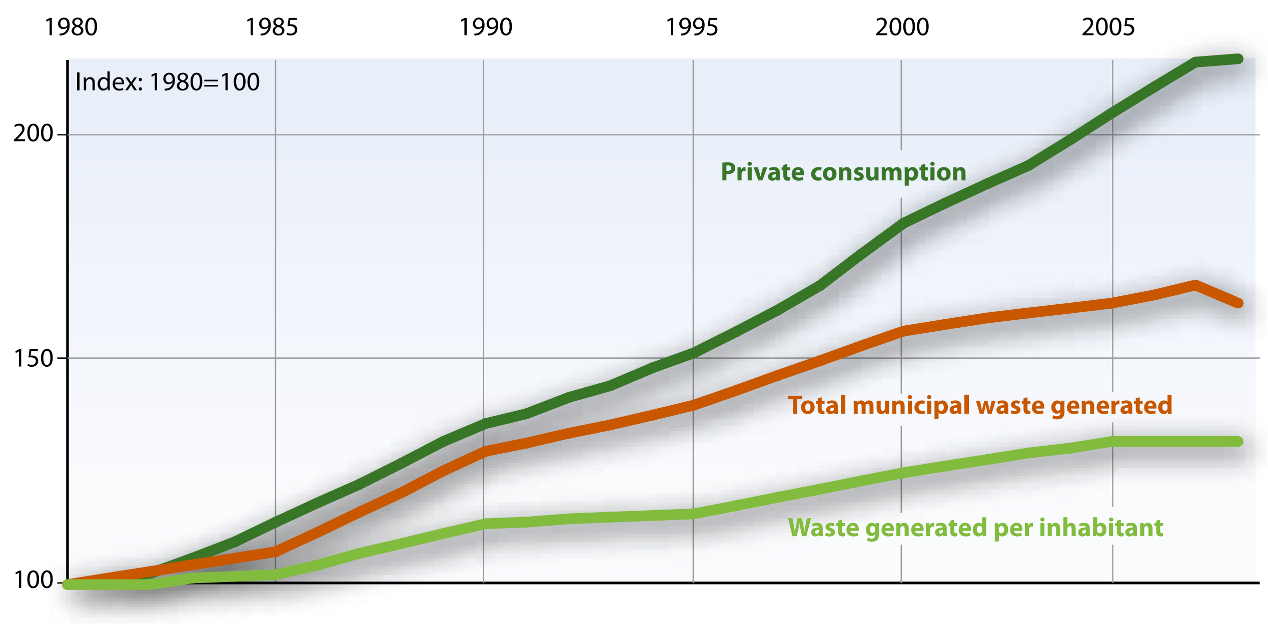


Figure 5: Relationship between private consumption and municipal waste in OECD countries
Note: The indicators presented here relate to amounts of municipal waste generated. They show waste generation intensities expressed per capita and per unit of private final consumption expenditure (which excludes public expenditures on education, health and similar categories) in 2006, and related changes since 1980.
Source: OECD (2008b)

International Coastal Cleanup (ICC) study between 1989 and 2007 counted 103,247,609 pieces of waste in world's seas. Cigarettes and cigarette filters accounted for almost a quarter of the material (25,407,457 pieces) (UNEP 2009a). Marine litter has been reported to have significant impacts on wildlife and sensitive ecosystems, human health and safety and the economies of coastal areas (Ocean Conservancy 2010).

Waste generation is linked to both population and income growth. Of the two, income level is the more powerful driver. Figure 3 shows the correlation between MSW generation and GDP. In high-income countries, an urban population of 0.3 billion generates approximately 0.24 million tonnes of MSW (0.8 kg per capita per day), while in low-income countries around the same amount (0.26 million tonnes per day) is generated by 1.3 billion people (0.2 kg per capita per day), a quarter of the level in high-income countries.

Figure 4 shows estimates of MSW generation in different parts of the world. It rose in the US and the EU by 21 per cent and 14 per cent respectively from 1995 to 2007. However, due to increased awareness and policy interventions addressing waste management (for example, EU regulations stimulating recycling of obsolete vehicles since 2000 and electrical and electronic waste since 2002), the rate of MSW generation slowed in the EU and (to a lesser extent) in the USA in the period from 2003 to 2007. The linkage between affluence and waste generation remains quite strong, in spite of improvements in efficiency, and represents a significant challenge for developing countries as they become wealthier, particularly in Asia (World Bank 1999). At best, relative "decoupling" has begun in OECD countries, with a stabilisation of per-capita waste generation in the last decade, as shown in Figure 5. The recent awareness on benefits of waste minimisation, but also the shifting of waste-intensive production to developing and emerging countries may have contributed to this development. Landfill remains the predominant method of disposal in these countries (OECD 2008b).

Waste volumes are not necessarily the most important challenge ahead. Mixed MSW, hazardous health-care waste, and industrial waste streams can impose serious health and ecological risks if these wastes remain uncollected or dumped in uncontrolled and unsecured landfill sites. In low-income countries, for example, collection rates are lower than 70 per cent, with more than 50 per cent of the collected waste disposed through uncontrolled landfilling and about 15 per cent processed through unsafe and informal recycling (Chalmin and Gaillochet 2009). Given the amount of valuable components in MSW, the mixing of wastes also means a lost opportunity to recover components that could be recycled and used as new resources.

E-waste presents a serious and growing challenge to both developed and developing countries. It is a highly heterogeneous waste stream and one of the fastest-growing segments of MSW, especially in developed and emerging economies. Table 1 gives the estimated quantity of e-waste generated in 11 countries. China generates 64 per cent of the world's e-waste, followed by India (13 per cent) and Brazil (11 per cent). Senegal, Uganda, India, China and South Africa are examples of countries where e-waste generation is expected to rise by a factor of 2 to 8, by 2020 (UNEP and United Nations University [UNU] 2009). E-waste

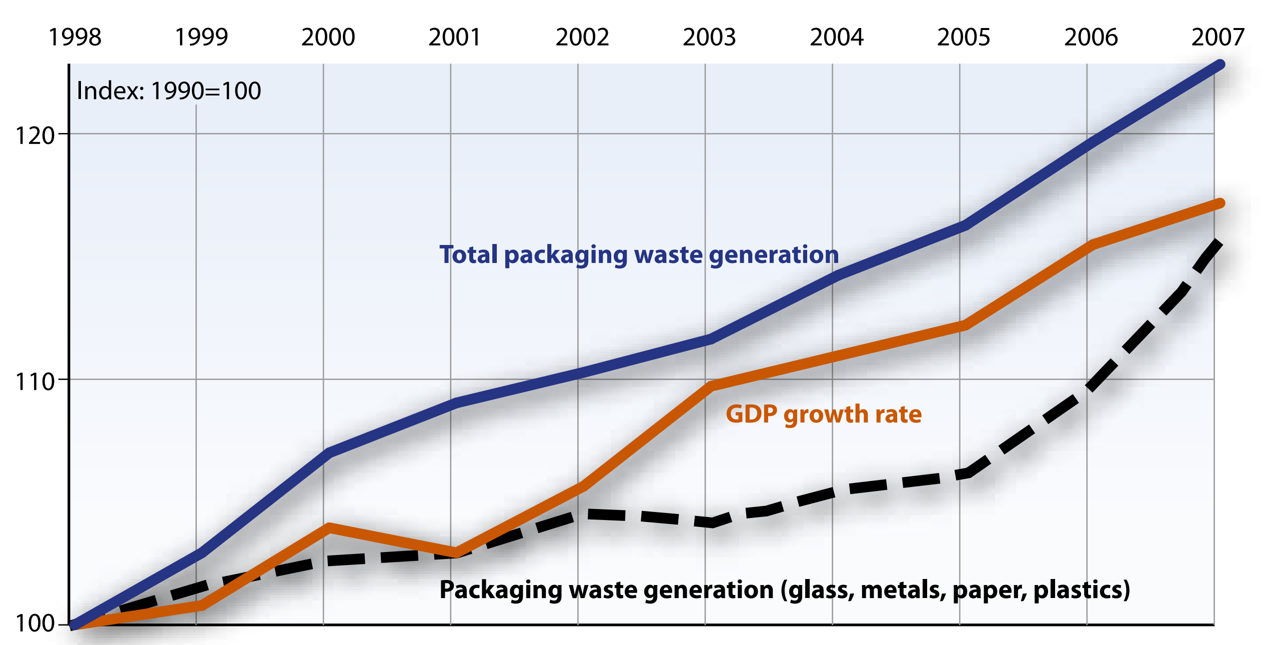


Figure 6: Trend in GDP and packaging waste growth from 1998 to 2007 in EU15
Source: EEA (2009)

is a major source of new and complex hazardous waste additions to MSW.

Globally, UNEP and UNU estimate that 20 to 50 million tonnes of e-waste are disposed of each year, which accounts for 5 per cent of all MSW. E-waste also has a significant role to play in the recycling sector in developing countries even though it is not necessarily generated in those countries. With sales of electronic products in China and India and across Africa and Latin America predicted to rise sharply in the next ten years, the challenge is only set to grow (UNEP and UNU 2009).

Adding to the complexity of waste streams is the impact of increasing trade on waste. Lack of information on the constituents of waste products, such as valuable raw materials and toxic pollutants, makes trading of such waste challenging and risky. There have been increasing packaging requirements to minimise damage to goods in transit. Packaging requirements have also increased to meet the tightened food health and safety standards. Figure 6 shows the steady increase in packaging waste coinciding with rising GDP in EU15 from 1998 to 2007. As this trend of increasing trade and packaging continues, so will the increase in the absolute generation of packaging waste and complexity of the MSW streams.

The waste problem has been accentuated by the issue of waste trafficking. Several developed countries have been illegally dumping hazardous waste and exporting significant quantities of used electrical and electronic products to developing countries that do not have adequate infrastructure to manage them. Such illegal shipments are a matter of global concern. The Basel Convention requires its members to report the aggregated numbers, but there is ambiguity in the available data on hazardous shipments and difficulty in dealing with illegal activities. Another issue is the difficulty in classifying used electronic or electrical products as second-hand products and hazardous waste. These shortcomings heighten the threat that the hazardous waste poses to the environment and human health.[2]

2. It may, however, be noted that the export of used electronic products is legal if the importing country has a sufficient recycling infrastructure to deal with these wastes.

Health and environment risks

The increasing volume and complexity of waste poses serious risks to human health and the environment. These risks are most obvious in situations where waste collection and treatment is insufficient or even absent but can also occur in situations where collection and treatment methods are already established. In industrialised countries, despite progress on sanitary landfill technology and incineration, and the control of direct human exposure to the waste at the related facilities, there are concerns over waste-disposal-related syndromes. While few studies exist, many health indicators have been considered in epidemiological research for health impacts from landfill sites and older incinerators, including cancer incidence, mortality, birth defects and low birth weight (WHO 2007). Protests over waste facilities in developed countries are now more than a simple Not In My Back Yard (NIMBY) reaction. Local residents often reject landfills and incinerators because of fears over health and safety and mistrust of the authorities to ensure that minimum safety or environmental protection standards are enforced. A related problem is the falling property values or the loss of livelihoods (e.g. related to agriculture, tourism) around landfill areas.

In developing countries, owing to low or inappropriate collection, deficient waste treatment and disposal infrastructure, limited financial resources, and weak enforcement of laws, open, uncontrolled, and unsecured "dumps" are the most commonly-used method of managing waste. At these sites, dumping of mixed waste occurs alongside open burning, grazing of stray animals and leakage of hazardous substances such as leachate and gas. Uncontrolled dumping can also block drainage systems and contribute to floods, which cause additional health and environment problems.

Uncontrolled dumpsites have been linked to many harmful health effects such as skin and eye infections, respiratory problems, vector-borne diseases like diarrhoea, dysentery, typhoid, hepatitis, cholera, malaria and yellow fever. Rodents and other stray animals have also been known to spread a variety of diseases including plague and flea-born fever. There are, however, no global estimates of waste-related health costs or economic costs of waste and only a limited number of country studies exist. In the Republic of Palau (an island nation in the Pacific Ocean), for example, the cost of waste-related health damage amounts to US$697,000 per year (about US$32 per capita) (Hajkowicz et al. 2005). In Tonga, total economic cost of waste was estimated to be at least TOP 5.6 million a year (about US$2.8 million) of which US$ 0.45 million was related to the health cost to private individuals (Lal and Takau 2006).

A lack of alternative livelihoods and the value of recovered materials entice many poor men, women, and even children to engage in dumpsite scavenging in low- and middle-income countries. Waste pickers are vulnerable to intestinal, parasitic and skin diseases. A UNEP (2007) study carried out at a 30-acre Kenyan dumpsite called Dandora found that about 50 per cent of the examined children and adolescents living close to the dumpsites (from a total of 328) had respiratory ailments and blood lead levels exceeding international threshold (10 micrograms per decilitre of blood). Further 30 per cent were confirmed to have high exposure to heavy metal poisoning detected by red blood cell abnormalities. Other severe effects observed in waste-picker children in India include worm infestation, scabies, xerophthalmia and lymph-node enlargement (Hunt 1996).

The volume of waste generation is one challenge for controlling the impact on human health and ecosystems, but it is the growing hazardous component of all waste streams that is most alarming. Unless action is taken to properly collect and segregate waste materials, many developing countries face the challenge of mixed and growing waste streams beyond what the current waste-management infrastructure can cope with. Investment in institutions and physical infrastructure to properly collect and segregate waste materials needs to happen to avoid imminent and serious consequences to environmental quality and public health in these countries with potentially long-term economic impacts.

GHG emissions

The organic fraction of the municipal waste sector contributes to about 5 per cent of the total GHG emissions known to be responsible for climate change. According to the Intergovernmental Panel on Climate Change (Bogner et al. 2007), post-consumer waste-generated GHG emissions were equivalent to approximately 1300 $MtCO_2$-eq in 2005. In the waste sector, landfill methane is the largest source of GHG emissions, caused by the anaerobic degradation of organic material in landfills and unmonitored dumpsites. In the EU, emissions from waste (including disposal, landfill sites and water treatment) amount to 2.8 per cent of total EU27 GHG emissions (Eurostat 2010c). Emissions from landfills depend on waste characteristics (composition, density, particle size) and conditions in landfills (moisture, nutrients, microbes, temperature and pH). Landfill gas (LFG) is about 50-60 per cent methane with the remainder CO_2 and traces of non-methane volatile organics, halogenated organics and other compounds. Further, ozone depleting substances (ODS) released from discarded appliances (e.g. air conditioners, refrigerators) and building materials (foams), as well as industrial waste practices, contribute to ozone-layer depletion. Many of those ODS are also potent GHGs that contribute to climate change.

2.2 Opportunities

The opportunities for greening the waste sector come from three inter-related sources: 1) growth of the waste market, driven by demand for waste services and recycled products; 2) increasing scarcity of natural resources and the consequent rise in commodity prices, which influence the demand for recycled products and WtE; and 3) emergence of new waste-management technologies. These developments have opened up significant opportunities for greening the waste sector.

Growth of the waste market

Despite data limitations, there is a clear indication that the market for waste management is growing. The world market for municipal waste, from collection to recycling, is worth an estimated US$410 billion a year (Chalmin and Gaillochet 2009). This estimate can only be indicative since assessing the exact market size is difficult given the paucity of reliable data, particularly in developing countries, and existing data being limited to the "formal" component of the waste-management sector.

Four factors are driving this growth: 1) the overall increase in the volume and variety of the waste generated; 2) rising political awareness of the need to better manage waste in the context of avoiding ecological and health risks and climate change; 3) urbanisation in emerging economies, which is typically accompanied with a growing interest in a better living environment including better waste management; and 4) development of formal and informal

Box 1: Companies resorting to eco-friendly packaging due to increased consumer pressure

Increased consumer demand for recycled products has compelled many companies to refurbish their product packaging to reduce the impact on the environment. Examples in North America include Hewlett Packard (HP), EnviroPAK (St. Louis) and Oxobioplast Inc. (Toronto). HP insists that all its packaging be recycled and labelled as such. EnviroPAK has shown great interest recently in using complex recycled paper pulp for packing electronic, small household appliances, medical products, consumer goods, CDs and DVDs, automotive parts and food and bottled goods. By opting for paper pulp in the place of expanded polystyrene, the company has claimed to save 70 per cent in packaging and shipping costs. Oxobioplast Inc. uses an additive called "Revert" to render its plastic products biodegradable by breaking apart their polymer chains after a permitted period of use.

Source: Adapted from MachineDesign, 25 October 2008

trade in secondary raw materials recovered from waste.

Change in the consumer demand is a major determinant underlining the potential "greening" of the waste sector. With increased environmental awareness, more and more consumers have started demanding recycled products and waste-derived compost. Box 1 gives examples of companies switching to eco-friendly packaging in response to consumer demand. In order to accrue benefits from recovered resources, there has been increased interest in investing in technologies such as biomethanation and WtE.

Of course, the waste market as it stands today is not necessarily green and the ways in which waste is collected and recycled may not fully comply with environmental standards and regulations. Very little data exist at present with which to estimate the magnitude of the green waste market, beyond estimates of rates of recycling. Indeed, with recycling rates of the informal sector reaching 20-50 per cent and existing solid-waste management activities being of poor standard in developing countries, it may not be prudent to use the existing data without prior validation (Wilson et al. 2009). Furthermore, where waste collection and recycling involves child labour or indecent and unsafe working conditions, the waste market should not be considered green.

The growth of the waste market, however, does provide an opportunity for greening the sector. As the market evolves and becomes mature, consumers are likely to demand stringent standards in order to avoid any health and environmental risks. In the waste sector, existing standards focus mostly on the protection of environmental and human health, but working conditions and standards for recycled products are increasingly receiving attention. Market development in this direction thus provides a platform on which to systematically introduce green standards into waste management systems.

Box 2: Recession and the paper-recycling rate in the UK

The UK paper industry produced 4.3 million tonnes of paper and cardboard in 2009, which was 14 per cent less than the previous year. Consumption declined by 10 per cent and exports dropped by 8 per cent compared with 2008, owing to the recession. The paper-recycling rate rose, however, to an all-time high of 90 per cent in 2009 and the collection rate increased by 2 per cent year on year. The UK's paper-recycling rate is expected to rise to 100 per cent with the advent of new private enterprises investing in facilities for the sector.

Source: Adapted from Packagingeurope, 25 January 2010

Scarcity of resources

Rapid population growth and economic expansion have led to escalating demand for energy, basic industrial commodities and consumer goods. Energy consumption, for example, is predicted to rise steeply as a result of an estimated expansion of the world's population by 2.3 billion by 2050, which is expected to be almost entirely concentrated in the urban centres of Asia, Latin America and Africa (Pareto and Pareto 2008). According to Leggett (2005), however, the world's oil reserves are not adequate to cope with the combined forces of depletion and demand between 2008 and 2012. Reduced energy supply has an immediate impact on energy-intensive manufacturing sectors such as mining and metal industries, reducing the production of materials and pushing up the cost of manufacturing.

Apart from oil and other commodities, metals are of vital importance to the global economy, whether in the manufacturing of buildings or cars or in the rapidly

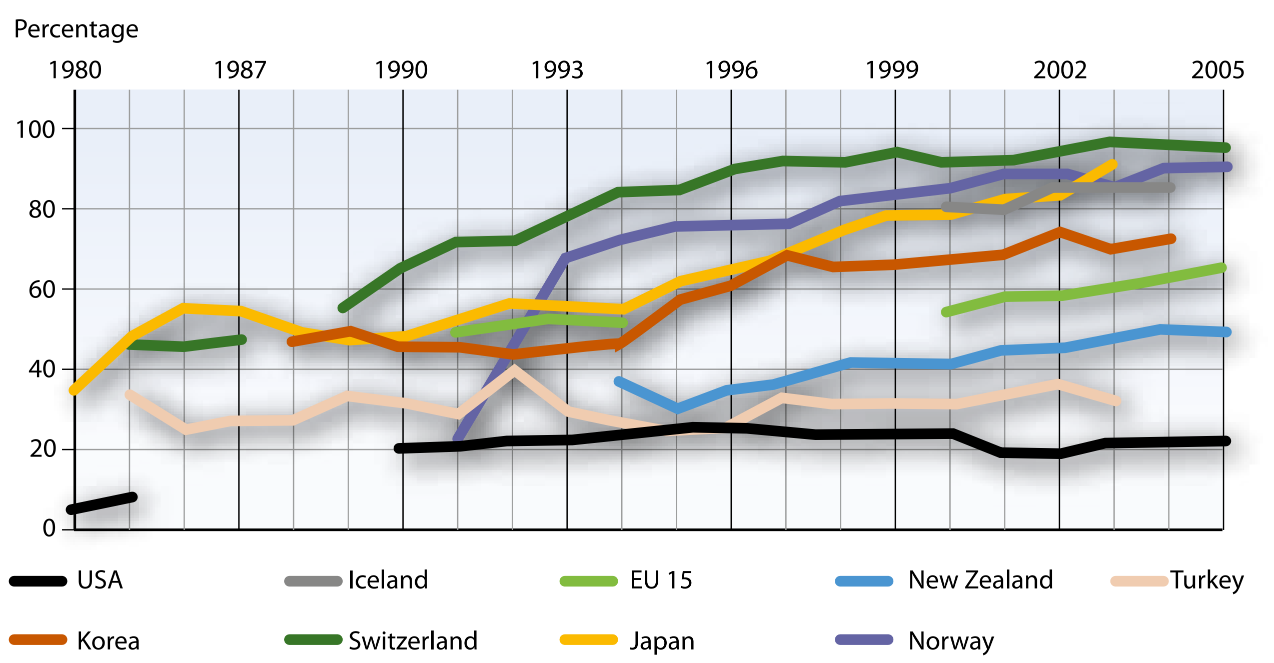


Figure 7: Trends in glass recycling from 1980 to 2005 (percentage of apparent consumption)
Source: OECD (2008b)

expanding production of mobile phones, air conditioners, refrigerators and other electronic consumer goods. If the total world population were to enjoy the same level of metals-use as in industrialised countries, the demand for metal stocks would be 3-9 times present levels.

Amid this rapid consumption of the earth's resources there appears to be great potential to create new markets by recycling and reusing existing metals, minerals, plastic, wood and other materials. Currently, however, only a quarter of the 4 billion tonnes of municipal waste produced each year is recovered or recycled (Foreword to Chalmin and Gaillochet 2009). For example, scrap metals, paper and cardboard, compost, plastics are all valuable, relatively easy to recover from waste streams and can displace raw materials that are likely to become less readily available. One tonne of electronic scrap from PCs, for example, contains more gold than that recovered from 17 tonnes of gold ore and 40 times more concentrated copper than that found in copper ore (USGS 2001).

The increasing scarcity of resources and the rising cost of extracting raw materials, which feeds into higher commodity prices, are turning waste into a "new" source of resources to be "mined". Examples include the reprocessing of metal waste, composting, waste to energy, recycling of e-waste and C&D waste. Figure 7 shows the rising trend in glass recycling in several OECD countries. Demand for recycled products can also increase at times of economic difficulty, such as has been experienced in many countries over the past two years. Box 2 shows how recession had a positive impact on the paper-recycling rate in the UK. The same, however, cannot be said of countries such as China and India, where the average value of municipal scrap dropped by up to 45 per cent during the economic slowdown, probably because of the shrinkage of aggregate demand. Similarly, the prices for used paper dropped dramatically in Germany when demand in China and India declined.

New technologies

The greening of the waste sector is also facilitated by significant breakthroughs in technologies required for collection, reprocessing and recycling waste, extracting energy from organic waste, and efficient gas capture from landfills. Compactor trucks, fore-and-aft tippers, container hoists and open-or-closed top tailers are now available for the collection and transportation of waste. Recovering energy and other useful products from waste has been enabled by considerable technological breakthroughs. WtE technologies have replaced incineration in many OECD countries. Mechanical and biological treatment (MBT) and biomethanation have, for example, been recognised as suitable for processing organic wet waste in developing countries. However, incomplete segregation of dry and wet organic waste has been a major barrier to the widespread successful adoption of these technologies in these countries. Techniques such as vermin-composting and rapid composting have led to conversion of organic waste into useful agricultural manure at a pace faster than natural decomposition. With the aid of advanced technologies, energy-rich components of waste can be converted into useful products – a classical case of this concept is Refuse Derived Fuel (RDF), a popular product derived from high-calorific-value waste.

3 Making an economic case for investing in greening the waste sector

A case for investing in greening the waste sector may be made on various grounds. In the past, cases have been made largely on environmental and health-related grounds, based on costs that can be avoided by proper collection and disposal. These arguments, particularly health-related ones, continue to be important for motivating policy actions.

In order to scale up the greening of the sector, however, environmental and health-related arguments alone are inadequate or may be seen as competing with economic imperatives. For policy-makers to channel significant resources towards the greening of the sector, they need to appreciate how such actions are likely to contribute to economic performance and job creation relative to business-as-usual (BAU) scenarios. Adequate economic arguments are, therefore, needed to motivate fundamental changes in the management of the sector.

To make a primarily economic case for investing in greening the waste sector, three steps are needed, which are elaborated on in this section. First, we need to have an idea of the extent to which the sector could be greened. Second, we need to have some ideas about the financing gaps for priority areas. Third, given the priorities of greening the sector, we need to show the potential gains if green investment is made in those areas.

3.1 The goals and indicators for greening the waste sector

There are no established international targets for greening the waste sector, apart from the control of specific hazardous substances as governed by international conventions. Most goals are national or even local. For example, in northern Europe, the Republic of Korea and Singapore, over 50 per cent of waste is subjected to material-recovery processes (Chalmin and Gaillochet 2009). Japan has set material-flow indicators that fall under three categories, viz., "input", "cycle" and "output", to compare developments in recycling rates with those of previous years. The indicators include resource productivity in yen per tonne (increased from 210,000 in 1990 to 390,000 in 2010), recycle-use rate (increased from 8 per cent in 1990 to 14 per cent in 2010), and final-disposal amount (decreased from 110 million tonnes in 1990 to 28 million tonnes in 2010 (Ministry of Environment, Government of Japan 2008).

China has adopted the Circular Economy (CE) approach in a move towards achieving a more balanced growth as part of its 11th five-year plan. Pintér (2006) has shortlisted two input indicators (direct material input and total material requirement), one output indicator (domestic processed output), two consumption indicators (domestic material consumption and total material consumption) and two balance indicators (physical trade balance and net addition to stock) that could give credible information on the status of implementation towards achieving the CE goal.

The Republic of Korea planned to increase its waste-recycling rate of MSW from 56.3 per cent in 2007 to 61 per cent in 2012 (Ministry of Environment 2008). Under the directive on packaging and packaging waste, the EU increased the target for overall recycling from 25 per cent (min.) and 45 per cent (max.) in 1994 to 55 per cent (min.) and 80 per cent (max.) in 2004 (EC 2009). As an example of city-level 3R policies, London's draft 2011 waste-management plan sets a goal of 45 per cent municipal waste recycling/composting by 2015, 70 per cent commercial/industrial waste recycling/composting by 2020 and 95 per cent re-use and recycling of C&D waste by 2020 (Mayor of London 2010). Table 2 gives further examples of goals and targets that can be used to measure progress in greening the waste sector.

In its Draft National Waste Management Strategy (NWMS), the Department of Environmental Affairs (2010) of South Africa has set out a minimum set of target parameters for use by municipalities in the provision of waste services. The target parameters include, number of households receiving a waste service (per cent over time), budget allocations to ensure financial support (percentage increase in budget over time), equipment and infrastructure provision, number of staff trained or capacitated to improve service, proportion of community that is aware of the waste-management services, reduction of waste to landfill and improvement of cost recovery measures. Individual municipalities are required to set out relevant target figures under these parameters.

It is, therefore, difficult to have one-size-fits-all goals for the greening of the waste sector. Generally speaking, however,

Targets	Examples
Resource efficiency or productivity	**1. Japan's Sound Material Cycle Society Target** Resource productivity (yen/ tonnes) calculated as GDP divided by amount of natural resources, etc. invested, to be increased from 210,000 in 1990 to 390,000 in 2010 **2. London Waste Targets from London Plan Draft, Mayor of London** 85% regional self-sufficiency by 2020 (meaning dependency on only local and recycled resources)
Waste recycling rate	**1. Republic of Korea's Green Growth Target for Waste** Increase in percentage of MSW recycling from 56.3 % in 2007 to 61 % in 2012. **2. Japan's Sound Material Cycle Society Target** Cycle use rate (Cyclical use amount ÷ [cyclical use amount + amount of natural resource input]), to increase from 8% in 1990 to 14% in 2010. The status as of 2000 was 10%. **3. London Waste Targets from London Plan Draft, Mayor of London** 45% municipal waste recycling/composting by 2015 70% commercial/industrial waste recycling/composting by 2020 95% re-use and recycling of C&D waste by 2020.
Waste landfilled	**1. The EC Landfill Directive Council Directive 1999/31/EC** not later than 16 July 2016, biodegradable municipal waste going to landfill must be reduced to 35 % of the total amount by weight of biodegradable municipal waste produced in 1995 or the latest year before 1995 for which standardised Eurostat data is available. **2. Japan's Sound Material Cycle Society Target** Amount of waste landfilled to be reduced from 110 million tonnes in 1990 to 28 million metric tones in 2010. The status in 2000 was 56 million tonnes. **3. Flemish Waste Management Policy, Belgium** Residents should not generate more than 150kg of residual waste (waste to be landfilled or incinerated) per inhabitant per year.

Table 2: Indicators to measure the greening of the waste sector

Sources: EC (1999), Ministry of the Environment, Government of Japan (2008), Ministry of Environment, Republic of Korea (2008), EEA (2010), Lee (2010), Mayor of London (2010)

in greening the waste sector, all countries should seek to: 1) avoid waste in the first place through sustainable community practices, 2) minimise the generation of waste; 3) where waste is inevitable, recover materials and energy from waste and remanufacture and recycle waste into usable products, and 4) treat any remaining unusable waste in an environmentally friendly or in the least damaging way. For developing countries, one of the goals should be the formalisation of the waste sector, following environmental guidance and labour- protection measures.

The goals of greening the waste sector cannot be achieved without increased investment. Minimising waste generation requires changes to product design and production processes upstream (some of the related issues are addressed in the Industry chapter). Downstream recovering, remanufacturing, recycling, and final treatment require new facilities or upgrading of existing facilities. Investment is also needed to train the labour force in the sector as well as to formalise the informal sector.

3.2 Spending in the waste sector

There is a substantial variation across countries in the magnitude of government spending on the waste sector. Waste management is a municipal service that is mostly financed through municipal funds, although private involvement has been observed in recent times. Section 5.1 describes the various financing options available for the sector. The percentage of the waste spending relative to GDP may be similar for developing and developed countries (looking at specific cases), but there is a significant difference in the amount spent on waste management expressed in per capita terms. Dhaka city, for example, spends US$0.9 per capita per year (0.2 per cent of GDP) on MSW management whereas Vienna spends US$137 per capita per year (0.4 per cent of GDP) (Fellner 2007).

Another major phenomena to note is that developing countries typically spend more than half of their waste budget in collection alone (mainly on labour and fuel), although the collection rate remains low and the transport of waste inefficient. Spending on other segments of the waste-management chain such as appropriate treatment, recovery and disposal technologies and facilities is generally rather low.

In these countries, increased investment in basic collection services, the transport of waste and cleaning up dumpsites is a starting point for greening the sector. Investment can be targeted, for example, at techniques such as route optimisation and transfer stations, which can bring down the capital and operational costs of providing waste services.

In emerging economies with rapid growth and urbanisation, the need for increased investment in greening the waste sector is particularly strong. The World Bank, for example, has estimated that China has to increase its national waste management budget by at least eight-fold from

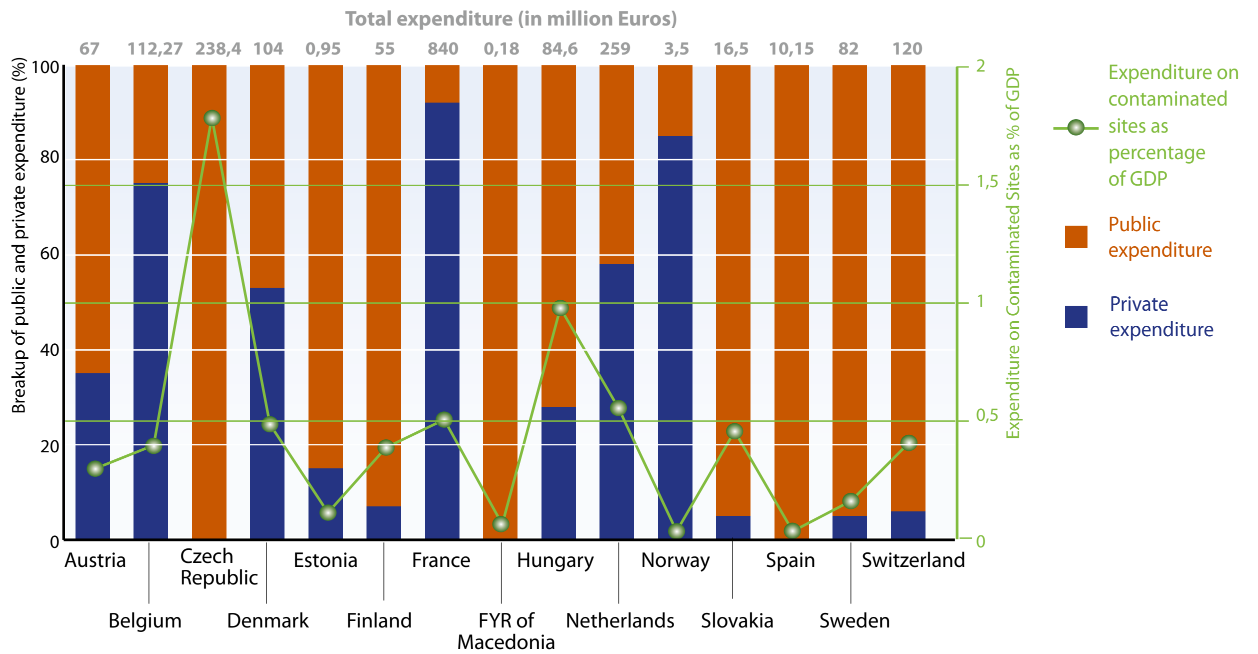


Figure 8: Total public and private expenditure on reclamation of contaminated sites in Europe

Source: Adapted from EEA (2007)

1999 levels by 2020, which requires the allocation of 230 billion RMB (US$126 billion) to provide and construct MSW management infrastructure (World Bank 2005).

European countries spend a significant amount on reclaiming contaminated sites, which can become valuable assets for industrial estates and commercial areas (see Figure 8). Expenditure ranges from 0.4 to 0.5 per cent of GDP in countries including Belgium, France, the Netherlands and Switzerland, to 1 per cent in Hungary and 1.8 per cent in the Czech Republic. In most of these countries, the private sector participates in funding the reclamation. In Czech Republic, the Republic of Macedonia, and Spain, however, the spending comes entirely from the public sector.

The appropriateness of different waste treatment methods can be influenced by factors such as urban population density, availability of space and policy enforcement capacity. In places of higher population density and limited space such as in the cities of Japan and northern Europe, most waste is incinerated. In places of lower population density and greater availability of space such as Australia, controlled sanitary landfilling is more common. State-of-the art sanitary landfilling is also used in the UK, Ireland, the USA, Greece, Spain and Italy. In some developing countries, emerging economies and even regions of developed countries where policy-enforcement capacity is weak, open landfills and incineration without energy recovery remains common practice.

Fundamentally, however, the choice of treatment options is based on a cost-benefit analysis. For example, if we only focus on the cost of technologies, landfilling appears to be as attractive as composting. Porter's data of 2002, however, shows that landfilling will incur an additional environmental and social cost of between US$45 and US$75 per tonne. In this context, composting becomes a more attractive option than landfilling. Thus, a total cost-benefit analysis that addresses economic, environmental and social perspectives becomes necessary in making the right choice of technology.

Recognising the negative impacts of the least-preferred waste management options, many national and regional authorities have established command-and-control targets for better management of landfill sites and incinerators, and diversion of waste away from these facilities. For example, the US Resource Conservation and Recovery Act (RCRA) (1976) was amended (Federal Hazardous and Solid Waste Amendments (HSWA)) in 1984 to include the phasing out of land disposal of hazardous solid waste. The Landfill Disposal Programme Flexibility Act (1996) also stipulates environmental management standards for land disposal. In Europe, the European Union Landfill Council Directive 99/31/EC of 26 April 1999 aims to prevent or reduce as far as possible negative effects on the environment from the landfilling of waste, by introducing stringent technical requirements. The Landfill Directive also obliges Member States to reduce the amount of biodegradable waste going to landfill to 35 per cent of 1995 levels by 2016. The Directive on the Incineration of Waste (2000/76/EC) produces similar regulation for thermal treatment facilities. Japan's Sound Material Cycle target was to reduce the amount of waste landfilled from 110 million tonnes in 1990 to 28 million tonnes in 2010. These Command And Control (CAC) approaches have been effective, particularly because economies of scale could be achieved by the legislative measure and the supply of waste materials could subsequently be ensured. However, CAC approaches are costly and require substantial enforcement capacity to produce results.

Particulars	Low-income countries	Middle-income countries	High-income countries
GDP in $/capita/year	< $5,000	$5,000 – $15,000	$5,000 – $15,000
Average consumption of paper and cardboard by kg/capita/year	20	20 – 70	130 - 300
Municipal waste (kg/capita/year)	150 – 250	250 – 550	350 – 750
Formal collection rate of municipal waste	< 70%	70% – 95%	> 95%
Statutory waste management framework	No or weak* national environmental strategy, little application of the statutory framework, absence of statistics	National environmental strategy, Ministry of the Environment, statutory framework but insufficient application, little statistics	National environmental strategy, Ministry of the Environment, statutory framework set up and applied, statistics
Informal collection	Highly developed, substantial volume capture, tendency to organise in cooperatives or associations	Developed and in process of institutionalisation	Quasi non-existent
Municipal waste composition (% weight basis)			
Organic/fermentable	50 – 80	20 – 65	20 – 40
Paper and cardboard	4 – 15	15 – 40	15 – 50
Plastics	5 – 12	7 – 15	10 – 15
Metals	1 – 5	1 – 5	5 – 8
Glass	1 – 5	1 – 5	5 – 8
Moisture content	50% – 80%	40% – 60%	20% – 30%
Calorific value (in kcal/kg dry basis)	800 – 1,100	1,100 – 1,300	1,500 – 2,700
Waste treatment	Uncontrolled landfills > 50% Informal recycling 15%	Landfill sites > 90%, start of selective collection, organised recycling 5%, coexistent informal recycling	Selective collection, incineration, recycling > 20%
Informal recycling	Highly developed, substantial volume capture, tendency to organise in cooperatives or associations	Developed and in process of institutionalisation	Quasi non-existent

* In some countries, environmental strategies are weak and not comprehensive.

Table 3: Waste collection typologies by GDP per capita
Source: Adapted from Chalmin and Gaillochet (2009)

In low-income countries, recycling is mostly controlled by an informal sector that is usually unrecognised by governments and primarily driven by the cost of raw materials and cheap labour. But the poor collection-to-generation ratio and exploitation of the available recyclable component by the informal sector makes it difficult to calculate overall recycling levels in developing countries. Table 3 gives the waste collection typologies by GDP per capita, which shows the informal sector being a dominant force in the waste management system.

Global data, however, do not exist to show the investment gaps between the current state of the waste sector and the desired "green" state. This poses a challenge for estimating how much investment is required, globally, to green the waste sector.

3.3 Benefits from investment in greening the waste sector

Greening the waste sector is expected to generate substantial economic, environmental and social benefits. They include: 1) natural resource and energy saving; 2) creation of new businesses and jobs; 3) compost production supporting organic agriculture; 4) energy production from waste; 5) reduced GHG emissions; and 6) contributions to equity and poverty eradication. Improved health, avoided health costs, avoided water contamination, and the consequent cost of alternative water supply are also important streams of benefits. In addition, greening the waste sector in the entire supply chain is expected to generate a whole range of benefits not fully identified in the above list. Given the limited availability of quantitative information, however, this section is not able to substantiate these benefits. Further research is needed in these areas.

Resource and energy conservation

Practicing 3R reduces the demand for raw materials. This is called the resource conservation effect (Ferrer and Ayres 2000). The United States Energy Information Administration (EIA) suggests, for example, that recycling paper will save up to 17 trees and reduce water-use by 50 per cent. Also related to this resource conservation effect is the embedded market value of the waste recyclables. In the State of Washington, USA, for example, such value (which was not captured) from solid waste recyclables disposed – including paper, cardboard, metals, plastics, glass, and electronics – grew from US$182.4 million in 2003 to US$320 million in 2008 (State of Washington 2010). A

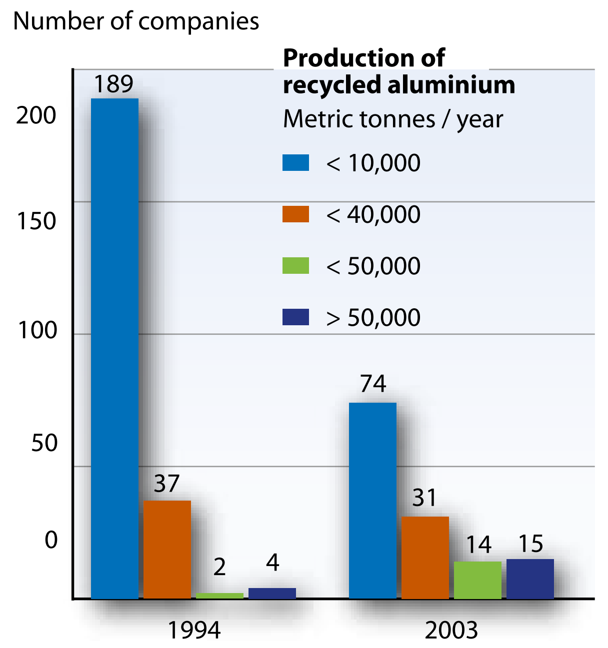


Figure 9: Growing capacity of recycled aluminium industry in Western Europe

Source: Adapted from EEA and OEA (2006)

positive example, however, is found in Viridor, a leading UK waste management company whose turnover in 2008/09 reached £528 million and whose profit had grown at 22 per cent since 2000/01, 40 per cent of which resulted from value recovered from waste (Drummond 2010).

Aluminium is a major recyclable resource. According to the European Aluminium Association and Organization of European Aluminium Refiners and Remelters, the global aluminium recycling rates are about 90 per cent for transport and construction appliances and 60 per cent for beverage cans. The lower cost of recycled aluminium results from drastically lower energy consumption than is required to smelt it from the raw material, bauxite. Recycled aluminium can be used in all its applications, from castings for automotive and engineering components to extrusion billets, rolling slabs to a deoxidising agent in the steel industry.

Figure 9 shows the growing capacity of the aluminium industry in Western Europe, which almost tripled its output from about 1.2 million tonnes in 1980 to 3.7 million tonnes in 2003, primarily because the recycling activity of smelters increased by 94 per cent in this period. By doing so, Europe conserved approximately 16.4 million tonnes of bauxite and 200,000 tonnes of alloying elements such as silicon, copper, iron, magnesium, manganese, zinc and other elements used for strengthening and other purposes. Europe also saved 1.5 million m^3 of landfill space in the process.

EEA demonstrates that by recycling 1 tonne of aluminium, the following resource savings could be accrued: 1.3 tonnes of bauxite residues; 15 m^3 of cooling water and 0.86 m^3 of process water. Furthermore, 2 tonnes of CO_2 and 11 kg of SO_2 can be avoided.

Type of material	Energy savings[1,2] (%)	GHG flux saving from recycling[3] (kg CO_2 eq. per tonne of recycled material)	Savings on carbon price in US$ (13.4 US$ per tonne of CO_2 eq.)
Aluminium	90-95	95	1273
Ferrous	74	63	844
Textiles	NA	60	804
Steel	62 - 74	NA	-
Copper	35 - 85	NA	-
Lead	60 - 65	NA	-
Paper	40	177	2,372
Zinc	60	NA	-
Plastic	80 - 90	41 (HDPE)	549
Glass	20	30	402

NA: Data not availablea

Table 4: Energy savings and GHG flux savings due to waste recycling

Source: 1BIR (2008), 2BMRA (2010), Glass Packaging Institute (2010) and 3European Communities (2001)

Aside from resource conservation, there also exists an energy-saving benefit from substituting virgin materials with resources recovered from waste streams. According to the Natural Resource Defence Council (NRDC), recycling is the most energy conserving of all waste management strategies. NRDC (1997) stresses that materials sent to an incinerator release energy only once, whereas recycling can provide energy savings through several production cycles. Recycling a tonne of aluminium and steel, for example, saves the equivalent of 37 and 2.7 barrels of oil, respectively. On the contrary, when incinerated, these materials absorb heat and reduce the amount of net energy produced.

Energy savings in turn bring reductions in GHG emissions. For example, recycling in the UK is already saving around 10-15 million tonnes of CO_2 equivalent per year (WRAP 2006). Table 4 provides estimates on energy savings from waste recycling and the net GHG flux (which refers to the net amount of GHG saved in an activity factoring the related emissions, absorptions, and offsets) saving from avoided landfilling.

A potential trade-off from making the transition to a "resource recovery"-based economy, however, may include an initial loss in economies of scale already established in extraction, which could have implications for the manufacturing industries perhaps in terms of increased cost of goods in the short to medium term. This has yet to be quantitatively studied. In any event, it is expected that – as the systems of 3R get mainstreamed in business processes and as the markets mature – the costs of goods

Box 3: Cost savings and resource recovery from recycling

■ The Prostheses Foundation in Chiang Mai, Thailand conducts a sensational programme using recycled materials. The foundation produces artificial limbs from aluminium ring-pulls collected from beverage canisters. The ring-pulls contain titanium, a light, strong, lustrous, corrosion-resistant and valuable metal. They are collected from across the country, including from several large companies. Some 35,000 ring-pulls produce 1 kg of useable metal, from which two artificial limbs can be fashioned. The foundation has recycled nearly 5,000 tonnes of ring-pulls and has created a positive net socio-economic impact. Prosthetics made of recycled aluminium are much cheaper (typically Thai Baht (THB) 5,500 (US$160) a piece) than similar imported ones (THB 90,000 (US$ 2,650). Furthermore, an artificial leg made from recycled ring-pulls weighs just 6 kg, while many similar imported products weigh about 11 kg.

Source: Prosthetic Foundation Official Website, Journal (2007)

■ A recycling campaign to collect used mobile phones in Japan was launched in November 2009 and involved 1,886 stores and supermarkets. Those who returned used mobile phones in exchange for purchasing a new device were invited to enter a lottery to win coupons worth 1,000-50,000 yen (equivalent to US$12 to US$600) depending on the price of the mobile phone they bought. The initiative collected 569,464 mobile phones containing precious metals amounting to 22 kg of gold, 140 mg of silver, 10 g of copper and 4 mg of palladium in just 4 months.

Source: Mohanty (2010)

will stabilise and could even go down. Box 3 provides examples of recycling leading to cost savings and the recovery of precious metals.

Job creation

The labour force that underpins the recycling sector contributes significantly to solving one or more global environmental issues (e.g. climate mitigation or preventing pollution). These workers, whether they are formally employed or are self-employed, should be considered a category of "the agents of change" that environmental and economic policies rely upon. The high value of their contribution to climate policies and social value-added should therefore be widely and more clearly recognised.

Recycling is one of the most important sectors in terms of employment creation. However, many recycling or waste-management-related jobs can not be considered "green" as they do not match the basic requirements of "decent work". Priority indicators of decent work include: child labour, occupational health and safety, social protection and freedom of association (various forms of organisation of workers such as unions, local associations and cooperatives). On the other hand, because jobs in the recycling chain represent a source of income for workers who usually have low levels of education or poor backgrounds, these jobs are an important element of poverty alleviation. A detailed discussion of the social dimension is presented in Box 4.

A recent estimate suggests that up to 15 million people are engaged in waste collection for their livelihood in developing countries (Medina 2008). The US recycling industry is estimated to have earned US$236 billion in revenue in 2007, employing over a million people and accounting for about 2 per cent of the country's GDP (EPN 2009). Over half a million waste pickers have been reported in Brazil and the country has close to 2,400 companies and cooperatives involved in recycling and scrap trading (UNEP 2008).

In Buenos Aires, an estimated 40,000 waste scavengers are estimated to have an economic impact of US$1.78 million per year, close to 0.05 per cent of the city's GDP (Medina 2008). Other estimates put the number of waste scavengers in India at least at a million, while in China up to 10 million workers are reportedly involved in recycling activities (UNEP 2008). Scheinberg et al. (2010) studied informal recyclers in six cities: Cairo, Egypt; Cluj-Napoca, Romania; Lima, Peru; Lusaka, Zambia; Pune, India; and Quezon City (part of Metro Manila), the Philippines, and found that more than 75,000 individuals and their families are engaged in recycling about 3 million tonnes of waste per year with an economic value of more than US$ 120 million.

In developing countries the recycling segment of the waste industry is predominantly controlled by the informal sector, and it is often hazardous, unsafe work. Typically, 1 per cent of the urban population in developing countries is involved in informal scavenging, most of who are women and children. Hence, efforts are needed to provide recognition, respect and appropriate protection to ensure that issues related to health and safety are adequately addressed.

According to the Institute of Local Self Reliance (ILSR), sorting and processing recyclables alone sustains ten times more jobs than landfilling or incineration on a per-tonne basis. The recycling industries in the USA experienced remarkable growth from 8,000 companies employing 79,000 people

Box 4: The social dimension of waste management and recycling jobs – implications for decent work and poverty reduction[3]

In recent years, motivated by the need to simultaneously address the environmental degradation and boost income generation at the local and community level, a number of projects for recycling materials have been implemented in developing countries. Given that jobs involving the collection, processing and distribution of recyclables are usually performed by workers who have few options elsewhere in the economy, jobs in the recycling chain bear a significant pro-poor component.

In Ouagadougou, Burkina Faso, a project for collecting and recycling plastic waste has helped improve the environmental situation and has created jobs and generated income for locals. The project gave rise to the first recycling centre in the country, which is managed by 30 women and two technicians, all locals working eight hours a day, five days a week, and earning the equivalent of US$50 per month, a relatively good salary compared with other occupations in the local economy. The 2,000 or so waste collectors earn up to US$0.8 per day. Since implementation, the city and its suburbs are cleaner. Furthermore, many people have managed to secure an income, either by collecting the plastic waste or by working as full-time employees at the recycling centre. Many of them used to be among the poorest of Ouagadougou's suburban population (ILO 2007).

In Dhaka, Bangladesh, a project generating compost from organic waste helped create 400 new jobs in collection activities and 800 new jobs in the process of composting. Workers collect 700 tonnes of organic waste per day, which obtains 50,000 tonnes of compost per year. These jobs provide workers with health insurance, access to a daycare center and a free meal. Other benefits include cheaper compost, a reduced need for irrigation and improved soil quality (Sinha and Enayetullah 2010).

From an employment/social perspective, it is critical to address the need for the progressive formalisation of the waste sector at the same time that environmental and economic objectives are being pursued. This can be tackled by creating new types of jobs and reorganising the economic segments. Typical examples include door-to-door collection of MSW, up-stream sorting of municipal and industrial waste, industry-to-industry waste exchanges, segmentation of waste collection and waste recovery services (e.g. used lead acid batteries, oily waste), the emergence of contracting services, collective organisations, skills-development programmes to come to terms with the type of material that is handled by workers and enterprises and the use of environmentally-sound technologies for waste management, and the introduction of targeted Occupational Health and Safety (OHS) programmes.

The application of national labour laws and OHS legislation to the informal economy is one of the most important challenges facing many countries. At the same time, OHS provides possibly the easiest entry point for the extension of basic labour protection including basic OHS measures. The work of the ILO and its recommendations regarding the informal economy should be considered in the context of the formalisation of the waste-management sector (workers, skills, OHS, co-operatives, etc) (ILO 2010).

Social innovations have proven critical in achieving sustainable outcomes by favouring a stakeholders approach. In this regard, utilising social and environmental entrepreneurs and/or trade unions to help informal waste workers to improve their working and living conditions are key options to consider. For example, the Best of 2 Worlds project, a result of joint work by Solving the e-waste Problem (StEP) and Umicore a precious metal refining group, investigates the eco-efficiency of the manual dismantling of e-waste in China with control over environmental factors.

From a green-economy perspective, enhancing decent work and labour standards are also an equally important priority for the creation of productive jobs alongside the need to exploit the economic opportunities that the waste sector can yield. This can be partly achieved through technical and technological improvements. However, the sector is also replete with attempts to introduce technologies that are not adapted to local contexts, leading to major setbacks.

3. Box developed based on contributions received from ILO to this chapter.

Box 5: Turning urban manure into organic fertiliser

The Kunming Dongran Technology Company in China is a business that specialises in treating human waste through anaerobic digestion and turning the bio-slurry into an organic fertiliser. Dongran Technology was founded in 2003 with a capital investment of 10 million RMB. With the advancement of its scientific capabilities, the Yunnan National Reform and Development Commission approved Dongran as a Build-Operate-Transfer project for Kunming City's Wu Hua District. This allows the enterprise to receive government funding to finance, design, construct, and operate a facility, and to recover its investment, operation, and maintenance expense. In most urban areas, human waste is treated with wastewater, but Dongran specifically treats human waste as a separate entity and therefore reduces the likelihood of disease transmission. Additionally, through Dongran's separation of manure from the wastewater treatment process, the Environmental Protection and Sanitation Bureau's waste management burden is reduced. While Dongran receives money from Kunming's Wu Hua District to treat the waste, Dongran's main source of income is from producing organic manure through the fermentation of human waste, which turned the waste into a marketable product. The solid organic manure is used on tobacco farms, a major industry and source of income for Yunnan Province, and also on vegetables, flowers, fruits, and tea, and the liquid organic manure is often used as a nutrient for seeds.

Source: http://greeningchina.wordpress.com/2010/08/25/turning-urban-manure-into-organic-fertilizer/

and generating US$4.6 billion in sales in 1967 to more than 56,000 public- and private-sector facilities that sustained 1.1 million jobs generating US$236 billion in gross annual sales in 2000 (ILSR 2002). Recovery and recycling of used electrical and electronic appliances creates servicing or technician jobs. Such working skills should be developed through training and national certification programmes focusing on repairing and servicing requirements for used appliances.

As the waste business becomes more sophisticated, new avenues for employment are opening up. These include the application of information technology (e.g. for waste-tracking and mapping using Geographic Information Systems (GIS) and/or Geographic Positioning Systems (GPS), accounting software for waste-charging using Management Information System (MIS); mass communication for awareness, and training for skill development. Data on these new developments are, however, not readily available.

Although waste collection, segregation, and reprocessing are labour-intensive activities, the overall effect on net employment cannot be generalised. Reduction in employment could result from centralisation of energy recovery and treatment operations such as composting and landfilling. Porter (2002) cautions that jobs created by recycling replace jobs elsewhere in the economy and are often low-wage positions. In the process of greening, job losses in industries involved in the extraction of virgin materials and associated utilities could be of concern, as the increased use of recycled material implies reduced resource extraction, despite broader gains to the economy. However, the overall net employment effect appears to be positive. For example, studies have found that for every 100 jobs created in recycling, 13 jobs are lost in solid waste and virgin material extraction in North Carolina (CEQ 1997).

The concept of "creative reuse" has also arisen, generating new jobs and "value-added" products that could be sold for profit. UNCTAD observes that international trade in creative goods and services grew at an unprecedented average rate of 8.7 per cent a year from 2000-05, with China being the leading exporter (UNCTAD 2008). Organisations such as the School and Community Reuse Action Project (SCRAP) in the USA and the Scrap Arts Project Limited in the UK promote the creative reuse of waste by offering training through workshops. China has a thriving business in the manufacture of recycled products that are mostly made from waste or semi-finished recycled products available in Africa (see Box 4 for an example of waste recycling generating decent jobs and helping to reduce poverty).

Compost production

The use of composted organic waste as a fertiliser and soil conditioner brings economic benefits to small-scale farmers and reduces nutrient run-off and nitrogen leaching (Nyamangara et al. 2003). It could also increase carbon management properties of the soil and enhance the crop yields. An estimate of the economic value of these benefits, however, is not readily available. Box 5 provides an example on how organic waste can be turned in to a marketable product with wider benefits for the municipality. The chapter on agriculture expands on the business case for using waste to enhance crop production.

An indirect estimate is in terms of the avoided loss of trade owing to the excessive use of chemical fertilisers. The Food and Fertilizer Technology Center (FFTC) for the Asian and Pacific region, for example, have attributed the reduction in export volume and foreign demand of some agricultural produce in the region to high fertiliser residue levels. Such economic losses could be avoided by using organic compost for agricultural production.

Box 6: Rural energy supply from waste

■ Agri-business ventures promoting conversion of organically-rich biomass waste into biogas have great potential to supply power to rural regions. The Asian Development Bank (ADB) has supported the installation of over 7,500 biogas digesters in more than 140 rural villages in China and has suggested potential models for agri-business ventures such as community-based, small-scale industries, small- and medium- scale industries and large-scale industries for the Greater Mekong sub-region (GMS).

Source: Owens 2009

■ Anaerobic digestion of organic solid waste to generate fuel for cooking has been shown to be a promising option for villages and small towns in tropical countries such as India. More than 2,000 small-scale plants running on kitchen and market waste and a few anaerobic medium-scale plants in India and Sri Lanka are reportedly working successfully.

Source: EAWAG 2007.

■ About 500 rural households in the Indian state of Bihar have been benefiting from off-grid power generated from rice husk since 2008. Three quintals of rice husk are used per day in a power plant to generate 32 kilowatts of power. The rice husk costs Rs60 (US$1.3) per quintal. The production cost per plant per month is about Rs 20,000 (US$426). There is sufficient electricity for a household to light up two rooms and charge a mobile phone for about US$ 2 per month.

Source: (IFC 2010)

Energy production from waste

Recovering energy and other useful by-products from waste has been made possible by considerable technological breakthroughs, which have led to the implementation of WtE projects. The WtE market was estimated at US$19.9 billion in 2008 and according to forecasts, the market would grow by 30 per cent by 2014 (Argus Research Company, Independent International Investment Research Plc and Pipal Research Group 2010). The Republic of Korea, for example, has a set a target for proportion of energy to be sourced from waste and biomass at 3.17 per cent in 2013 and 4.16 per cent in 2020 (Ministry of Environment 2009). This is expected to result in a reduction of GHG emissions of 9.1 million tonnes in 2013 and 44.82 million tonnes in 2020. The nation has planned to convert all of its waste facilities to energy-recovery by 2020 by building at least 74 RDF and biogas plants, 24 energy-generating incinerators and 25 landfill-gas recovery plants (Ministry of Environment 2009).

In most cases, energy-recovery projects provide opportunities for generation and distribution of power on a decentralised basis where the electricity grid may not be available. For example, agricultural residue generated primarily in rural areas amounting to 140 billion tonnes globally has been reported to have an energy potential equivalent to 50 billion tonnes of oil (UNEP 2009c). Box 6 provides examples of the role of waste in meeting the demand for rural energy in Asia and successful entrepreneurial endeavours.

Energy-recovery projects have also been the recent focus of government investments in developed countries. In particular, there has been much interest in the EU owing to the binding targets under the EU Renewable Energy Directive (OECD 2009). Figure 10 shows the rising trend for energy production from renewable (biomass residues) and non-renewable (pellet-based waste to energy) municipal waste in the EU.

While biomethanation has been successful in Europe owing to excellent source-segregated waste upstream, the technology has not been so successful in many Asian cities where segregation of waste at source is low or almost absent. Large-scale biogas plants have been proved to be economically viable with return on investments (RoI) reported in the order of 7 per cent to 15 per cent (Singh 2006). Smaller decentralised biogas plants benefit from a lower pay-back period owing to the avoided cost of disposal resulting in a pay-back of 2 to 4 years.

With advanced technologies, waste itself can be converted into useful energy products. The EU alone has been estimated to produce three million tonnes of RDF in 2003 (EC 2003). Thermal technologies have been reported to contribute to a major share of the market, namely to about 93 per cent (US$18.5 billion). The rest of the market share, about 7 per cent (US$1.4 billion), was attributed to biological technologies. Japan, Canada and the UK are also experimenting with advanced thermal technologies such as Plasma Arc Gasification.

Reduced GHG emissions

The greening of the waste sector offers promising opportunities to mitigate climate change. According to recent national estimates by UNFCCC, the waste sector, including waste water, produces on average 2.8 per cent of national GHG emissions (IPCC 2007a). The Montreal Protocol's Technology and Economic Assessment Panel

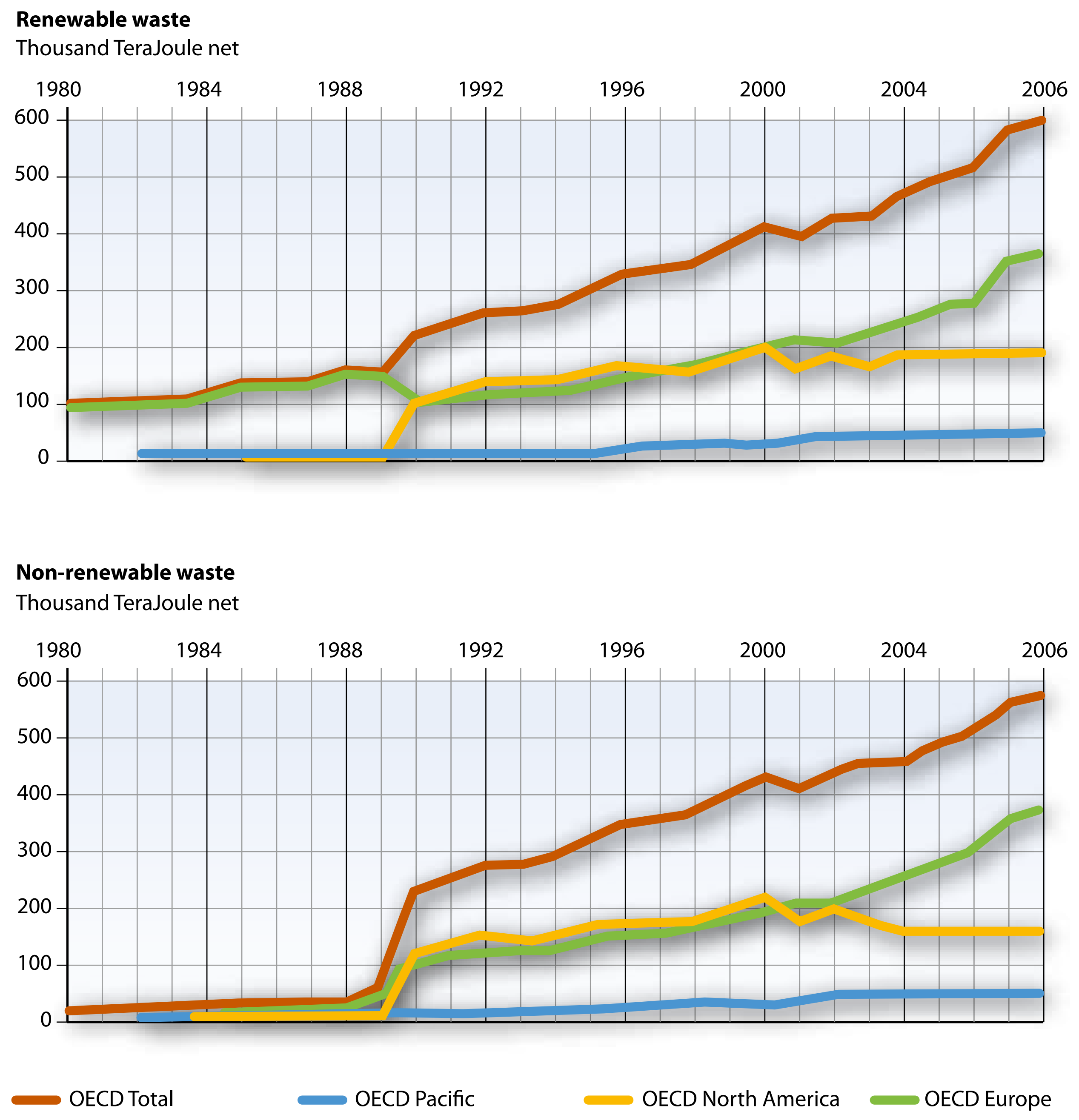


Figure 10: Energy production from renewable and non-renewable municipal waste in Europe
Source: UN (2010a)

(TEAP) estimated that worldwide ODS banks are available at approximately 3.78 million ODP-weighted tonnes in 2002 (55 times the global consumption of ODS in 2007) and have the potential to release over 20 billion tCO_2-eq of GHGs (UNEP 2009b).

Incineration and industrial co-combustion for WtE are believed to be able to provide important climate related benefits in two areas.

First, these technologies help reduce GHG emissions. According to IPCC (2007b), the total global mitigation potential for reducing landfill methane emissions in 2030 is estimated to be more than 1000 $MtCO_2$-eq (or 70 per cent of estimated emissions) at costs below US$ 100/tCO_2-eq/yr. Between 20 and 30 per cent of projected emissions for 2030 can be reduced at negative cost and 30-50 per cent at costs of less than US$ 20/tCO_2-eq/yr. More significant emission reductions are achievable at a higher cost, by additionally exploiting the mitigation potential in thermal processes for WtE.

Second, they can earn carbon credits. The CDM introduced under the Kyoto Protocol awards credit to avoided emissions from waste and hence can be applicable for all waste to energy, landfill gas recovery for power generation and composting projects. Figure 11 depicts the total number of CDM projects registered by a few non-annex I countries and

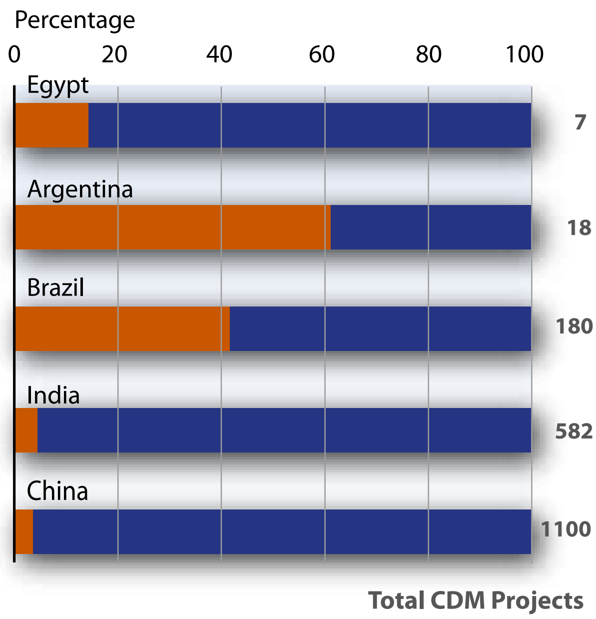


Figure 11: CDM projects registered by a few Non-Annex I Countries (as on December 2010)

Source: Data sourced from UNFCCC (2010)

the fraction of projects registered in the "waste" sector as on February 2010. The World Bank has estimated the potential annual carbon finance revenues per million residents at US$2,580,000 for landfill gas recovery, US$1,327,000 for composting, up to US$3,500,000 for recycling and US$115,000 (plus the fuel savings) for transfer stations (Hoornweg and Giannelli 2007). Landfill gas recovery from 1 million tonnes of waste leads to a reduction of 31,500 tonnes of CO_2 equivalent to a potential yielding revenue of US$140,000 per year (carbon price at 4.5 US$ per tonne), when registered as a CDM project (Greiner 2005).

Most of the landfill sites in China and India have been small and non-sanitary, and many larger sites have only been built over the last 10 years. This has resulted in the low number of CDM projects in the waste sector (9 per cent of all registered CDM projects). This situation is expected to change over the next ten years.

Brazil is the leading developing country that has exploited the CDM option for the waste sector with 72 registered projects and over 10 million CERs. The CER potential of proposed Landfill Gas to Energy (LFGTE) projects in 11 landfills from four countries, viz. Brazil (3), Colombia (6),

Box 7: Waste-based carbon credits

■ Fly ash Re-utilisation earns carbon credits

In India, about 26,000 hectares of land is covered by ash ponds. This land contains nearly 90 million tonnes of flyash that is generated annually in the country. It is estimated that every tonne of flyash reused to make concrete reduces 1 tonne of CO_2 equivalent GHG emissions. Lafarge India Pvt. Ltd. has implemented a CDM project activity through fly ash reuse to replace clinker in Arasmat Cement Plant in Chattisgarh, India. By increasing the fraction of flyash (to replace clinker) added to blended cement procured from a thermal power station, the project activity has been successful in reducing approximately 69,359 tonnes of CO_2e per year, with a potential to earn CERs worth US$0.9 million.

Source: UNFCCC 2006

■ Material recycling from solid waste earns carbon credits

A new small-scale methodology called "AMS-III AJ Recovery and Recycling of Materials from Solid Wastes" valid from 26 March 2010 was approved by the CDM Executive Body (EB). This enables the recovery and recycling of High Density Poly Ethylene (HDPE) and Low Density Poly Ethylene (LDPE) plastics in MSW to process them into intermediate or finished products such as plastic resin. It negates the need to produce virgin HDPE and LDPE materials in dedicated facilities and results in energy savings and reduced emissions and is eligible to earn carbon credits. However, the wastes must be procured locally, from sources located within 200 km of the recycling facilities; plastics already segregated from the rest of the waste and transported more than 200 km distance are not eligible.

Source: CDM EB 2010

■ CDM projects in Dhaka, Bangladesh

Waste Concern, a non-profit organisation in Bangladesh, has registered two waste-related CDM projects in Dhaka. One of the projects involves composting 700 tonnes of organic waste a day in the city and generating some 624,000 TCO_2 equivalents over the first crediting period of 2006-2012. The project will reduce GHG emissions by diverting high organic waste from a landfill to an aerobic composting process. Another project on landfill-gas extraction and utilisation at Matuail landfill site, Dhaka, has been registered to realise 566,000 TCO_2 equivalents over the same period.

Source: UNFCCC (2005)

Peru (1) and Uruguay (1), has been estimated at 16.98 million tCO_2eq by the World Bank. CER benefits from waste recycling are illustrated in Box 7.

Supporting equity and poverty reduction

Waste is the sector in which the issue of equity and poverty is probably most acute. The pollution from many below-standard waste treatment and disposal facilities directly impact populations living close to these facilities. It has been observed that hazardous waste dumps and incinerators are mostly located in the poorest neighbourhoods, both in developed and developing countries (Wapner 2002). Much of the literature citing waste facilities in the USA discusses race and poverty elements (Jenkins et al. 2002). Furthermore, the lack of alternative livelihood options and the value of recovered materials entice many poor men, women and even children to engage in scavenging activities in the low and middle income countries without any health protection.

Greening the waste sector includes considerations of these equity and poverty issues. Investing in greening the sector is not only about building facilities; it also includes the formalisation of the sector so that workers receive training, health protection and benefits, and a fair compensation for their labour. In addition, greening the waste sector favours decentralised, localised and labour-intensive waste treatment systems as opposed to centralised, large-scale, capital intensive waste facilities so as to generate job opportunities for local communities.

4 Effects of increased investment in the waste sector

A systems-dynamics model was used to identify the likely effects of increased investments in the waste sector at the global level (working with global averages), with particular emphasis on waste management and recycling. In an ideal case, the analysis of investments in improved solid waste management would cover both the generation of waste and the entire waste management chain, including collection, segregation, transportation, recycling and recovery, treatment and disposal, but lack of data has limited the inclusion of all this. The estimates presented below should therefore be interpreted as illustrating the nature and scale of waste generation and highlighting possibilities to invest in waste collection and treatment. There are also considerable differences between countries, which are not reflected in the global figures, including both generation and costs.

The economy-wide model assumes 2% of the global GDP to be allocated on a yearly basis as additional investment in 10 green sectors (G2) over the period 2011-2050. The results of this investment are then compared with those of a business-as-usual (BAU) scenario without additional investment, and a BAU2 scenario, in which the same additional amount is invested following the projected trends of BAU. In the case of the waste sector, the comparison is between G2 and BAU (G2 and BAU2 are similar and mainly differentiated by the emphasis put on the different areas of the waste management system).

Within this multi-sector model, the waste sector is allocated 0.16% of the global GDP or US$ 108 billion in 2011, which rises with GDP to US$ 310 in 2050, corresponding to an average annual investment US$ 143 billion over the period 2011-2050. The purpose of the exercise is to illustrate what would happen if a given amount of additional investment is made available to green the waste sector (alongside the greening of the other sectors). The approach, however, does not lead to results as to how much investment is needed to reach a specific target in greening the sector. Due to data limitations, the model is also not able to estimate effects in terms of the market values of, for example, recycled materials and products, recovered energy and composted fertilisers. The modelling of the overall green economy investment scenarios across sectors is presented in detail in a separate chapter.

In the model, waste generation (i.e. before recycling and recovery) is driven primarily by population and GDP. In 2010, an estimated 11.2 billion tonnes of solid waste were collected globally.[4] Of this, 8.4 billion tonnes are agricultural and forestry organic waste and 1.8 billion tonnes are MSW, and the rest consists of industrial waste, e-waste and waste from construction and demolition (C&D waste).[5] Under a Business-as-usual Scenario (with no additional investments) the amount of solid waste generated each year is projected to rise 17 per cent to 13.1 billion tonnes in 2050.

The total waste collected is treated, in general, using six different approaches, including landfill, energy recovery, material recovery, incineration, composting and recycling, which all are likely to expand in the future. For example, the total power generation from waste in 2010 was estimated at about 71,600 GWh incinerating 192 million tonnes of municipal waste, with a capacity of 54 GW primarily from waste combustion plants. Under BAU (without additional investments), this generation capacity is expected to grow modestly to just over 200 GW by 2050, corresponding to 0.5 billion tonnes of waste incinerated per year. The size of landfills is also expected to expand, especially if no additional efforts are made to build WtE plants. In the BAU scenario, total accumulated waste in landfills will increase by 50 per cent from the currently almost 8 billion tonnes to 12 billion tonnes. The modern municipal waste landfills that enable production of biogas, only account for a small share, but further improvement in terms of technology and economic performance are expected in the future. Regarding material recovery from wastes, under the BAU scenario, the total amount of recyclables in MSW is projected to increase from 0.18 billion tonnes in 2010 to 0.28 billion tonnes in 2050.

The "green" investment scenario then allocates 0.16 per cent of the global GDP to three areas of waste management: waste recycling, composting of agricultural and forestry organic waste, and waste collection. Investments for waste recycling and composting (including energy recovery) are prioritised (to support material recovery and agricultural activities) and the residual investment is spent on increasing waste collection. An average of about US$33 billion per year is allocated to waste recycling and composting over the entire period, under G2, based on a global average estimated cost of recycling of $100 per tonne of waste. The average annual investment for waste collection is US$110

4. The model refers to collected and not generated as typically only the waste that is collected appears in statistical data.

5. Note that these two categories overlap: MSW can also include parts of organic waste. Please note that Chalmin and Gaillochet (2009) have reported that 3.4 to 4 billion tonnes of municipal and hazardous waste are produced every year.

billion for G2. The allocation for waste collection under G2 reflects the need to handle the net increase in waste generation in the coming decades.

In the G2 scenario, the investment leads to an increase in the percentage of MSW, industrial waste and e-waste recycled from 9.9 per cent in 2010 to 33.4 per cent 2050, which is 6.6 per cent higher than in the BAU.

These improvements can be broken down into: 1) a doubling of the recycling rate of industrial waste, (increase from 7 to 15 per cent), and 2) near full recycling of e-waste (from a current estimated level of 15 per cent)[6], and 3) an increase of about 3.5 times over the current recycling rate of MSW – the principal source of recycled materials, from 10 to 34 per cent.

Further, by 2050, all organic waste would be composted or recovered for energy in the simulations, compared with 70 per cent under both BAU scenarios. The increase in composting would increase the supply of organic fertiliser with positive impacts on soil quality and yield in the agriculture sector.[7]

Under the BAU scenario the proportion of total waste collected that ends up in landfills is projected to increase from 22 per cent to 28 per cent by 2050. With the additional investment assumed under G2, this proportion would be reduced to less than 5 per cent. The primary reason for the reduction is a decrease in the proportion of MSW reaching landfill declining from 60 to 20 per cent. Further, the reduction can be attributed to the increased recycling of organic waste, C&D and e-waste. The total amount of landfill waste would stabilise at 8 billion tonnes in the G2 case in 2014, and decline sharply to return to a 1970 level of 3.5 billion tonnes in 2048.

Based on relatively simple assumptions of the labour intensity of waste recycling, composting and collection activities, the assumed green investments in the waste-management sector are also expected to contribute to job creation. Almost 10 per cent additional jobs globally are expected to be created by 2050, compared to BAU2 at 23-24 million, only in waste collection activities.[8] These global averages, however, do not reveal regional differences. It is reasonable to expect, for example, that higher job increases could be achievable in faster growing, emerging economies where current rates of collection and recycling are low. It is also important to recall that these simulations do not include investments in reducing waste generation, which could reduce the stream of waste generated and thus cost the corresponding downstream jobs.

In summary, the simulations, though limited in scope and detail illustrate the potential for considerably reducing the proportion of solid waste going to landfill – by four-fifths – by investing in collection, recycling, including composting, as well as generating energy from organic waste.

6. Given the time period for the projection of 40 years, a significant increase for the amount of e-waste being recycled is possible, while, however, acknowledging that a rate of 100% may not be realistic.

7. As discussed in the chapter on agriculture.

8. This is based on a labour intensity of 1760 persons/million tonnes of waste collected.

5 Enabling Conditions

Mobilising increased investment in greening the waste sector on a large scale will not take place automatically. There are a number of essential conditions required to enable countries to move towards that direction. This section describes four of them: 1) financing; 2) incentives; 3) policy and regulatory measures; and 4) institutional arrangements.

5.1 Financing

Investing in greening the waste sector requires substantial financial resources for both capital expenditures and operation. Such resources may be found from: 1) private investments; 2) international funding 3) cost recovery from users; and 4) other innovative financing mechanisms. For financing from the general banking system and capital markets, further information is provided in the Finance Chapter.

Private investment

Private-sector involvement, often in the form of Public-Private Partnerships (PPPs) can, if certain conditions are met, be efficient and reduce the fiscal pressure on government budgets. Private-sector involvement has, for example, reduced the waste service cost by at least 25 per cent in countries including the UK, USA and Canada and by 23 per cent in Malaysia (Bartone 1999). Privatisation of transport services for waste management has resulted in a cost saving of 23 per cent for the city of Rajkot in India (USAID 1999).

Studies in the Republic of Ireland have also found that tendering can substantially reduce the costs incurred by local authorities in providing refuse collection services. Crude comparisons of costs before and after tendering and the costs of local authorities versus private contractors indicate that tendering can yield savings of between 34 and 45 per cent. The bulk of these cost savings are attributed to real efficiency gains as a result of contracting out (Reeves and Barrow 2000).

PPPs arrangements can be of many types. In the case of service contracts, the private partner has to provide a clearly defined service to the public partner. In the case of a management contract, the private partner is responsible for core activities like operation and maintenance. Some types of private participation arrangements are leased, where the private partner is fully responsible for operation and maintenance and the public partner is responsible for new investments. Single or multiple private players may be involved depending on the type of waste management solution.

Developing countries are beginning to see the benefits of PPPs (Ahmed and Ali 2004). In many Columbian cities and a few large cities in India and China, municipalities provide infrastructure and equipment while private waste collectors provide the labour. In New Delhi, India, an aerobic windrow composting plant is run through a concession agreement for 25 years and a waste management project leased for 10 years on the basis of Develop, Build, Operate and Transfer (DBOT) (Babu 2010).

In the Philippines, a privately-built high-temperature incinerator for high-risk health-care waste is being used by more than 200 medical centres and hospitals with a monitoring system. Dakar, Senegal, experienced a public-private joint venture that was initially a monopoly but later took to more competitive privatisation arrangement with multiple service contracts. These are some examples of innovative financing through PPPs to deliver improved services and enhanced cost efficiency.

International funding

Certified Emission Reductions (CERs) can be a potential source of inter-governmental funding. However, at the moment, the CERs issued to waste-sector projects are much lower than the CERs claimed by the project proponents in the documents submitted to UNFCCC. Modelling for methane generation and avoidance estimations has been unclear, leading to over-estimation of CERs, which in turn result in project rejections in some cases. A few technical issues such as high leachate levels inhibiting gas extraction and other problems in monitoring and verification have been major barriers in developing countries. Addressing such barriers will enable developing countries to utilise CDM revenues for greening the waste sector.

Apart from CERs, another major international source of funding for greening the waste sector is multilateral development banks. For example, about 199 waste-related projects worth US$15.7 billion were supported by the World Bank in various regions in 2009. Of all the regions, East Asia and Pacific has been receiving a major portion (37 per cent) of the support, with commitments of up to US$3.1 billion in 2009, as depicted in Figure 12.

Multilateral Environmental Agreements (MEAs) lead to the creation of specific funds that can support initiatives that lead to greening of the waste sector. For example, the Multi Lateral Fund (MLF) for the Implementation of the Montreal Protocol, the Global Environment Facility and bi-lateral donors have offered their financial assistance to the United Nations Development Programme (UNDP) to enable developing countries and Countries with Economies In

Transition (CEIT) in complying with the Montreal Protocol's control measures pertaining to the phase-out of ODS. In this process, aspects of product discards and waste management get addressed. ICF (2008) suggests that while non-Article 5 countries use ODS levies (e.g., tax per kg of refrigerant imports/production), municipal taxes, and taxes on new equipment, A5 countries could use direct assistance from the MLFs, and/or through appropriate carbon trading platforms such as CDM for implementing an approved ODS destruction methodology. MLFs could consider co-funding incremental costs associated with the removal and destruction and/or recovery and recycling of ODS refrigerant and foam from appliances, or finance the disposal of older appliances.

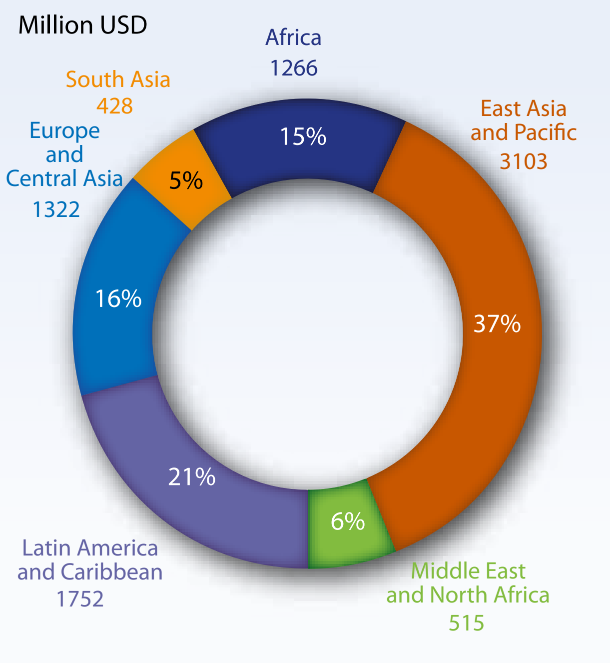


Figure 12: The World Bank's estimated investments in MSW management across various regions

Source: Data sourced from World Bank (2009)

Cost recovery from users

Waste services are provided as public services in many countries. Payments for waste collection and transport services by households, enterprises, and large-scale industrial installations, for example, can help recover the capital cost and defray the operational costs.

Indeed, cost recovery is a strategy to generate funding for investing in greening the waste sector. It has the potential to shift the costs of environmental and public health management – including administrative, capital, and operational costs – to households, allowing for more appropriate sharing of costs following the polluter pays principle. Cost-recovery measures can include administrative charges and fees covering the establishment and maintenance of registration, authorisation or permitting systems, and user charges and fees for publicly provided waste collection, treatment and disposal services. Environmental liability measures or environmental fines can also be designed in a way that helps ensure the cost of remediation and clean-up as well as environmental health cost is covered by the negligent parties, i.e. responsible polluters rather than drawing resources from public budgets.

Other innovative financing mechanisms

Micro-financing and hybrid financing are particularly useful innovative financing mechanisms for supporting small-scale efforts. The "Participatory Sustainable Waste Management Project" established in Brazil in 2006, for example, created micro-credit funds from donations (Hogarth 2009). These funds are used as working capital for financing waste transportation and waste-related emergency responses. The funds are also used to extend loans to waste-pickers who will repay their loans after receiving payment from recycling depots.

Another example is that of micro-financing for micro-enterprises managing a 40 year old, 2 million tonnes garbage heap called Smokey Mountain in Metro Manila, Philippines. The micro-enterprises are involved in collection, sorting, and sales of waste through a Material Recycling Facility (MRF). Micro-financing enabled these enterprises to borrow loans and increase their capacity to generate revenue. Through a donated bioreactor, the enterprise is processing up to 1 tonne of waste daily, supported by awareness programmes on segregation of organic waste in 21 buildings in the neighbourhood (UN 2010b).

Hybrid financing models (combining debt and equity) are being increasingly explored to support economically challenged waste management projects. Examples exist from the early 2000s in the UK, when the British government introduced prudential borrowing which gave municipal councils more freedom to borrow, removing any restriction on how much debt they could run up (UN 2010b).[9]

Another innovative financing model includes joint financing by two or more municipalities to optimise investments and attract modern technologies (such as WtE projects), which are not competitive on smaller scales (OECD 2007).

5.2 Economic incentives and disincentives

Economic incentives and disincentives serve to motivate consumers and businesses to reduce waste generation

9. Local authorities could decide for themselves whether and at what levels they borrow money for financing any purpose relevant to their functions provided that they meet requirements for prudent management of their financial affairs (Asenova et al. 2007). The Department of Environment, Food and Rural Affairs of the UK government advised prudential borrowing for low-risk investments. For example, about 60 per cent of an MBT process was funded through prudential borrowing in West Sussex Council.

and dispose of waste responsibly, thereby contributing to increased demand for greening the waste sector. The incentives commonly prevalent in the waste sector include: 1) taxes and fees; 2) recycling credit and other forms of subsidies; 3) deposit-refund; and 4) standards and performance bond or environmental guarantee fund.

Volumetric landfill taxes can encourage the reduction of waste and are easy to implement. Their effectiveness, however, depends on the tax rate per tonne of waste and on the existence of adequate monitoring and enforcement measures. It is also important to ensure that the tax does not result in increased illegal dumping rather than encouraging 3R.

Pay-as-you-throw (PAYT) is another way of discouraging waste generation. Precaution against illegal waste dumping or misuse of recycling facilities, should be taken, however. Full financing of the waste-management infrastructure has to be assured and sufficient awareness-raising is necessary. PAYT has a positive impact on recycling. For example, PAYT increased the recycling rate from 7 per cent to 35 per cent in Portland, Oregon and from 21 per cent to 50 per cent in Falmouth, Maine in just one year of implementation (Shawnee Kansas 2009).

Waste avoidance can also be achieved by assigning a disincentive for items such as plastic bags. For example, Nagoya city in Japan, after extensive consultation with retailing companies and two years of piloting, assigned a charge for plastic shopping bags in April 2009. The scheme was adopted by 90 per cent of the shopping market. The initiative reduced plastic-bag usage during shopping by 90 per cent as of December 2009. About 320 million bags weighing 2,233 tonnes were estimated to have been saved between October 2007 and October 2009 (Environmental Affairs Bureau 2010).

It is important to formalise the informal sector enterprises and support them through incentives in order to develop local markets and small and medium formal recycling enterprises. Recycling credit schemes can be a way to incentivise municipal or private recycling by raising its profitability, but they have limited applications so far. Another form of positive incentive is subsidies to offset the costs of clean-up. Box 8 gives an example in New York City.

At the household-level waste-collection fees based on weight or volume for "brown" waste – to be either incinerated or landfilled – in tandem with free collection for recyclables, including organic matter, are widely used to incentivise 3R activities. This type of policy usually co-exists with investments in either "kerbside" collection or community deposit sites for recyclables. For example, in the Republic of Korea, a Volume Based Waste Fee (VBWF) system was introduced in 1995 to replace a fixed-fee system. VBWF is a pay-per-sack scheme where households place residual waste in pre-paid sacks and recyclables are collected free of charge. The VBWF system led to a reduction of MSW generation of 21.5 per cent from 1994 to 2009 and an increase in the recycling rate from 15.4 per cent in 1994 to 61.1 per cent in 2009 (Ministry of Environment 2010).

5.3 Policy and regulatory measures

The most common types of policy and regulatory measures include:

- regulated targets for minimisation, reuse, recycling; and required targets for virgin materials displacement in production inputs;

- regulation relevant to the waste management "market", i.e. permitting/licensing requirements for

Box 8: Incentives for private investment in "brownfield" clean-up and remediation

In August 2010, the Mayor of New York City and the commissioner of the New York State Department of Environmental Conservation announced an agreement that paved the way for the city to start cleaning up "brownfields," or light-to-moderately contaminated areas that are not toxic enough to qualify for federal or state Superfund clean-up programmes. About 7,000 vacant or underused acres around the city could be readied for new development under the programme.

In 2008, the city created an Office of Environmental Remediation to run the programme, which began with a small site in the Bronx. One of an estimated 1,500 to 2,000 brownfields around the city, it was chosen as the site of Pelham Parkway Towers, an affordable housing complex.

The brownfields programme, which offers financial incentives to developers to offset some of the costs of cleaning up properties, is expected to expedite the cleaning process and put an end to "self-directed clean-ups" managed by developers without government oversight.

Source: New York Times, 5 August, 2010

waste handling, storage, treatment and final disposal; and recycled materials standards; facilities standards, including pollution control technologies; and

- land-use policies and planning.

In most cases, a particular piece of policy or legislation may encompass these different types of regulations. The discussions below will, therefore, not differentiate these different types.

Regulatory pressure in waste management started off in the mid-seventies with the tightening of waste disposal laws in developed countries. The EU directive (1975) on the disposal of waste oil and the US RCRA (1976) governing disposal of solid and hazardous waste have been the foremost regulatory measures that identified waste management as a municipal issue for government policy.[10] Box 9 gives an example of how an EU directive has influenced the UK to cut down on the amount of biodegradable waste going to landfill.

The Basel Convention on Transboundary Movement of Hazardous Wastes and their Disposal was adopted in 1989 and entered into force in 1992. The Convention provides for a strict notification scheme and addresses issues such as minimising the generation of hazardous wastes in terms of quantity and hazardousness, disposing them of as close to the source of generation as possible, reducing the movement of hazardous wastes, maximising environmentally sound waste reuse and recycling, promoting environmentally sound waste disposal and treatment and extending waste service coverage.

Since the early nineties, the EU has been actively developing waste-related policy measures. The EU Directives on Packaging (1994), Waste Communication Strategy (1996), Landfill (1999), End of Life Vehicles (EoLV) in 2000, Waste Electrical and Electronic Equipment (WEEE) in 2002 and thematic strategy on waste prevention and recycling of waste and sustainable use of natural resources (2005) and EU's revised Waste Framework Directive (2008) and Raw Material Initiative (2008) have been instrumental in greening the region's waste management industry. Meeting the 85 per cent EoLV target by 2006 had the potential to reduce the landfilling cost for EU by 80 million euro per year, which is a cost saving of 40 per cent as compared to the cost that prevailed prior to the directive. Meeting the 95 per cent target by 2015 will reduce the cost further by 80 per cent (GHK and Bio Intelligence Service 2006). The WEEE directive has compelled electrical and electronic firms across the world to adopt effective product life cycle policies such as take-back and recovery policies. Overall, green initiatives such as the one taken to meet EoLV and WEEE requirements have been beneficial to the companies and overall save the company 40-65 per cent in manufacturing costs through the reuse of parts and materials (Ali and Chan 2008).

Individual countries have also moved forward with waste related regulations and their enforcement. The German Packaging Ordinance introduced in 1991 helped encourage recycling of packaging waste which is collected through a third party organisation. British Columbia Recycling Regulation of 2004 brought about a considerable increase in the proportion of recycled waste in Canada.

Developing-country examples include the Law of the People's Republic of China on the Prevention and Control of Solid Waste Pollution adopted in 1995, South Africa's National Waste Management Strategy in 1999, India's Municipal Waste Management and Handling Rules in 2000, the Philippines's Ecological Solid Waste Management Act in 2000, Malaysia's Solid Waste and Public Cleansing Management Act in 2007 and Indonesia's Act regarding Waste Management in 2008. Although the real effects of such measures will come from implementation, the existence of these instruments provides a signal of political commitments to greening the waste sector.

Apart from broad national policies and legislations, there are also specific regulations. Extended Producer Responsibility (EPR) or Producer Take-Back Responsibility programmes such as the Green Dot Programme in Europe

Box 9: Landfill diversion in the UK

The EU landfill directive has been a key driver in pushing the UK to look for private investors to manage its waste. The directive requires member states to cut down on the amount of biodegradable waste going to landfill to less than 35 per cent of 1995 levels by 2020. Rising generation of waste is making it even more difficult for member states such as the UK to meet the landfill targets. Therefore, the Department for Environment, Food and Rural Affairs is promoting a pipeline of projects costing up to US$12.8 billion in investment that will require funding under the government's Private Finance Initiative (PFI). More incinerators are also being planned by private contractors.

Source: Adapted from Reuters, 16 April, 2010.

10. RCRA was the Principal Federal law enacted in the USA governing the disposal of MSW and hazardous waste and covers many regulatory functions of hazardous and non-hazardous waste. Its most prominent provisions is said to be the "Subtitle C" programme which tracks the progress of hazardous wastes from their point of generation, their transport, and their treatment and/or disposal. 'Superfund Sites' refer to the abandoned waste management facilities that are regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

Location	Description of community cooperation
Dhaka, Bangladesh	In Dhaka, decentralised composting has been effectively implemented through community involvement. Waste Concern in Dhaka has established a business model to this effect. Community contributions in the form of a user-charge account for 30 per cent of the project revenue and made this practice financially viable. The programme created new employments for the communities and improved livelihoods in the region. Source: Zurbrügg et al. 2005
Nagpur, India	Door–to-door (D2D) collection of waste with community cooperation has achieved a concrete savings of the order of Rs 50 million (equivalent to US$1 million) in the municipality's solid waste services. An NGO was involved to boost the involvement of the community. The initiative provided livelihoods for 1,600 people from the most deprived segment of society. The effort also boosted the financial credibility of the NGO involved, raising the budget level at least thirty-fold. Source: Agarwal 2005
Cairo, Egypt	The Zabbaleen minority community has been engaged in informal waste picking in Cairo, Egypt, since the 1930s. About 20,000 Zabbaleen were involved in waste-picking (30-40 per cent of an estimated 9,000 tonnes per day), recycling up to 80 per cent of the waste collected. Since the establishment of associations in 1970s, and launching a Zabbaleen Environment and Development Programme in 1981 with support from the Ford Foundation, the World Bank, Oxfam and others, working conditions and the basic infrastructure for waste collection and sorting has improved considerably. During the 1990s, the Zabbaleen continued to work under a franchise system by paying a license fee to the Cairo and Giza Cleansing and Beautification Authorities for the exclusive right to service a specific number of apartment blocks. They collected fees directly from households (on average US$0.3 to 0.6). A primary school, a paper recycling project, a weaving school, a health centre and a project to support small industries have all been established to support the waste pickers. The use of donkey carts for waste collection was banned. Source: Aziz 2004 and Wilson et al. 2006

Table 5: Community Cooperation in Waste Management

have motivated European-based manufacturers to simplify packaging. Such programmes have triggered innovative design concepts such as Design for Environment (DfE) and Design for Disassembly (DfD). These concepts can help heightened green awareness in the supply chain and consumer behaviour. In the Republic of Korea, for example, EPR was enforced on packaging (paper, glass, iron, aluminium and plastic) and specific products (battery, tire, lubricating oil and fluorescent lamp) since 2003. According to the Ministry of Environment of the Republic of Korea, the initiative resulted in recycling of 7.7 million tonnes of waste between 2003 and 2008, an increasing recycling rate by 13.5 per cent compared with that before EPR implementation and an economic benefit of 1.7 trillion won, equivalent to US$1.6 billion (Ministry of Environment 2010).

Industries can have voluntary, self-regulatory measures. For example, Hitachi has designed washing machines that could be easily disassembled, saving 33 per cent of the manufacturing time and machines that needed less service, winning consumer confidence and reducing disposal cost. Similarly, Fuji Xerox collects used photocopy machines, printers and cartridges from nine countries in the Asia Pacific region, disassembles and classifies the parts into 64 categories for reuse in new machines. Philips has launched a range of green flagship products such as Ultra High Performance lamps with 52 per cent less packaging, 25 watt T8 lights with 40 per cent less mercury, flat-screen TVs with 17 per cent less packaging, DVD players weighing 26 per cent less and defibrillators weighing 28 per cent less than their predecessors, among others.

5.4 Institutional arrangements between formal and informal sectors

In many developing countries, command and control policies may not be as effective as economic instruments due to institutional capacity. Additionally, investments in the waste technologies have sometimes failed to reap benefits because of weak institutions. Investments are often deterred because of flawed institutions or missing markets.[10] Furthermore, institutional capacities to control imports of used goods/waste into developing countries are either non-existent or non-functional.

One of the major institutional issues in the waste sector is the relationship between the formal and informal segments of the sector. A major cause for a thriving informal sector in developing countries is the difficulty to achieve economies of scale in formalising the existing informal recycling units. Porter (2002) identifies five types of market failures in formal recycling: 1) Failure to provide households with correct market signals on recycling; 2) Failure to recycle the correct amount and choose the appropriate kind of recycling by municipally owned or controlled recycling facilities as they are bound by constraint on profit making; 3) the unstable nature of the recycling market; 4) Sub-optimal policy decisions on taxing and subsidising substitutes for virgin products; and 5) Failure to provide manufactures with correct market signals on disposal and recycling of their products and packaging.

Yet, the informal sector plays a significant role in waste management, especially through informal waste collection and recycling. Incentivising formal recycling activities, providing micro-finance and access to the markets could help in shifting the informal sector to formal regime. In addition, raising awareness on the social and health related benefits of formalisation may help in understanding importance of intangible benefits.

The operations of the informal waste businesses are subject to risks to human health and often imply working conditions that are not decent. It is important to address the health and safety risks from use of recycled and recovered products and to devise appropriate policies, regulations, and standards. Developing countries will need to adapt some of these frameworks to ensure that the workers in the informal sector and customers of the recycled products are well protected.

Suchada et al. (2003) highlight that when there was a close operating relationship between the formal and informal sectors of the waste recycling industry, the sector has been observed to function efficiently achieving a recycling rate of 38 per cent of the total waste stream. Often, however, cooperation between government authorities and workers in the informal waste sector is weak owing to distrust.

The formalisation of waste-pickers, where desirable, often requires political support and policy reforms. But formalisation is not the only way to secure greater cooperation between the public, formal private and informal private sectors. Community based organisations (CBO) and Non-Governmental Organisations (NGO) have contributed to empowering the informal waste workers by extending micro-credits and arranging for external funding.

In community-based waste management programmes, a community leader identifies a service provider and/or plans and manages the services. Micro and small enterprises are also taking shape in developing countries such as Brazil, which unlike CBOs and NGOs, engage in waste picking activities for-profit (Ahmed and Ali 2004). Community cooperation has helped achieve considerable success in many developing countries. Waste collection through community organisation into cooperatives and micro-enterprises has been useful to manage municipal waste. Table 5 describes a few examples across the world where community cooperation has helped set up businesses in waste management.

6 Conclusions

The increasing volume and complexity of waste is posing threats to ecosystems and human health, but opportunities do exist to green the waste sector. These opportunities come from the growing demand for improved waste management and for resource and energy recovery from waste. This change in demand is driven by cost savings, increased environmental awareness and increasing scarcity of natural resources. The development of new waste-related technologies on 3Rs and technologies such as MBT and advanced biomethanation has facilitated the greening of the sector. The growth of the waste market is a reflection of the underlying demand for greening the sector – especially the new paradigm of linking waste to resource use across the life-cycle of products.

Different countries face different waste related challenges, but the path to greening the waste sector shares common milestones. Prevention and reduction of waste at source is essential for all countries, although this is particularly important in developing countries given their higher level of population growth and increasing material and resource consumption. The absolute growth of population and income implies that the absolute volume of waste is unlikely to decline. Greening the sector is therefore the only way to decouple. It is important to reduce conversion of used materials into municipal waste. Proper collection, segregation, transport, and recycling of waste as well as the construction of basic facilities are essential steps in many developing countries. In most cases, in these countries, an additional intervention is the cleanup of existing dumpsites, which are harming the environment and the health of waste pickers most of whom are poor men, women and even children. It is therefore crucial to ensure that stringent regulations are in place and comprehensive environmental policies addressing the necessity of recycling and reducing landfills are developed.

The waste recovery and recycling part of the waste treatment chain probably holds the greatest potential in terms of contributions to a green economy. As natural resources become scarcer and with the prospect of peak oil, the commercial value of materials and energy recovered from waste could be substantial. The current recycling rate of all types of waste is likely to improve. Some developed countries and emerging economies have set high standards for themselves in this area and are likely to acquire comparative advantages in remanufactured and recycled products. Developing countries, when planning their treatment facilities, may want to take into consideration the potential growth of resource and energy recovery as an increasingly significant industry. The choice of waste treatment options ought to include a full range of benefits including avoided environmental and social costs, rather than be based only on the costs of technologies per se.

Indeed, there are multiple benefits from greening the waste sector, although quantitative data are hard to come by. These benefits include resources recovered from waste helpingw to avoid extraction of raw materials, new products such as compost and energy derived from waste, lower cost of reducing GHG emissions, carbon credits, avoided health costs, and job creation. Greening of the sector will involve formalisation of the informal sector in many developing countries, including the provision of proper training, health protection, and decent level of compensation for waste workers, and thereby contribute to improving equity and poverty alleviation. Additional efforts are needed to collect data and conduct quantitative analysis at country level – taking a total cost perspective – to enable policy makers to design their strategy for greening the waste sector on a more informed basis.

Mobilising investment to green the waste sector requires a number of enabling conditions. Governments should increase their budgetary allocations to the sector. Further, entering into partnerships with the private sector has the potential for reducing the fiscal pressure while enhancing the efficiency of service delivery. In many developing countries, the success of such arrangements is to a large extent dependant on a reasonably sound institutional framework and sufficient capacity to ensure transparency in awarding contracts to private service providers. Micro-financing, international development assistance and other financing mechanisms can also be explored to support localised waste treatment systems that provide employment opportunities to local communities while reducing the need for distant transport of waste. Another important component in greening the waste sector in many developing countries is building trust between the public sector and the informal waste sector. Care should be taken not to exclude poor waste-pickers from the formalisation process.

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