URBAN DEVELOPMENT SERIES

MORE GROWTH, LESS GARBAGE

By Silpa Kaza, Siddarth Shrikanth, and Sarur Chaudhary

WORLD BANK GROUP

More Growth, Less Garbage

Urban Development Series

The Urban Development Series discusses the challenge of urbanization and what it will mean for developing countries in the decades ahead. The series aims to delve substantively into a range of core issues related to urban development that policy makers and practitioners must address.

Cities and Climate Change: Responding to an Urgent Agenda

Climate Change, Disaster Risk, and the Urban Poor: Cities Building Resilience for a Changing World

East Asia and Pacific Cities: Expanding Opportunities for the Urban Poor

East Asia's Changing Urban Landscape: Measuring a Decade of Spatial Growth

The Economics of Uniqueness: Investing in Historic City Cores and Cultural Heritage Assets for Sustainable Development

Financing Transit-Oriented Development with Land Values: Adapting Land Value Capture in Developing Countries

Regenerating Urban Land: A Practitioner's Guide to Leveraging Private Investment

Transforming Cities with Transit: Transit and Land-Use Integration for Sustainable Urban Development

Urban Risk Assessments: Understanding Disaster and Climate Risk in Cities

What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050

More Growth, Less Garbage

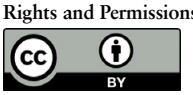
All books in the Urban Development Series are available free at https://openknowledge.worldbank.org/handle/10986/2174.

More Growth, Less Garbage

Silpa Kaza, Siddarth Shrikanth, and Sarur Chaudhary

1818 H Street NW, Washington, DC 20433
Telephone: 202-473-1000; Internet: www.worldbank.org

1 2 3 4 21 20 19 18



Cover photo: © Parilov / Shutterstock. Used with permission. Further permission required for reuse.

Library of Congress Cataloging-in-Publication Data has been requested.

Contents

Boxes

Figures

Tables

Acknowledgments

More Growth, Less Garbage was prepared by Silpa Kaza (Task Team Leader) with support from Siddarth Shrikanth and Sarur Chaudhary. This effort builds on *What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050*, a publication funded by the government of Japan through the World Bank's Tokyo Development Learning Center. *More Growth, Less Garbage* was prepared by the World Bank's Urban, Disaster Risk Management, Resilience and Land Global Practice and funded by the World Bank and the Tokyo Development Learning Center.

Updated data was provided or confirmed by Abeer Al-Aysah, lead statistician in the Federal Competitiveness and Statistics Authority of the United Arab Emirates; Elynur Saad, senior executive in the National Environment Agency of Singapore; Jaemin Song, professor at the Seoul National University; Shiko Hayashi, programme director at the Institute for Global Environmental Strategies; and Harsh Goyal, Kremena Ionkova, Silpa Kaza, Sandeep Kota, Catalina Marulanda, and Frank Van Woerden from the World Bank. Tony Fujs from the World Bank's Development Economics Group manages the waste management database and interactive website and has included the updated data and waste generation projections estimations.

Sarur Chaudhary modeled the waste generation projections and further developed the regression model from *What a Waste 2.0* originally built by Mersedeh TariVerdi. Mersedeh TariVerdi provided critical guidance for this updated analysis.

The team thanks the individuals who generously provided information and feedback for the case studies: Shiko Hayashi, programme director at the Institute for Global Environmental Strategies; Haruka Imoto, operations officer at the World Bank; Jaka Kranjc at Zero Waste Europe; Michael Orr, recycling director at the Cambridge Department of Public Works, Jaemin Song, professor at the Seoul National University; and Rap Villavicencio, project officer at the Mother Earth Foundation. The case studies were written by Siddarth Shrikanth.

The study was prepared under the guidance of Sameh Wahba, global director of the Urban, Disaster Risk Management, Resilience and Land Global Practice and Maitreyi Das, practice manager.

The team thanks the peer reviewers from the World Bank who provided critical expert comments: Catalina Marulanda, practice manager of the South Asia Urban Unit; Frank Van Woerden, lead environmental engineer; Kremena Ionkova, senior urban development specialist; Nancy Lozano, senior urban economist; and Maria Edisa Sappelso, economist.

Tokyo Development Learning Center

Launched in 2004 in partnership with the Government of Japan, the Tokyo Development Learning Center (TDLC) is a pivotal World Bank program housed under the Global Practice for Urban, Disaster Risk Management, Resilience and Land. Located in the heart of Tokyo, TDLC serves as a global knowledge hub that aims to operationalize Japanese and global urban development knowledge, insights, and technical expertise to maximize development impact. TDLC operates through four core activities: Technical Deep Dives, Operational Support, Insights and Publications, and the City Partnership Program.

Prologue

This publication has coincided with the occurrence of COVID-19, a pandemic with far-reaching impacts on people's health and the global economy. As the situation evolves, we expect to get a clearer picture of the impacts of COVID-19 on waste, but for now the impacts of the pandemic on waste generation and waste management systems are too fragmented and varied to draw long-term, evidence-based conclusions. For this reason, the modeling exercise in this publication does not factor in pandemic impacts.

When evidence does become available, we expect to see the impact of several overlapping and conflicting trends. A reduction in economic activities prompted by disease prevention measures was resulting in a temporary reduction in waste generation. Waste collection has also been impacted by lockdowns and funding shortages in some areas. Some cities have limited or halted recycling and composting programs to redirect budget for public health purposes and to limit workers' contact with waste. Meanwhile, the use of single use, disposable materials and protective equipment has increased for health and safety reasons, further stretching cities' capacity to properly manage waste. The informal sector has also been heavily affected, resulting in negative impacts on recycling rates in already struggling recycling markets.

In short, the impacts of COVID-19 on municipal waste are complex, vary across countries and are not yet fully understood. More data will be needed to assess the changing characteristics and volumes of waste in the wake of the pandemic.

While the pandemic has cast uncertainty on many sectors of activity, it has also shed light on the significance of waste management systems for people's health and raised the importance of addressing their limitations. As cities start to recover from COVID-19, there is an opportunity to build more resilient waste management systems to ensure safe, healthy, inclusive communities while also pursuing a circular economy approach. Our hope is that the waste reduction strategies described in this report will inspire city leaders and other decision makers to be on a more sustainable waste management trajectory and prevent a waste crisis. In addition, the waste management sector can also serve as a critical part of a green, resilient recovery with potential for significant job creation.

Acronyms

BAU	business-as-usual
GDP	gross domestic product
EKC	Environmental Kuznets Curve
EPR	extended producer responsibility
EU	European Union
JPY	Japanese Yen
KRW	Korean Won
MSW	municipal solid waste
OECD	Organization for Economic Cooperation and Development
RFID	radio-frequency identification
UN	United Nations

SECTION 1

Introduction

In 2018, the World Bank published *What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050*. Based on municipal waste generation data from 217 countries and economies, the report estimated that global waste generation was set to increase by 70% from 2016 to 2050, driven by increases in prosperity and urbanization. This projection is more than double the population growth estimates for the same period. With 93% of waste in low-income countries currently being openly dumped and burned, the world faces a looming waste crisis that threatens to impose substantial environmental, social, and financial costs on our societies.

What a Waste 2.0 highlights the need for an integrated solid waste management system that approaches the sector holistically. It underscores the need to have systems in place to both better manage municipal waste, as well as to minimize waste generation at the source to tackle the waste crisis as a whole.

This publication presents an updated picture of how waste generation could grow if the world continues along the current trajectory and how to consider changing that path. Historically there has been a positive relationship between waste generation and income per capita. This publication explores the possibility of decoupling waste generation, and thus consumption, from economic growth. Five case studies of waste reduction, in terms of residual waste and/or total waste, are highlighted from cities and countries across the world. In each location, decisions to reduce or divert waste were driven by a different factor, such as lack of land, the need to be more resilient, or the need to reduce costs of the overall waste system.

Based on these stories, scenarios were developed to estimate potential changes to the current business-as-usual trajectory, which estimates waste generation to grow from 2.24 billion tonnes in 2020 to 3.88 billion tonnes by 2050. If waste reduction policies were adopted in more places around the world, we could envisage a world in 2050 with more growth and less garbage than today.

SECTION 2.

An Updated Global Picture of Solid Waste

Since the publication of *What a Waste 2.0*, the World Bank has received updated waste generation data for 44 countries[1]. The analysis in this publication uses the dataset from *What a Waste 2.0* from 2018 which consists of data over previous several years, with the exception of the updated information from 44 countries, and is used to estimate waste generation for 2020, 2030, 2040, and 2050.

This publication is intended to help practitioners and policymakers better understand the potential impact of waste reduction decisions on waste projections rather than serve as an update on the global waste management situation. The updated data is for countries whose governments have directly provided new information, countries who were high generators in the 2018 publication and had more recent data available, and countries where the World Bank had recent engagements or could readily access publicly available data. Of the top ten generators from the *What a Waste 2.0* publication, there is updated data for six of the countries: Brazil, China, Germany, India, Japan, and the United States.

The methodology for projecting waste has been refined and incorporates the latest literature to allow for improved global waste generation estimates and forecasts. The income level classifications are assumed to be the same as in the 2018 publication since the waste generation data is primarily from that publication.

Refer to *What a Waste 2.0* for information on data collection and calculation methodologies and the worldbank.org/what-a-waste website for the latest data available.

1 Countries with updated data include Albania, Austria, Belgium, Brazil, Bulgaria, China, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, India, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, North Macedonia, Malta, Montenegro, Norway, Poland, Portugal, Republic of Korea, Romania, Serbia, Singapore, Slovakia, Slovenia, Spain, Sweden, Switzerland, The Netherlands, Turkey, United Arab Emirates, United Kingdom, and United States of America

Box 2.1 Definition of Income Levels (USD per capita per year)

Low: $1,025 or less
Lower middle: $1,026 - $4,035
Upper middle: $4,036 -$12,475
High: $12,476 or more

Data Source: World Bank Classification by Income, Gross National Income per capita, 2015

Photo: GAIA Asia Pacific

Updated waste generation figures

In 2020, the world was estimated to generate **0.79** kg of waste per capita per day, with volumes generally correlated with income levels, and varying drastically across regions. That figure has risen from the **0.74** kg/capita/day reported in *What a Waste 2.0* for 2016, reflecting growth in generation as well as updated data. Across the world, an estimated **2.24** billion metric tons (tonnes) of municipal solid waste was expected to be generated in 2020. The residual fraction – which includes waste that is landfilled, incinerated or otherwise ultimately disposed – is estimated to be **1.86** billion tonnes.

Box 2.2 Total versus Residual Waste

Two measures of waste generation are used for the analysis:

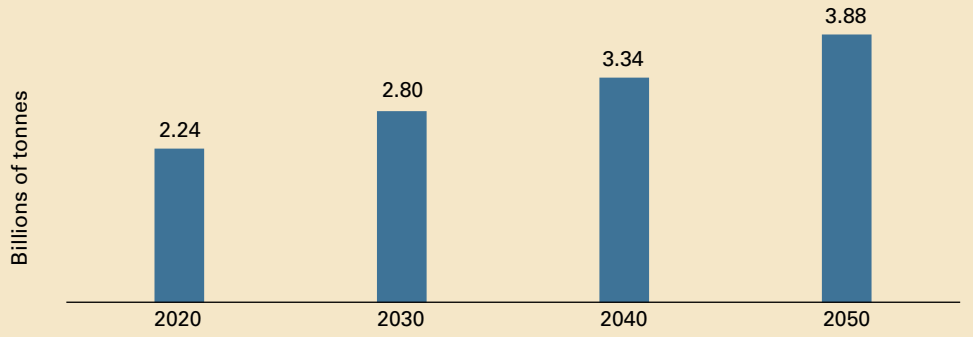
Total Waste –refers to all municipal solid waste regardless of how it is managed.

Residual Waste –refers to the subset of municipal solid waste that is ultimately disposed of after other fractions are diverted for productive uses. Final disposal methods can include dumping, landfilling and incineration.

The total amount of waste generated is expected to grow to **3.88** billion tonnes by 2050 under a business-as-usual scenario, which represents a **73%** increase from 2020 or **93%** compared to the waste generations estimates in 2016 in *What a Waste 2.0*. By 2050, global waste generation is expected to stand at **1.09** kg of waste per capita per day, on average.

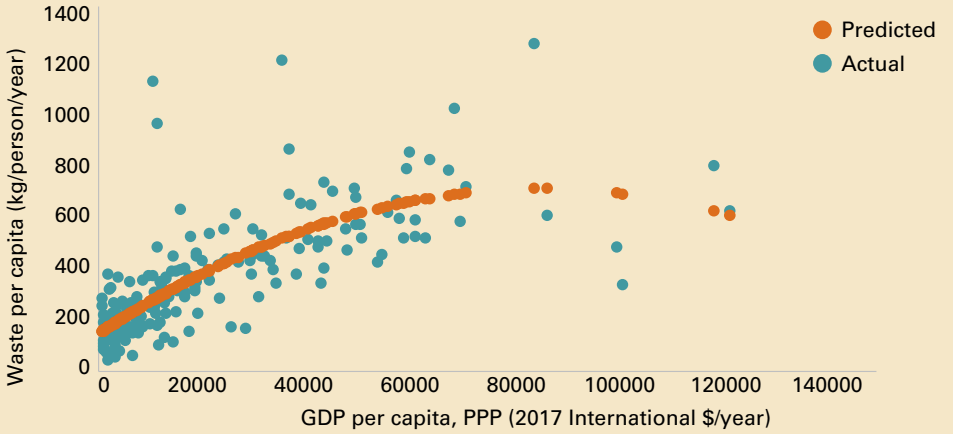
Over the same timeframe, assuming existing waste management practices remain, residual waste -- that is, waste which is not recovered – is projected to grow to **3.32** billion tonnes, representing **0.94** kg of residual waste per capita per day, on average.

Figure 2.1 Projected Global Waste Generation



According to the regression analyses between per capita waste generation and national income across countries, waste generation per capita is strongly and positively correlated with GDP per capita, measured with a purchasing power parity adjustment in constant 2017 international $, until around **$60,000**. Beyond that point, generation rises only modestly before approaching a plateau at income levels beyond around **$85,000**. At very high levels of per capita GDP beyond this, there is a slight negative correlation between per capita income and waste generation with the relationship trend beginning to curve down.

Figure 2.2 Waste Generation: Actual and Model Prediction



Box 2.3 Methodology for Business-as-Usual Waste Generation Projections

To ensure cross-comparability of waste generation data and to develop projections for global waste generation, available waste generation data were adjusted from a variety of origin years to 2020, 2030, 2040 and 2050.

Key Assumptions:

This analysis assumes that waste generation grows primarily based on two factors:

- **Gross domestic product (GDP) growth:** As a country advances economically, its per capita waste generation rates increase. Economic growth is reflected using GDP per capita, based on purchasing power parity to allow for comparison across countries.
- **Population growth:** As a country's population grows, amounts of total waste generated rise accordingly.

Methodology Overview

The model uses the World Bank's World Development Indicators' GDP per capita, PPP (constant 2017 international $) for the waste per capita regression model, the Organization for Economic Co-operation and Development (OECD) GDP per capita projections, PPP (constant 2005 international $) for the waste per capita projection estimates, and the United Nations (UN) population growth rates.

- **Relationship between GDP growth and waste generation rates:** The observed relationship between GDP growth and waste generation is reflected in figure 2.2. A regression model was used to capture the relationship between GDP per capita and waste generation per capita. The model was developed using country-level baseline waste generation data from the data collected and GDP per capita data from the associated year. In the specification that best fits the model, the independent variable is GDP per capita and the dependent variable is waste generation per capita. The overall functional form was chosen in line with the Environmental Kuznets Curve (EKC) and was found to be statistically significant. The EKC hypothesizes that factors that are related to environmental damage (such as pollution and waste) are first anticipated to rise and then fall with increasing income levels.
- **Proxy waste generation rates:** The regression model was used to estimate the expected growth in each country's waste generation rate based on the growth in that country's GDP per capita. Using the regression model coefficient and intercept, as well as GDP per capita data for the base

Box continues

year and for the projection years, proxy waste generation rates per year were modeled for each country for the base and target years, per equation B2.2.1. In case any country did not have GDP per capita information available for the base year, its waste generation rate per capita is calculated using the average GDP per capita of countries from the same region and income level. In any case projection information for GDP growth rates was not available, the average regional GDP growth rate for the appropriate income level was used.

Proxy waste generation per capita per year

$$= 136.41 - 0.014(\text{GDP per capita}) - (8.3 \times 10^{-8})(\text{GDP per capita})^2 \qquad \text{(B2.2.1)}$$

$$(14.12) \quad (0.0011) \quad (1.5 \times 10^{-8}) \quad \text{(robust standard errors in parentheses)}$$

- **Projected waste generation:** The change in proxy waste generation rates developed through the model was used as the growth rate for waste generation for that country. This growth rate was applied to the actual baseline waste generation per capita rate from the data collected to adjust actual waste generation rates from the base year to 2020, 2030, 2040 and 2050, per equation B2.2.2. If a growth rate could not be calculated for an economy or territory because of a lack of GDP data, an average of the countries in the region with a similar income level was used.

$$\text{Projected Waste Generation Rate}_{\text{Target Year}} = \text{Proxy Waste Generation Rate}_{\text{Target Year}} \times (\text{Actual Waste Generation Rate}_{\text{Base Year}} / \text{Proxy Waste Generation Rate}_{\text{Base Year}}) \qquad \text{(B2.2.2)}$$

In addition to the total waste, residual waste generation rate is also calculated using the share of residual waste from waste treatment and disposal data gathered. In case this was not available for a particular country, a proxy which is the average of other countries at the regional level was used.

$$\text{Projected Residual Waste Generation Rate}_{\text{Target Year}} = \text{Projected Waste Generation Rate}_{\text{Target Year}} \times \text{Residual Share of Total Waste} \qquad \text{(B2.2.3)}$$

- **2020 waste generation:** The adjusted per capita waste generation rate for 2020 was multiplied by the projected population level for 2020.
- **2030, 2040 and 2050 waste generation:** The adjusted per capita waste generation rates for 2030, 2040 and 2050 were multiplied by the respective projected population levels for the target year.

In adjusting and projecting waste generation, urbanization rates and potential changes in country income classification based on GDP projections are not considered due to limited urban and rural waste generation data and to simplify the analysis.

Data Sources

- Waste Generation: Best available national waste generation data from What a Waste 2.0 and updates for specific countries
- Base Year, 2020, 2030, 2040, and 2050 Population: UN Population Projections, Medium Variant, 2019 Revision
- GDP per Capita, PPP (constant 2017 international $): World Bank's World Development Indicators
- GDP per Capita, PPP (constant 2005 international $): OECD

Differences across income levels and regions

Waste generation patterns remain starkly different across income levels and regions. Residents of countries with higher levels of prosperity generally produce more waste. In 2020, high-income countries are estimated to generate **1.60** kg/person/day of waste on average, compared to **0.91** kg/person/day for upper-middle income countries and **0.47** kg/person/day for lower-middle income countries. Finally, low-income countries generate only **0.41** kg/person/day. The figures paint a clear picture of past trajectories of development: rising incomes have gone hand-in-hand with higher waste generation. Decoupling the two, encouraging behaviors and promoting methodologies that reduce or limit the amount of waste generated in urbanizing countries or in growing economies, will be crucial if countries are to embark on sustainable development trajectories in the coming years.

Figure 2.3 Projected Total Waste Generation by Income Group

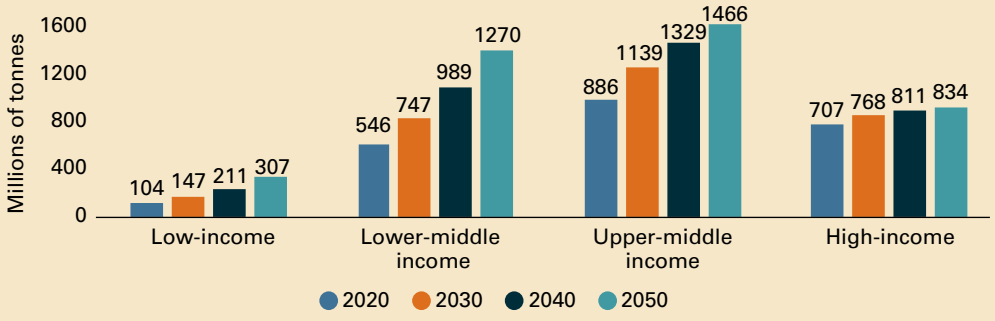
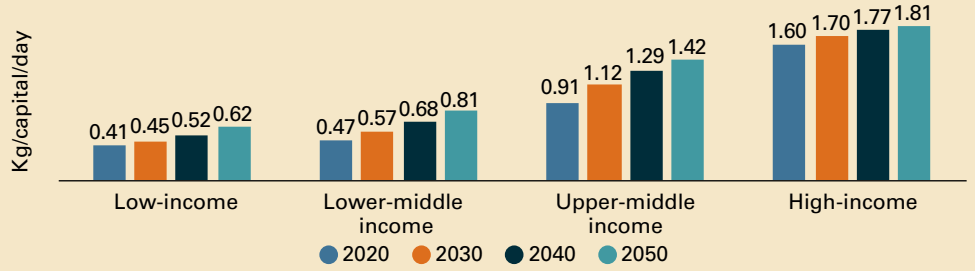


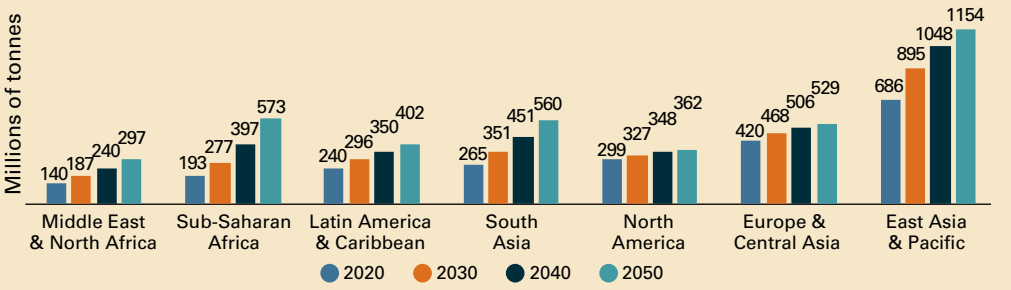
Figure 2.4 Projected Waste Generation per Capita by Income Group



Different regions of the world produce varying levels of waste, which in part reflects income disparities. In aggregate, the East Asia and the Pacific region is estimated to produce the most waste in 2020, followed by Europe and Central Asia. By 2050, however, that picture is expected to shift, with South Asia and Sub-Saharan Africa overtaking the latter in overall terms. Changes in estimations to waste generation in South Asia and the East Asia

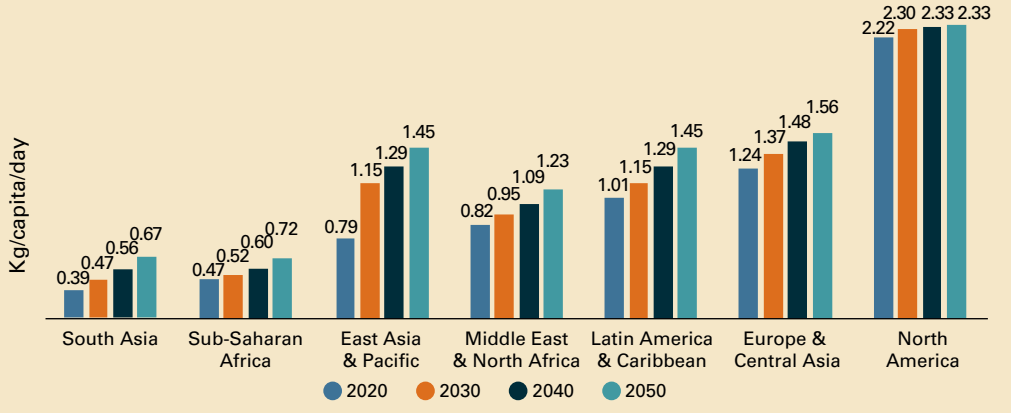
and Pacific regions, as well as low-middle income and upper-middle income countries, are driven by updated data for India and China where waste generation data were revised downwards and upwards, respectively.

Figure 2.5 Projected Total Waste Generation by Region



On a per capita basis, North America is estimated to produce the most waste, at about **2.22** kg/person/day estimated on average in 2020. The Europe and Central Asia region is estimated at a distant second, at **1.24** kg. South Asia and Sub-Saharan Africa have large populations, but are estimated to produce far less waste per capita at **0.39** kg and **0.47** kg respectively. These regional disparities are expected to persist in the coming decades, even as some regions experience faster economic growth than others.

Figure 2.6 Projected Waste Generation Per Capita by Region



SECTION 3

Overview of Case Studies of Waste Reduction

As cities and countries grapple with the challenge of unchecked waste generation, they can take inspiration from the many success stories of waste reduction and diversion from across the world. Five case studies were selected which represent a diverse range of population levels, geographic regions, and income levels. These local and national governments have focused on reducing the total amount of waste generated by their residents, on minimizing the amount of residual waste by expanding recycling and composting programs, or both in some cases.

Given the wide range of waste generation across regions and income levels, the cases intentionally did not include low-income countries which generate little waste per capita to start with. While there are many successes globally, the selected cases focus on middle and high-income countries which had enabling conditions that allowed for scaling up of interventions. These cases offer important lessons for those attempting to replicate these successes and decouple waste generation from economic growth in the coming years.

3.1 Methodology for Scenario Projections

The first case is **Cambridge**, a mid-sized city in the United States that dramatically expanded its curbside recycling and composting programs and created innovative technology tools and campaigns to encourage reduction and reuse. In **Yokohama**, in the Greater Tokyo area, granular waste separation, resident education and enforcement resulted in steep reductions in total and residual waste in the wealthy mega-city. **Tacloban** is a middle-income city in the Philippines, which embarked on an ambitious zero waste strategy in the aftermath of a devastating hurricane that had overwhelmed its dumpsite and threatened the wellbeing of its residents. In this one case, overall waste quantity did not change but the residual fraction was reduced. In **Ljubljana**, the city capitalized on Slovenia's requirements as a European Union Member State to meet waste management

targets and has far exceeded targets on waste reduction and recycling. Finally, a national experience is included with the **Republic of Korea** - where the country halved per capita waste generation over a decade in the 1990s, even amid rapid economic growth, through its system of strong financial incentives and laws.

Each location was driven by different needs for action, had unique enabling conditions, and had varied waste reduction results:

Table 3.1 List of locations for case studies and achieved waste reductions

	Case	Reduction in residual waste per capita	Reduction in total waste per capita
1	Cambridge, United States	30%	4.8%
2	Yokohama (Greater Tokyo area), Japan	39%	12.1%
3	Tacloban, the Philippines	31%	N/A
4	Ljubljana, Slovenia	56%	15%
5	Republic of Korea	69%	50%

Photo: City of Cambridge

3.2 Estimating the Scale of Opportunity

While each country and city have unique circumstances, these cases provide a range for the scale of waste reduction opportunities for policymakers attempting to implement similar programs. To estimate potential waste reduction opportunities, hypothetical scenarios were created based on each

of the cases and applied to other similar countries in the decades to 2050. In four of the five cases, the scenarios were applied to countries with similar income levels and higher. For Tacloban, since the main driver was to become more resilient to natural disasters, an additional scenario was applied to countries with "high" and "very high" risk index values from the World Risk Index.

A critical assumption is that countries with similar circumstances would have potential to achieve the same reductions in per capita waste generation, overall and residual, against their baseline, with total waste generation growing with natural increases in population. Finally, these scenarios are compared against the business-as-usual projections for these country groups to provide a sense of the potential impact if such policies were rolled out.

Box 3.1 Methodology for Scenario Projections

In addition to the above business-as-usual case, waste generation, total and residual, is also estimated over time for different scenarios that apply when similar countries follow a policy followed by the country in the case.

The projected waste generation rate for 2020 from the business-as-usual (BAU) scenario is used as the base. As the waste generated is assumed to follow the same trajectory as the representative country, it is assumed that the waste generation rates would see the same drop from the base year of 2020 as the representative case saw and then remain at that level for the rest of the period of projection. Hence, any change in waste generation rates after this period of reduction in waste would depend only upon the population projections using the following formulae:

$$\textit{Projected Total Waste Generation Rate per Capita}_{\textit{Target Year under Policy Scenario}} = \textit{Projected Total Waste Generation Rate}_{\textit{2020 under BAU}} \times (1 - \textit{Reduction in Waste Achieved under Policy Scenario}) \quad \textit{(B2.2.4)}$$

$$\textit{Projected Residual Waste Generation Rate per Capita}_{\textit{Target Year under Policy Scenario}} = \textit{Projected Residual Waste Generation}_{\textit{2020 under BAU}} \times (1 - \textit{Reduction in Residual Waste Achieved under Policy Scenario}) \quad \textit{(B2.2.5)}$$

As mentioned, the formulae help calculate projections for the years 2030, 2040 and 2050 using the projected waste generation rate in 2020 as a base.

Data Sources

- Waste Generation: Best available national waste generation data from What a Waste 2.0 and updates for specific countries
- Base Year, 2020, 2030, 2040, and 2050 Population: UN Population Projections, Medium Variant, 2019 Revision
- GDP per Capita, PPP (constant 2017 international $): World Bank's World Development Indicators
- GDP per Capita, PPP (constant 2005 international $): OECD
- Disaster Risk Index Rankings: World Risk Index

SECTION 4

Case Studies and Scenario Modelling

4.1 Cambridge Scenario Projections

Cambridge, in the Greater Boston area, has long been a pioneer in its handling of municipal waste. In 2009, however, the city of 110,000 that is home to Harvard University and the Massachusetts Institute of Technology adopted an ambitious goal: to reduce residual waste from households by 30% by 2020. A decade later, the city has become one of the few in North America to meet as well as exceed its waste reduction targets. Despite its population growth and economic activity, Cambridge managed to bend the curve on waste generation.

Interventions

Cambridge began a concerted effort to educate and empower residents, improve existing programs, and offer new services to reduce residual waste – which was later developed into the Zero Waste Master Plan in 2018. The city's interventions included:

1. **Expanding its recycling system and driving down contamination**
   In 2011, the city switched to a single-stream recycling system, paired with a campaign to expand participation. Recycling collection was expanded to over 45,000 households in 2019, providing 95% of residents with a curbside recycling service. As part of the zero-waste master plan, the recycling program was expanded to include curbside mattress pickups, keeping the bulky items out of the waste stream. Following China's imposition of strict contamination standards for recyclables in 2018, the city began a "Recycle Right" campaign that spanned social media, billboards, and door-to-door education to reduce contamination rates, focused on the most commonly mis-sorted items. As a result, contamination dropped from 11% to 6% within a year, further improving waste diversion.

Photo: Siddarth Shrikanth

2. **Focusing on diverting organic waste from landfill**
   Identifying organic waste as a priority area for waste and GHG reduction, the city began encouraging composting in homes, schools and drop-off points starting in 2010. The scheme was later expanded to provide curbside food scrap collection in 2014, which now covers 65% of the city's households. In parallel, the city ran campaigns in schools and elsewhere to reduce food waste.

3. **Creating new schemes to promote reduction and reuse**
   City officials partnered with local businesses and community groups to raise the profile of waste minimization. Cambridge passed a "bring your own bag" ordinance in 2015, years ahead of the City of Boston and Massachusetts as a whole and continued to provide support for community zero-waste efforts. The Department of Public Works

created an online "get rid of it right" tool, where residents are able to enter the names of items to receive information on local reuse networks such as Freecycle, an online platform for citizens to give and get items for free locally. By supporting fix-it clinics, the city has also attempted to extend the life of electronics and other durable items and minimize avoidable waste.

Impacts

- 30% reduction in residual waste – from 0.71 kg/capita/day in 2008 to 0.51 kg/capita/day in 2019[2]
- 2.4% reduction in total city-managed waste, including recycling and organics, between 2012 and 2018, despite a 3.2% rise in the number of households served
- 75% increase in organic waste volumes handled
- 1633 tonnes of curbside food scraps collected in 2018, contributing to 8% reduction in waste managed
- Recycling contamination rates reduced to 6%, against the US average of around 25%

Enablers

Cambridge's success was made possible by a number of enabling factors, including:

- The city's strong financial position, which enabled up-front investments
- A highly engaged and environmentally progressive population
- High waste disposal fees (over US$110/tonne for landfilling) that created a strong incentive for waste reduction
- Supportive state-level regulations in Massachusetts

Looking Ahead

In the short term, Cambridge remains committed to rolling out the rest of its Zero Waste Master Plan, including a further expansion of the organic collection system, diverting other items such as carpets and textiles, and disincentive schemes such as pay-as-you-throw policies and standard waste containers. With rising disposal costs and public support, the city expects that its financial investment made to date will pay for itself over the medium term. Cambridge will now attempt to achieve an even more ambitions long-term target: to reduce waste by 80% by 2050.

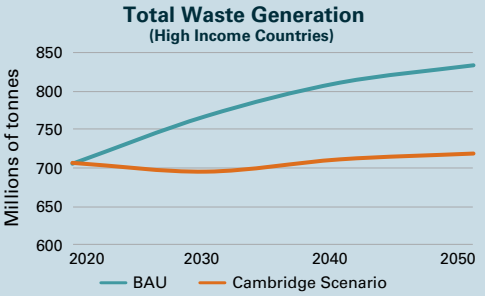
2 Based on an average household size of 2.00 in 2020, according to the Cambridge Planning Department

Box 4.1 Cambridge Scenario Projections

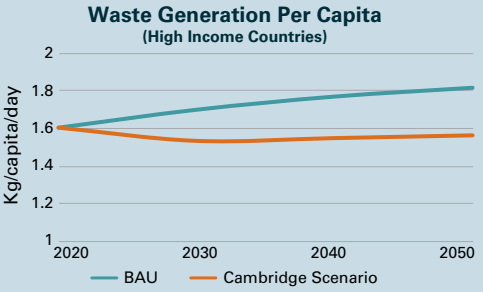
The experience of Cambridge demonstrates the potential waste reduction opportunity for developed economies, even without the large populations and resources of mega-cities. With a number of cities and countries, particularly at the higher end of the income distribution, struggling with steep disposal costs, expanding local organic waste management and recycling could also help tilt the overall economics in favor of a waste reduction program as it did for the city of Cambridge.

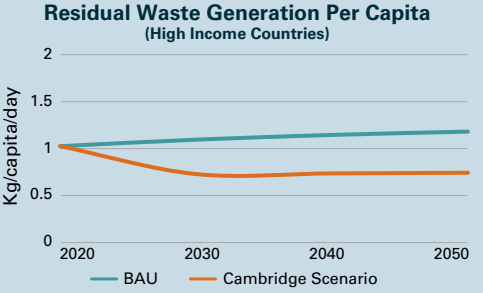
This scenario projects waste generation as if high-income countries mimicked the waste reduction success of Cambridge. Relative to a business-as-usual case:

- Overall waste generation for high-income countries could be **14%** lower, and **115** million tonnes of waste could be avoided annually by 2050.



- On a per capita basis, residual waste could be **37%** lower by 2050, at **0.75** kg/person against our BAU projection of **1.18** kg for these countries. Similarly, total waste per capita would be **14%** lower, at **1.56** kg rather than **1.81** kg if current trends continue.





4.2 Yokohama Scenario Projections

Japan has long been seen as a leader on waste management. Starting in 2000, with laws to establish a "sound material-cycle society," the national government has worked closely with cities to plan and implement waste reduction and recycling programs.

Yokohama, a city of nearly 4 million in the Greater Tokyo area, demonstrated how Japan's cities could turn that national strategy into tangible results. Faced with high incineration costs and a lack of land and landfill availability, the city launched an action plan in 2001 to dramatically reduce waste generation and expand recycling. Much like the country as a whole, Yokohama has successfully decoupled waste generation from economic growth. Despite the challenges of creating change in the most populous metropolitan area in the world, the city achieved ambitious reduction targets over the last two decades.

Interventions

National interventions by the Japanese government

As waste management agencies faced rising capital and operating costs in the 1990s and early 2000s that were increasingly passed on to households, all levels of government had strong incentives to promote reduction and recycling. The national government laid out a framework of roles and responsibilities and took charge of information management and technical and financial assistance to local governments.

Photo: Silpa Kaza

As part of a new framework of laws starting in the 2000s, the national government mandated all of the country's over 1,700 local governments to report annual waste data to a central database and tasked them with producing regular waste management master plans with reduction targets over ten years. In parallel, a system of subsidies was created to share the cost of investments in waste management, so local governments typically bore less than 40% of the total capital costs contingent on meeting targets and comprehensive monitoring, while taking full responsibility for operational expenses. In addition, the national government promoted connectivity and knowledge exchange with local governments by sending national civil servants with expertise on secondments to assist them.

City-level interventions in Yokohama

Between 2000 and 2010, the city launched a plan, dubbed "G30", in reference to an initial target to reduce municipal waste generation by 30%. Interventions included:

1. **Introducing a granular separation and collection system**
   Source separation was at the heart of the G30 plan. Yokohama increased the number of household waste categories from five to ten, adding separated collection for streams such as used clothes and plastic containers. The city began collecting bulky items upon request and set up an online tool for citizens to pay special fees for oversized items.

2. **Stringent enforcement and community-based feedback**
   While waste collection continued to be funded through general taxation, the city also strengthened its enforcement efforts to encourage waste reduction. By collecting different streams on different days in semi-transparent bags, the city made the identification of mis-sorted waste easier. In addition, local volunteers were recruited as "garbage guardians" to identify mis-sorted bags and leave reminder notes for residents. In rare cases where community-based attempts to reduce mis-sorting failed, repeat offenders were issued fines of JPY2000.

3. **Launching a multi-channel public awareness campaign**
   Yokohama embarked on a multi-channel awareness campaign, beginning with a design contest for a mascot. Celebrity ambassadors were recruited, and the education campaign was rolled out across television, radio and the internet. Citizen groups were recruited to help disseminate information, and over 11,000 public meetings were held over 2 years (Hotta & Aoki-Suzuki, 2014). As climate change rose on the agenda, the city also made an explicit link between waste and greenhouse gas emissions to further motivate residents.

Impacts

Nationally, Japan reduced per capita waste generation by 19% between 2004 and 2017, from 416 to 336 kg/capita/year, with only 1% being landfilled.

In Yokohama, the city:

- Reduced residual household waste from 0.73kg/capita/day in 2001 to 0.46kg/capita/day in 2010, a 39% reduction
- Cut total household waste generation (including recyclables) from 0.68kg/capita/day in 2009 to 0.59kg/capita/day in 2018, a 12.1% reduction [3]
- Shut down two out its seven incinerators as a result of waste reduction, saving US$1.1 billion in incinerator renewal capital costs as well as US$6 million in annual operating costs (Premakumara, 2012)

Enablers

Waste reduction in Japanese cities, including Yokohama, has been enabled by:

- High disposal costs as a result of shrinking landfill capacity and cost-intensive incinerators which have been passed on to incentivize citizens to reduce waste generation
- A supportive national framework of laws that mandates the implementation of waste reduction, reuse and recycling and provides adequate technical and financial support
- A highly engaged and educated population that has proved willing to comply with policies

Looking Ahead

Japan aims to continue along its path of decoupling waste generation from GDP. The country is now turning its attention to reducing organic and plastic waste. A new law passed in 2019 targets food waste from businesses, and a system of mandatory plastic bag fees is set to come into effect in 2020.

Yokohama hopes to build on the success of the G30 plan with a new target: to reduce the total generation of waste, including recyclables, by another 10% by 2025. In line with its focus on climate change, the city also aims to reduce GHG emissions from waste processing by over 50% by 2025, and halve the amount of household food waste generated by 2030.

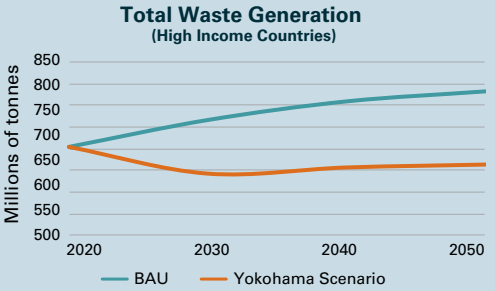
3 Calculated based on total household waste and population figures presented on p18 of http://citynet-yh.org/english/wp-content/uploads/2015/10/Intergrated_solid_waste_management_in_Yokohama.pdf

Box 4.2 Yokohama Scenario Projections

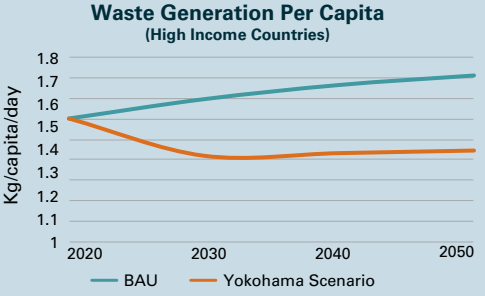
Japan has demonstrated that GDP and waste generation can be decoupled; within Japan, Yokohama has shown this can be achieved despite the challenges that come with administering part of the world's most populous urban area. The city's experience will resonate with other high-income areas across the world that often grapple with similar challenges: limited space for landfilling, high incineration and disposal costs, and a parallel ambition to reduce greenhouse gas emissions to tackle climate goals.

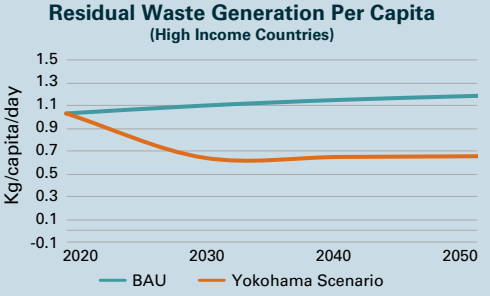
In this scenario, waste generation is projected assuming high-income countries were able to replicate the reduction success of Yokohama. Relative to a business-as-usual case,

- Overall waste generation in these countries could be reduced by 20%, avoiding 170 million tonnes of waste annually by 2050



- On a per capita basis, residual waste could be **45%** lower by 2050, at **0.65** kg/person against our BAU projection of **1.18** kg. Similarly, total waste per capita would be **20%** lower, at **1.44** kg rather than **1.81** kg if current trends continue.





4.3 Tacloban Scenario Projections

In 2013, Tacloban was struck by Typhoon Haiyan, one of the strongest tropical cyclones in history. The provincial capital of the Eastern Visayas region suffered a heavy toll: thousands lost their lives, many more were displaced, and local infrastructure lay in ruins.

Three years on from Haiyan, debris from the typhoon had overwhelmed the local dumpsite, and low collection coverage meant open dumping and burning were common. The city's waste management challenges caught the attention of the national environmental ministry, which served the city a notice for violating national waste management laws.

In response, Tacloban embarked on an ambitious zero waste effort in partnership with the Mother Earth Foundation, a local NGO that has two decades of experience providing technical assistance on waste management to local governments. The city bounced back from near-complete destruction to become a leading example of sustainable waste management in the Philippines.

Interventions

The city launched the Ecological Solid Waste Management Program in October 2016, beginning with a baselining exercise to better understand the city's waste generation, composition and management. Starting in 2017, interventions undertaken by the city included:

Photo: GAIA Asia Pacific

1. **Designing and enforcing city-wide policies in partnership with neighborhood leaders**
   Tacloban began by implementing an Ecological Solid Waste Management ordinance that mandated segregation at the household level, signaling a "no segregation, no collection" approach to households. Acknowledging that administrators of each city neighborhood ("barangay" in Filipino) would have to implement these policies, the city also issued detailed guidance that empowered barangay captains to enforce the new collection and segregation approach. Barangay officials, having received training through a series of workshops, later enforced their ordinances through community-based monitoring efforts. Small fines and community service orders were levied for residents who resisted the new policies

2. **Tailored community engagement and education**
   Barangays launched locally relevant awareness campaigns, designed with Mother Earth Foundation, to promote Tacloban's new zero waste approach. Residents were targeted with public addresses, billboards, flyers: the campaign sought to restore pride in the city following Haiyan's destruction, with an "I love Tacloban" message on promotional materials. Importantly, these messages were reinforced through a door-to-door campaign to encourage separation into four waste streams: biodegradable, recyclable, residual and hazardous. To reinforce these messages, residents were also given feedback on the accuracy of their waste separation by educators.

3. **Decentralized collection and sorting to minimize waste at the neighborhood level**
   Tacloban's focus was on minimizing residual waste, given capacity constraints and high costs at the sanitary landfill that had been established following the closure of the dumpsite. To encourage diversion, the city used its baseline assessment to design and implement a decentralized collection system at the barangay level. For the first time, residents received a regular collection service in return for doing their part to separate waste and divert recyclables and organics. Participating barangays also constructed community-scale sorting centers to minimize transport costs and encourage the participation of local scrap dealers and livestock farmers, who were enlisted to collect recyclables and food waste respectively. These interventions significantly reduced the amount of waste that had to be transported from material recovery facilities to the city's landfill.

Impacts

- 31% drop in landfill-bound waste, from 175 tonnes per day in 2016 to 121 tonnes per day by 2018

- ~70% of Tacloban's area covered by new separated collection system in 2019, representing 64 largely residential barangays
- Source separation compliance up from 10% in 2017 to 65% by 2019 in participating barangays
- ~US$375,000 in annual cost savings as a result of the zero-waste program, through lower transport costs and recyclable sales

Enablers

Tacloban's success was enabled by:

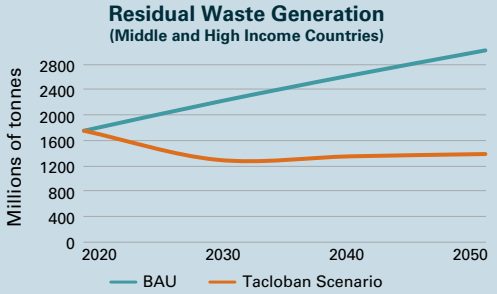
- The impetus provided by the breakdown of the waste system following Typhoon Haiyan
- Committed leadership from Tacloban's city and barangay-level officials who willing to undertake additional responsibility and enforce new policies
- Technical expertise provided by the Mother Earth Foundation and local recruits
- A collaborative funding model that combined US State Department grants and city funds
- Forward-looking national solid waste management laws that provided a legal framework

Looking Ahead

Tacloban now hopes to extend coverage of the new collection system to all of the city's neighborhoods, including in the central business district, and drive compliance rates higher through a combination of wider education and more stringent enforcement. Longer term, the city has set an ambitious goal: to increase its diversion rate to 95%, thereby turning Tacloban into a zero-waste model for the Philippines.

Box 4.3 Tacloban Scenario Projections

The case of Tacloban shows that fast-growing middle-income countries can make rapid reductions in residual waste generation through a set of locally relevant interventions. If all middle and high-income countries across the world were to replicate the performance of Tacloban, the residual waste generation per capita is estimated to potentially be 54% lower by 2050, avoiding 1.64 billion tonnes of waste disposal annually.

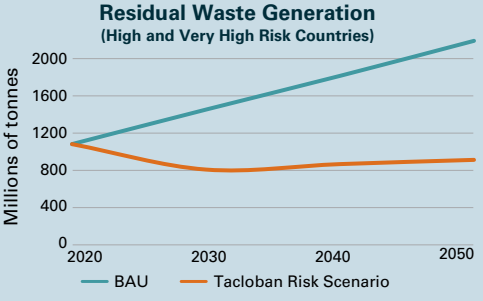


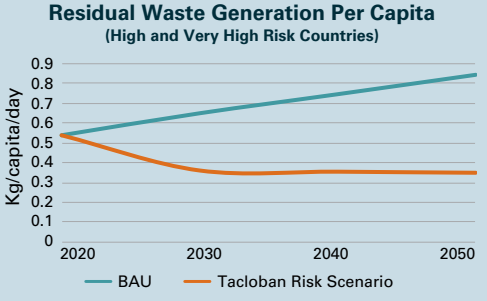
Since Tacloban improved their waste management to be more resilient to future disasters, a risk index lens was also applied to estimate projections. The city's waste management challenges were exacerbated by Typhoon Haiyan, but its recent progress on waste reduction has undoubtedly made it more resilient to future disasters. With reduced waste generation, disposal systems are less likely to be overwhelmed; in addition, flooding, a common consequence of unmanaged waste in drains and sewers, is now less likely. The lesson is clear: investing in waste reduction can reduce the risk of waste management systems being overwhelmed by similar events.

With natural disasters expected to increase in frequency and intensity with climate change, countries with similar risk profiles could take inspiration from Tacloban's experience as the city sought to proactively bolster their waste management systems.

The potential trajectories are modelled if countries were rated High or Very High risk on the World Risk Index, with the exception of upper-income economies, were to implement similar reduction policies as one way to strengthen their resilience to natural disasters. Relative to a business-as-usual case,

- Residual waste generation could be **58%** lower overall, avoiding **1.28** billion tonnes of disposed waste and lowering per capita residual waste in 2050 to **0.35** kg versus **0.84** kg in our BAU scenario





4.4 Ljubljana Scenario Projections

Twenty years ago, Slovenia landfilled nearly all of its waste. The country of just over 2 million, which joined the European Union in 2004, was focused ensuring full coverage of waste collection, as was its capital Ljubljana.

In the years since, Ljubljana has emerged as a European leader on waste prevention, comfortably exceeding EU targets by recycling over two-thirds of its waste and dramatically reducing its landfilling rate. The city transformed its approach to waste to become the European Green Capital in 2016.

Interventions

Ljubljana's public waste management agency, Snaga, undertook a series of interventions, including:

1. **Separating collection and treatment of waste, including organics**
   Ljubljana began separated collection of recyclables in 2002, followed by door-to-door collection of organic waste in 2006. In 2012, the door-to-door system was extended to recyclable paper and packaging waste, lowering barriers to participation by residents. Residual waste is now transported to a state-of-the-art regional facility, paid for with EU cohesion funds, to further separate recyclables, biologically treat organics, generate energy from residues, and minimize landfilling.

Photo: B7 Photography / Shutterstock.com

2. **Financial and operational incentives**
   City authorities implemented a system of financial and operational disincentives to reduce the amount of residual waste that residents generated in Ljubljana. The city transitioned to a pay-as-you-throw system for residual waste, with additional disposals (beyond a basic fee) charged at bins through a smart card system. Operationally, Snaga in 2013 reduced the frequency of residual collections, while maintaining recyclable and organic collection frequencies, creating a further incentive to sort waste into multiple fractions.

3. **Focusing on prevention and reuse**
   Snaga combined its messaging on waste separation with a number of campaigns to encourage residents to reduce waste generation. One such campaign, "get used to reusing", was accompanied by the opening of a "reuse center" in 2013 to help residents pass on items they no longer needed. Other campaigns have focused on food waste reduction and responsible consumerism. City authorities also decided to lead by example on waste prevention, passing legislation to discourage single-use items at public events such as the city's New Year's Eve party.

Impacts

- 15% reduction in total waste generation (including recyclables and organics) from around 0.91 kg/capita/day in 2004 to 0.77 kg/capita/day in 2014
  - 59% reduction in residual waste generated at the household level
- 68% of waste recycled or composted by 2018, over 20% above the EU average
  - Quantity of separated waste up collection up from 16 kg/person/year in 2004 to 145kg/person/year in 2014
- Ljubljana became the first capital city in the EU to commit to achieving Zero Waste goals in 2014 alongside Zero Waste Europe, an NGO building a network of zero waste cities

Enablers

Ljubljana's success was enabled by:

- A landfill tax introduced in 2001, which provided both incentives and revenue to build up recycling infrastructure
- The adoption of EU funding, legislation and targets on waste and recycling following Slovenia's accession in 2004
- Forward-looking city officials and the public waste agency, which combined ambitious targets with operational excellence

Looking Ahead

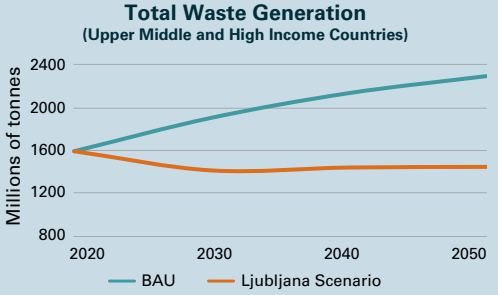
Ljubljana now hopes to accelerate progress towards its zero waste goals for 2025: increasing its separated collection rate to 78%, reducing per capita waste generation to 280 kg/person/year, and strengthening its position a model for waste reduction in Slovenia and the rest of Europe.

Box 4.4 Ljubljana Scenario Projections

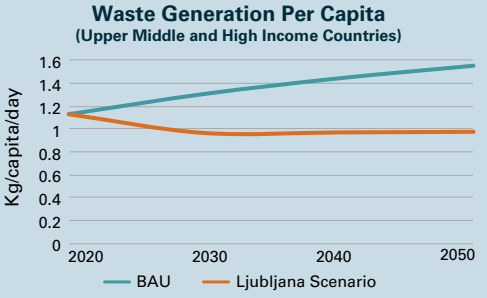
Slovenia's accession to the European Union around the turn of the millennium did not just coincide with a rapid phase of economic growth that catapulted it from upper-middle income to high-income status. It also demonstrated how cities like Ljubljana can achieve such growth while simultaneously reducing waste generation at the source and meeting ambitious recycling and composting targets.

If upper middle-income and high-income countries across the world were to replicate this success, relative to a business-as-usual case,

- Overall waste generation could be **37%** lower in these countries, reducing **857** million tonnes of waste annually by 2050



- On a per capita basis, residual waste could be **69%** lower by 2050, at **0.40** kg/person against the business-as-usual projection of **1.29** kg. Similarly, total waste per capita would be **37%** lower, at **0.97** kg rather than **1.54** kg if current trends continue. .



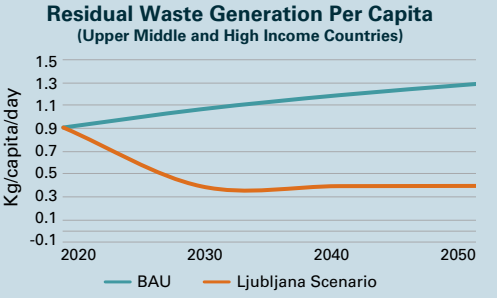


Photo: VittoriaChe / Shutterstock.com

4.5 Republic of Korea Scenario Projections

Through the 1980s and 90s, the Republic of Korea's economic boom, coupled with rapid population growth, were straining the country's waste management systems. Waste generation nearly tripled between 1974 and 1990, and overwhelmed landfills posed serious environmental and safety concerns.

In the two decades since, the country of 50 million has dramatically expanded its efforts to reduce waste, find productive uses and minimize its reliance on landfilling and incineration. Korea designed and implemented a series of national policies to become a leader in waste reduction and management.

Interventions

Korea undertook a series of national interventions, including:

1. **Implementing and refining a pay-as-you-throw collection system**
   Starting in 1995, the Korean government introduced volume-based pricing for household waste. Residents were required to purchase designated bags for residual waste, which were collected separately. Fees were set by municipalities and escalated over time – from roughly US$0.20/bag in 1995 to US$0.35/bag in 2001 – to ramp up the incentive to separate recyclables which were collected for free. In parallel, the government has worked with municipalities to increase the number

of curbside recycling streams, improving recovery rates for various materials. Specific disposal fees were also introduced for bulky items. Finally, the government imposed maximum fines of KRW 1 million (~US$800), creating a strong financial disincentive for non-compliance.

2. **Mandating producer responsibility for collection and recycling**
In 2003, the country built on an existing container deposit scheme to implement a comprehensive extended producer responsibility (EPR) policy that created a direct incentive for producers of packaging to collect and recycle their products. The system mandated recycling targets for each stream (plastic, glass, metal etc.) and included penalties that exceeded the cost of recycling if obligations were not met. The system was expanded to include several new items, including electronics, from 2013-2015, creating a comprehensive e-waste reduction program. While some manufacturers run take-back schemes for specific items, other streams are managed by municipalities, with producers paying into a fund to cover recovery costs.

3. **Focusing on food waste reduction and treatment**
The Korean practice of banchan, which encouraged a variety of side dishes with each meal, had long resulted in high levels of food waste. Starting in 2005, the Korean government introduced a ban on landfilling food waste to spur reduction policies. In 2013, a nationwide pay-by-weight system for food waste was implemented; this was enforced by designated bags, smart bins, and radio-frequency identification (RFID) tags. Food waste is collected separately and converted to biogas fuel or compost at processing plants. The availability of food waste-derived fertilizer has accelerated the urban farming movement, with Seoul alone witnessing a six-fold increase in the number of community gardens from 2012 to 2019.

Impacts

- Total municipal waste generation declined 50% from 1.95 kg/capita/day in 1990 to 0.98 kg/capita/day by 2000 (according to OECD data). Residual waste fell by an even steeper 69% as diversion rates rose from 5% to 41%
- Since then, waste generation has remained roughly flat at 1.05 kg/capita/day in 2016 despite GDP per capita nearly tripling since 2000. Diversion rates for municipal waste now stand at over 60%
- EPR policies helped increase the country's plastic recycling rate from 27% to 60% from 2006 to 2015
- Food waste recycling rate increased to 95% in 2019, up from 2% in 1995

Enablers

Republic of Korea's success was enabled by:

- Strong political will to improve waste systems as a result of environmental challenges
- Financial incentives provided by high waste disposal costs as a result of limited area for landfill
- Well-designed national policies, including an EPR framework, aligned with the policies of its 25 municipal governments with clear roles and responsibilities
- A public culture of environmental awareness and compliance, enhanced by government programs to educate and engage citizens on waste issues

Looking Ahead

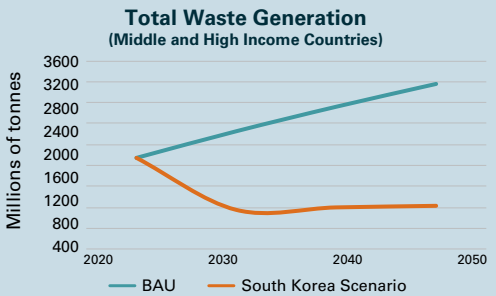
Korea aims to continue making progress towards waste reduction, passing a new Framework Act on Resource Circulation in 2018 that aims to further the country's transition to a zero-waste society. Korea is also turning its attention to the issue of single-use plastic: in 2019, the government banned the distribution of plastic bags at major supermarkets and has laid out plans to reduce its reliance on waste exports following China's National Sword policy in 2018.

Box 4.5 Republic of Korea Scenario Projections

Republic of Korea is often seen as a success story within the context of industrialized economies, but many of its most successful interventions were undertaken in the 1990s when the country was in middle income territory and experiencing rapid economic and population growth. Its success in balancing this growth with waste reduction policies holds important lessons for middle-income economies seeking a more sustainable development trajectory. In addition, Korea's more recent success in reducing organic waste has important implications for these countries' climate commitments.

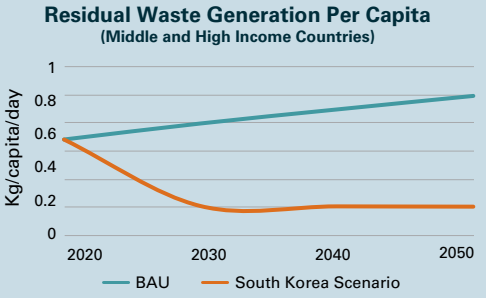
If middle and high-income countries across the world were to replicate this success, relative to a business-as-usual case,

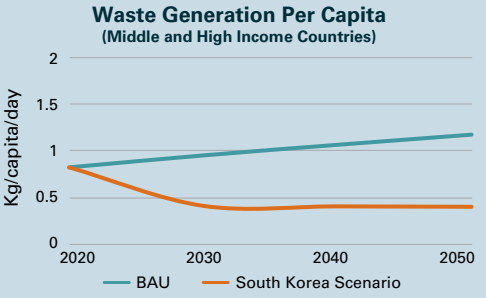
- Overall waste generation could be **66%** lower in these countries, reducing **2.35** billion tonnes of waste annually by 2050



Box Continues

- On a per capita basis, residual waste could be **79%** lower by 2050, at **0.20** kg/person against the business-as-usual projection of **0.99** kg. Similarly, total waste per capita would be **66%** lower, at **0.40** kg rather than **1.17** kg if current trends continue.





5. Conclusion

The case studies focus on reductions in overall waste as well as residual waste specifically. The interventions in the case studies are driven by different factors such as lack of land, high costs, or a desire to build a more resilient system but ultimately the results are similar across each location. The interventions are successful due to varied enabling environments, highlighting how municipal waste management can be addressed in multiple ways depending on the local circumstances.

The countries and cities included ranged from a 5% to 50% reduction in overall waste and a 30% to nearly 70% reduction in residual waste. Japan reduced waste per capita by nearly 20% between 2004-2017. If middle- and high-income countries followed Korea's practices, we could reduce waste generation by more than half compared to BAU in 2050, generating just 68% of today's waste. Our waste generation trajectory could drastically be reshaped. Low- and middle-income countries do not have to wait until their waste generation rates are comparable to those of high-income economies before taking action. Because they typically generate less waste per capita on average, it is to their advantage to improve and design integrated waste management systems now and prevent waste increases, to avoid further health and environmental crises.

There are many tools and global lessons learned that can help cities design sound integrated municipal waste management systems depending on the local context and available resources. With evidence-based planning, enforcement and monitoring, and performance measurements, cities can progress towards targets they set. In the case studies, all locations exceeded their original targets and measured performance over time. All the cases utilized financial incentives to achieve their targets by making waste generators pay or by making residual waste management more expensive relative to recycling and organics management, thus resulting in reduced waste.

An integrated municipal waste management system needs to be addressed from multiple angles as well as along the value chain. In addition to appropriate infrastructure and equipment, the institutional arrangements, legislation and policies, sustainable financing and cost recovery, public education and behavior change, capacity for service provision, environmental protection and social inclusion need to be factored in from the beginning. If citizens are unwilling to place their waste in designated locations, there is not enforcement of policies, or there is insufficient cost recovery, the system will quickly fall apart. There is no single solution to solve waste management challenges; however, when approached holistically, the system can be designed in a sustainable manner. The cases had infrastructure, clearly designated responsibilities, sound legislation, financial incentives, enforcement mechanisms, and strong citizen engagement which created an enabling environment.

In all of the cases, leadership and enforcement are foundational factors. There is involvement of various stakeholders including communities, the local government, service providers, and the private sector. While leadership may be contingent on the local circumstances, it takes time to involve stakeholders and build buy-in. Solutions will depend on local governance structures and will require enforcement and monitoring. Strong legislation or infrastructure by themselves will not lead to results without leadership and enforcement.

From the outset, building the system holistically rather than focusing on technologies will be critical. The cases show the progression of their systems and how the layered interventions resulted in positive outcomes. Starting simple and building on successes can lead to visible results and buy-in over time.

References

Modelling Dataset and Sources

Brazilian Association of Public Cleaning Companies (ABRELPE). 2019. "Panorama Dos: Residuos Solidos No Brasil 2018/2019." ABRELPE, Brazil. http://abrelpe.org.br/download-panorama-2018-2019/.

China Association of Urban Environmental Sanitation. 2017. "The China Municipal Waste Development Report." (in Chinese).

Dellink, Rob, Jean Chateau, Elisa Lanzi, and Bertrand Magné. 2017. "Long-term economic growth projections in the Shared Socioeconomic Pathways." *Global Environmental Change* 42: 200-214.

Garschagen, Matthias, Hagenlocher, Michael, Comes, Martina, Dubbert, Mirjam, Sabelfeld, Robert, Lee, Yew Jin, Grunewald, Ludwig, Lanzendörfer, Matthias, Mucke, Peter, Neuschäfer, Oliver, Pott, Simone, Post, Joachim, Schramm, Stephanie, Schumann-Bölsche, Dorit, Vandemeulebroecke, Bruno, Welle, Torsten and Birkmann, Joern (2016). World Risk Report 2016. World Risk Report. Bündnis Entwicklung Hilft and UNU-EHS. https://collections.unu.edu/eserv/UNU:5763/WorldRiskReport2016_small_meta.pdf.

Eurostat. 2021. "Municipal waste statistics: Statistics Explained." Accessed March 26, 2021. https://ec.europa.eu/eurostat/statistics-explained/pdfscache/10360.pdf.

Federal Competitiveness and Statistics Authority, United Arab Emirates. "Statistics by Subject." Accessed March 26, 2021. https://fcsa.gov.ae/en-us/Pages/Statistics/Statistics-by-Subject.aspx#/%3Ffolder=Agriculture%20Environment%20and%20Energy/Environment/Waste&subject=Agriculture%20Environment%20and%20Energy.

Kahn, Matthew Edwin; Lozano Gracia,Nancy; Soppelsa,Maria Edisa.2019. *Does Pollution Hinder Urban Competitiveness?*. Policy Research working paper;no. WPS 8739. Washington, D.C. : World Bank Group. http://documents.worldbank.org/curated/en/961131550092253676/Does-Pollution-Hinder-Urban-Competitiveness.

Kaza, Silpa, Lisa Yao, Perinaz Bhada-Tata and Frank Van Woerden. 2018. *What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050*. Urban Development Series. Washington, DC: World Bank. https://openknowledge.worldbank.org/handle/10986/30317.

Ministry of Environment, Government of Japan. 2019. "About discharge and treatment status of general waste (FY2018)." Accessed July 10, 2010. https://www.env.go.jp/press/107932.html.

Ministry of Environment, Republic of Korea. 2019. Accessed July 1, 2020. https://library.me.go.kr/#/search/detail/5686740%23btn-export.

Ministry of Housing and Urban Affairs, Government of India. 2019. "Solid Waste Management Including Hazardous Waste, Medical Waste and E-Waste" Accessed June 1, 2020. http://164.100.47.193/lsscommittee/Urban%20Development/16_Urban_Development_25.pdf.

National Bureau of Statistics of China. 2020 "China Statistical Yearbook of 2020. Accessed March 26, 2021. " http://www.stats.gov.cn/tjsj/ndsj/2020/indexeh.htm

National Environment Agency, Government of Singapore. "Waste Statics and Overall Recycling." Accessed June 19, 2020. https://www.nea.gov.sg/our-services/waste-management/waste-statistics-and-overall-recycling

National Institute of Rural Development and Panchayati Raj, Government of India. 2016. "Solid Waste Management in Rural Areas." Accessed June 1, 2020. http://nirdpr.org.in/nird_docs/sb/doc5.pdf.

United Nations. 2019. "World Population Prospects: The 2019 Revision." https://population.un.org/wpp/.

United States Environmental Protection Agency. December 2020. "Advancing Sustainable Materials Management: 2018 Fact Sheet Assessing Trends in Materials Generation and Management in the United Stated." Accessed March 26, 2021. https://www.epa.gov/sites/production/files/2021-01/documents/2018_ff_fact_sheet_dec_2020_fnl_508.pdf.

World Bank Open Data: Population 1960 -2018. N.d. https://data.worldbank.org/indicator/SP.POP.TOTL.

Yue Bo, et.al. 2014. "Characteristics of Rural Household Waste in China." Environmental Science & Technology (in Chinese), 37 (6): 129-134.

Cambridge

City of Cambridge. 2019. "Zero Waste Master Plan"

Orr, Michael. 2020. Recycling Director, Cambridge Department of Public Works. Personal communication with the World Bank.

Yokohama

City of Yokohama. 2011. "Municipal Solid Waste Management Master Plan"

City of Yokohama. 2018. "Yokohama City Master Plan for General Waste Management Promotion Plan 2018-2021".

https://www.city.yokohama.lg.jp/city-info/yokohamashi/org/shigen/sonota/hoshin/3r-plan/plan_2018-2021.files/pamphlet-eng.pdf

Hayashi, Shiko. 2020. Programme Director, Institute for Global Environmental Strategies. Personal communication with the World Bank.

Hotta, Y. and Aoki-Suzuki, C., 2014. Waste reduction and recycling initiatives in Japanese cities: Lessons from Yokohama and Kamakura. Waste Management & Research, 32(9), pp.857-866.

Japan Ministry of Environment. "Total MSW generation and MSW generation per capita". https://www.iges.or.jp/en/publication_documents/pub/issue/en/3317/3R_01.pdf

Jones, T.E., 2015. Japanese Solid Waste Management (SWM).

OECD Statistics. 2020. Waste Generation Per Capita filtered for Japan.

Premakumara, D.G. J. 2012. "Reduction of Municipal Waste by Promoting Integrated Sustainable Waste Management Practices".

https://www.iges.or.jp/en/publication_documents/pub/presentation/en/3487/JICA_2012_09_04[Waste_Management_Techniques_A-1].pdf

Resources & Wastes Recycling Bureau, City of Yokohama. 2011. "Integrated Solid Waste Management in Yokohama".

http://citynet-yh.org/english/wp-content/uploads/2015/10/Intergrated_solid_waste_management_in_Yokohama.pdf

World Bank. 2018. "Municipal Solid Waste Management – a Roadmap for Reform For Policymakers".

http://documents.worldbank.org/curated/en/813181537537614202/pdf/130055-WP-P162603-WasteManagement-PUBLIC.pdf

Tacloban

GAIA. 2019. "Sunshine After the Storm: A Typhoon-Ravaged City Rises to Become Zero Waste".

https://zerowasteworld.org/wp-content/uploads/Tacloban.pdf

United Nations University, Institute for Environment and Human Security (UNU, EHS). 2016. "World Risk Report 2016"

Villavicencio, Rap. 2020. Project Officer, Mother Earth Foundation. Personal communication with the World Bank

Ljubljana

BBC. 2019. "Ljubljana and its war on waste". https://www.youtube.com/watch?v=83uX7uJ30_4

Dakskobler, L. 2019. "From no recycling to zero waste: how Ljubljana rethought its rubbish". The Guardian.

European Commission. 2014. “Ljubljana becomes the first EU capital to adopt Zero Waste Goal”. https://ec.europa.eu/environment/european-greencapital/ljubljana-zero-waste-goal/

European Commission. 2016. “Upgraded waste management facilities for central Slovenia”

https://ec.europa.eu/regional_policy/en/projects/slovenia/upgraded-waste-management-facilities-for-central-slovenia

Kranjc, Jaka. 2020. Zero Waste Europe. Personal communication with the World Bank

Snaga. “Slovenian way to sustainable society”.

https://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetailDoc&id=27613&no=7

Zero Waste Europe. 2015. “The story of Ljubljana, first Zero Waste capital in Europe”.

https://zerowasteeurope.eu/2015/05/new-case-study-the-story-of-ljubljana-first-zero-waste-capital-in-europe/

Republic of Korea

Broom, D. 2019. “South Korea once recycled 2% of its food waste. Now it recycles 95%”. World Economic Forum.

https://www.weforum.org/agenda/2019/04/south-korea-recycling-food-waste/

Jang, Y. 2019. “EPR (Extended Producer Responsibility) System Toward a Material Cycle Society in Korea”. Chungnam National University presentation to World Bank.

OECD Statistics. 2020. Waste Generation Per Capita filtered for South Korea.

Park, J. 2019. “Recycling and Circular Economy” Korea University presentation to World Bank.

Seoul Solution. 2017. “Volume Based Waste Fee (VBMF) System for Municipal Solid Waste”.

https://seoulsolution.kr/en/content/6326

Song, Jaemin. 2020. Professor, Seoul National University. Personal communication with the World Bank

UN Environment Programme. 2003. “Korea Environmental Policy Bulletin - Volume-Based Waste Fee System”

https://www.unenvironment.org/resources/report/korea-environmental-policy-bulletin-volume-based-waste-fee-system

In 2018, the World Bank published *What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050*. Based on municipal waste generation data from 217 countries and economies, the report estimated that global waste generation was set to increase by 70% from 2016 to 2050, driven by increases in prosperity and urbanization. This projection is more than double the population growth estimates for the same period. With 93% of waste in low-income countries currently being openly dumped and burned, the world faces a looming waste crisis that threatens to impose substantial environmental, social, and financial costs on our societies.

More Growth, Less Garbage presents an updated picture of how waste generation could grow if the world continues along the current trajectory and how to consider changing that path toward lower waste levels. Historically there has been a correlation between waste generation and income per capita. This publication explores the possibility of decoupling waste generation, and thus consumption, from economic growth. Five case studies of waste reduction, in terms of residual waste and/or total waste, are highlighted from cities and countries across the world. In each location, decisions to reduce or divert waste were driven by a different factor, such as lack of land, the need to be more resilient, or the need to reduce costs of the overall waste system.

Based on these stories, scenarios were developed to estimate potential changes to the current business-as-usual trajectory, which estimates waste generation to grow from 2.24 billion tonnes in 2020 to 3.88 billion tonnes by 2050. If waste reduction policies were adopted in more places around the world, we could envisage a world in 2050 with more growth and less garbage than today.

WORLD BANK GROUP

Tokyo Development Learning Center

JAPANGOV
THE GOVERNMENT OF JAPAN