

Sahadat Hossain • H. James Law • Araya Asfaw

# The Waste Crisis

Roadmap for Sustainable  
Waste Management in Developing Countries





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Waste Management in  
Developing Countries*

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This edition first published 2022  
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John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, USA  
John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

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The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

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*Library of Congress Cataloging-in-Publication Data applied for*  
Hardback: 9781119811930

Cover Design: Wiley  
Cover Image: © Unsplash/CC0 Public Domain

Set in 9/13pt Ubuntu Regular by SPi Global, Pondicherry, India

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# Preface

The world is rapidly moving toward urbanization, and the amount of municipal solid waste (MSW), one of the most important by-products of an urban lifestyle, is growing even faster. Urbanization or “urban transition” is a process of shift in population densities from a rural/agriculture-based economy to a denser population with an industrial and service-based economy. Urbanization has generally been a positive force for economic growth, poverty reduction, and human development. With higher percentages of young urban dwellers, economic activity increases significantly in urban areas, which contributes to GDP growth of urban population in a country. Increase in population in urban areas and GDP growth results in increase in consumption ultimately leading to an increase in waste generation. Therefore, based on the latest data available, global waste generation in 2016 was estimated to have reached 2.01 billion tons (4.4 trillion lb) (World Bank Report 2018a). By 2030, the world is expected to generate 2.59 billion tons (5.71 trillion lb) of waste annually, and by 2050, waste generation across the world is expected to reach 3.40 billion tons (7.5 trillion lb).

However, sustainable waste management is a major issue for both developed and developing countries. Traditionally, as solid waste management practices and collection improve, waste will begin to be placed in open dumps or landfills, which still poses human health/safety threats via disease vectors, water pollution, and explosive conditions. Even though, source reduction or recycling is preferred choice of waste management, over 70% solid waste is open dumped or landfilled globally. Locally and globally, existing solid waste management/mismanagement presents challenges and opportunities.

**In developing countries** some current waste crises are presented as follows:

1. 1/3 to 2/3 of the solid waste is currently dumped indiscriminately in streets and drains, where it can breed insects and rodents that transmit communicable diseases such as dysentery, typhoid fever, cholera, yellow fever, and plague (Zhu et al. 2007).
2. Waste is traditionally burned in the streets and fields in and around city centers, producing dioxin emissions and damaging the air quality through soot emissions and the climate through carbon dioxide emissions. Poorly managed waste has an enormous impact on health, the local and global environment, and the economy, and improperly managed waste usually results in down-stream costs that are higher than the cost of managing the waste properly in the first place.

3. In developing countries, the rate of waste collection is between 20% and 60%. Uncollected waste dumped in open places, on roads and streets, in water bodies, and in most public areas is getting into city's drainage system. Presence of highly nondegradable plastic bottles and plastic bags are clogging the city's drainage system and causing flash flooding.
4. Inappropriate operational practices are causing serious health hazards for waste pickers at working face of a dumpsite. In some cases, failure of an open dumpsite is costing hundreds of people's lives living next to an open dumpsite (as in Koshe Dumpsite in Ethiopia).
5. Recent China Ban on importing recycled products from global market has caused serious effect on recyclables plastics and other waste components. Many cities are discarding their recycling programs and sending them to landfill as they did not have a local market for reusing the recyclables. Years of hard work to build recycling system and market needs revival with incentives from city officials or regulators. The problems created by China Ban can be a great opportunity for local young entrepreneurs to create new products and market using recyclables.

Regions of Africa, Latin America, South Asia, East Asia, the Pacific Islands, and the Caribbean are urgently in need of help in mitigating problems associated with increasing population growth, urban consumption, and waste production. If safe waste management practices are not incorporated into their development plans, the proliferation of poor health and sanitation conditions will persist. The real challenges of successful solid waste management are essentially those listed below.

- Lack of public awareness of waste management and its impact on health and well-being, the environment, and the local and global economies.
- Insufficient collection and management systems in developing countries that cause major health, sanitation, and environmental issues.
- Improperly managed open dumpsites and their serious consequence of environment and public health.
- Lack of space for new landfills every 20/25 years as urbanization and migration of population to urban areas causes serious strain on urban waste management system.
- Inadequate sustainable waste management technology and implementation of the technology in developing countries.
- Lack of training on waste management technology and lack of management assistance for local authorities and waste management personnel in developing countries.

- **The marginal or nonexistent guidelines or ROADMAP** for developing waste management protocols or regulatory frameworks at both the local and national levels in many of the poorest countries in the world.

***In Developed Countries:*** (i) Landfills typically occupy an area from several to hundreds of acres, and the current lack of available space for new landfills is a real problem for future waste management. Due to rapid growth and urbanization of cities beyond their current limits, many previously closed landfills which were outside the city limit during their closure, are now within the city limits. Opening a new landfill within the city limits often causes violent protests similar to those which occurred when demonstrations and protests against the opening of a new dump (landfill) on the slopes of Mount Vesuvius in October 2010 led to a riot and violent clash between the local residents and police. (ii) Waste minimization and the reuse of existing landfills is key for sustainable urban development, but even the most preferred choices of waste management, recycling, and reuse have inherent problems. For instance, Sweden is a recycling-happy land. The incineration of solid waste provides power to 250 000 of their homes and heats 810 000 homes. Recycling is so effective in Sweden that only four percent of all waste generated in the country is landfilled. However, the Swedes ran out of garbage needed for the incinerators and have had to import it from Norway (Hickman 2018).

In the last 40–50 years, developed countries have moved from open dumps to sanitary or engineered landfills, while the developing world is still practicing open dump methods. Very recently, the developing countries in South Asia, Latin America, Africa, and Eastern Europe have begun transitioning from open dumps to sanitary landfilling systems. However, based on the increasing rate of urbanization and the rate of increase in waste generation, the current ways of managing waste through landfilling or sanitary landfill systems may not be sustainable. Because of urbanization, it is almost impossible to find land on which to build new sanitary landfills every 20–25 years, so that is not a sustainable solution. The problems associated with the waste generation and management by current systems are summarized below.

- Populations in urban mega cities are increasing at an alarming rate, and the amount of waste that is being generated is also increasing.
- The available land for building residential houses to accommodate the influx of people from rural areas to urban areas is shrinking every day. Consequently, the cost of land for building a landfill within the city or in nearby cities is extremely high.
- The level of resistance to building new waste management facilities (landfills) within communities is very high, which causes major distress within the cities' political system. Therefore, the policy makers or city officials are reluctant to approve the construction of new landfills within the city limits.

- Waste-to-energy (WTE) or incineration can provide a lucrative solution to waste management as WTE plants can address the issue of land/space in both developed and developing countries. It is an appropriate technology for waste management in developed countries such as Europe, the USA, Japan, and South Korea, where the waste is relatively dry and the substantial presence of plastics, paper, and wood make it a good source of combustible materials. The waste in developing countries has a higher percent of food waste (more than 70%) and high moisture content than that of the waste in European countries. Therefore, generating power through WTE or incineration, using this low calorific (organic waste) and highly wet waste may not be applicable or cost-effective for developing countries, if without detailed studies and analysis.

The hierarchy of waste management may not be the same for all countries or all kinds of solid waste generated. In other words, **ONE SOLUTION DOES NOT FIT ALL**. The handling of solid waste requires solutions that are flexible, but robust enough for urban sustainability.

A clear understanding of waste generation, collection, and management practices, as well as **a roadmap for sustainable waste management in developing countries is vital** for environmental sustainability, good health, the safety of waste pickers and people living in communities near dumpsites, and above all, for creating healthy urban cities across the globe.

The proposed sustainable **Resource Management** system, **Sustainable Material And Resource Treatment (SMART)** facility, would replace traditional landfills and open dumps and be a viable solution for developed and developing countries. SMART facility will eliminate the problems associated with loss of materials, climate change impacts, post-closure monitoring costs, and most importantly the major roadblock for sustainable waste management **SPACE**. It will facilitate greater material recovery and reuse, accelerate waste degradation rates and renewable energy generation, perpetuate operations in the same location, improve the public's perception, create jobs, and enhance the acceptance by the greater urban community. Once source-separated, mixed waste can be processed in a SMART facility, and sustainable material/resource recovery and management will be a ONE-STOP operation. The design and operation of conventional landfills will be replaced by a biocell (within SMART facility). Biocell acts as a perpetual landfill and is a major part of a sustainable waste management system in which waste is never landfilled permanently. Rather than serving as a permanent storage facility, the biocell is a temporary repository that is used to retrieve all the potential benefits during the repository period. It will also accelerate waste decomposition and replace landfilling by treating the waste so that it produces greater levels of renewable energy quickly.

The proposed sustainable solution covers all the major components of sustainability, as well as the technical, economic, and social aspects of the system. The government

shoulders the responsibility of collecting and managing waste. Consequently, significant portion of cities budget is allocated to municipalities waste management. The challenge is to shift the burden from the city to the private sector by creating or enabling an environment for the business to flourish throughout the value chain from collection to processing waste to valuable products which are used by consumers while creating sustainable employment for urban dwellers with living income. Therefore, in the framework of Public Private Partnership (PPP) the SMART facility should be established to accommodate the interest of the government, the private sector, and the public at large. Therefore, SMART facility has the potential of creating of jobs for the people living around the waste management facilities, making it a source of income rather than a source of distress, sickness, and economic hardship. If the waste management system is managed correctly and sustainably, the unhealthy conditions that are presently observed all over the world can be minimized significantly and it should provide healthy living conditions for both poor and rich residents.

Developing countries need help from advanced or developed countries for appropriate technology of managing their waste. What works in one place/city/country may or may not work in another country. Therefore, training and human capacity building is vital and important component of sustainable waste management. Many developed countries are willing to share their experiences and offer their tried and tested solutions but finding an effective regional platform to deliver this exchange is simply absent.

**The Organized Research Center of Excellence (ORCE) – Solid Waste Institute for Sustainability (SWIS)** founded in January 2015 at the University of Texas at Arlington (UTA) is trying to bridge the gap that currently exists between developed and developing countries. The international collaborative partner of SWIS for training and capacity building is the International Solid Waste Association (ISWA). **The mission** of SWIS is to develop clean and healthy urban cities through sustainable waste management.

SWIS conducted its first international waste management training through ISWA-SWIS Winter School in January 2016. The training program is a collaborative partnership between ISWA and SWIS. The objective of the ISWA – SWIS Winter School was to provide advanced knowledge in the field of waste management to an international audience of existing and emerging solid waste experts. The unique aspect of ISWA-SWIS Winter School is that training is conducted both in-class and hands-on training over a two-week duration. The success and achievements of the 2016 ISWA-SWIS Winter School have been inspiring, motivating future possibilities and opportunities for the program. The SWIS team is committed to continuing the program every year, based on the success of the 1<sup>st</sup> winter school. Every year, participants are selected from developing countries that did not participate in previous years, as SWIS wants to reach out to more parts of the globe and involve more and more developing countries in sustainable waste management practices. In January 2020, SWIS completed its fifth successful SWIS' waste management training program. It has trained participants from more than 80 countries (including participants from every

continent). In 2019, the Winter School program was awarded and honored as one of the best global sustainable waste management training programs by ISWA at the annual ISWA World Congress Conference during the Gala Dinner in Bilbao, Spain.

Finally, the proposed SMART facility will replace the existing waste management through open dumps or landfills as the sustainable resource management facility in every community in years to come. A SMART facility's success relies on conducting public outreach and education program, getting alignment with all stakeholders, politicians, and decision-makers, working with waste pickers, and creating jobs, and transferring of technologies needed at each stage.

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# Series Preface

As the world's population, and with it the amount of resources we consume, continues to grow, it becomes ever more important to properly manage the "waste" that is generated by this growth. With the expanding volume and complexity of discarded domestic and industrial waste, and changing household consumption patterns, waste management is fast becoming one of the key challenges for the modern society.

According to some estimates, up to 2 billion people lack access to sound waste management. Uncollected municipal waste that ends up at illegal or improper dumpsites close to waterways and coasts generates marine litter, affecting marine ecosystems as well as the fishing and tourism sectors. Marine litter is primarily caused by the improper management of waste on land, which finds its way into the marine environment. Dumpsites, again caused by the improper collection and management of waste, can be sources of greenhouse gases and other short-lived climate pollutants. It is therefore recognized that the inadequate removal and treatment of waste poses multiple threats to human health and the environment. Particularly in low- and middle-income countries, open dumping and burning close to urban centers represent a substantial threat to human health and climate. However, advanced economies have shown that through effective waste management it is possible to significantly reduce these impacts and even, through recirculation of the materials in waste back into the production of new goods, minimize the broader impacts associated with consumption. Hence, the proper management of waste and resources is critical to successfully realizing several of the Sustainable Development Goals set out by the UN in 2015.

A sound and sustainable waste management system is a fine balance of a number of elements – technical, legislative, financial and business - carefully planned to unlock the economic potential of waste, including the creating of new jobs and development of new enterprises.

This series of books will address a range of topics that are integral to sound waste management systems. This will include technical solutions for waste collection and treatment, as well as addressing financing opportunities and the value of waste management, organizational and management challenges, and policy development and enforcement. The books will emphasize the need to adopt a holistic view of waste management by considering the total waste system, and then developing the most appropriate mix of infrastructure and services to manage the specific waste streams.

*The Waste Crisis: Roadmap for Sustainable Waste Management in Developing Countries* is the second book of the series and focuses mainly on technical aspects of sustainable waste management.

Björn Appelqvist  
Chair of the ISWA Scientific and  
Technical Committee (STC)

*Any opinions expressed in this publication are solely those of the authors. They do not necessarily reflect the opinions or standpoints of ISWA, or its members, on any specific issue – unless explicitly stated.*

# Acknowledgments

The authors would like to take the opportunity to thank everyone who helped them implementing different waste management projects and who helped them enthusiastically to complete this book. Special thanks to:

- Brenda Haney, Current Solid Waste Director, City of Lubbock, Texas, USA, for her time and support reviewing the book manuscript extensively and providing valuable guideline to improve the quality of the book. Brenda is an active executive board member of SWIS (Solid Waste Institute for Sustainability). We also like to acknowledge her active role as Organizer and Presenter during ISWA-SWIS Winter School in all five years (2016–2020). Brenda has been playing an instrumental role for the success of the Winter School.
- Vance Kemler, Past Solid Waste Director, City of Denton, Texas, USA, for his support and help in implementing many sustainable waste management ideas in the city of Denton Landfill during his tenure as a director. Vance is an active executive board member of SWIS (Solid Waste Institute for Sustainability). We also like to acknowledge his active role as Organizer and Presenter during ISWA-SWIS Winter School in all five years (2016–2020). Vance has been playing an instrumental role for the success of the Winter School.
- David Dugger (Past Landfill Manager, City of Denton, Texas, USA, and Current Manager of McKinney Landfill), Bill Sangster (Landfill Manager City of Irving, Texas, USA), Tiana Lightfoot Svendsen (Current Communication and Project Manager, US Plastics Pact, and past Recycling Director – City of Garland, Texas, USA), Dr. Patricia Redfearn (Solid Waste Director, City of Grand Prairie, Texas, USA) for their support and help implementing many sustainable waste management ideas in their cities. We also like to acknowledge their active participation and field demonstration during ISWA-SWIS Winter School in all five years (2016–2020).
- Our Winter School Ambassadors/participants from all over the world for sharing their waste management experience and stories from their countries selected from each Winter School, and their contribution to Chapter 3: Md. Shoriful Alam Mondal (Bangladesh), Thiago Villas Bôas Zanon (Brazil), Vishwas Vidyaranya (Colombia), Eshetu Assefa (Ethiopia), Medea Chachkhiani (Georgia), Visva Bharati Barua (India), Nour Kanso (Lebanon), Arely Areanely Cruz Salas (Mexico), Maria Ajmal (Pakistan), Soraia Taipa (Portugal), Dusan Milovanović (Serbia), Basem Abu Sneineh (UAE), and Tran Thi Diem Phuc (Vietnam).

- Tom Frankiewicz (US-EPA) and Silpa Kaza (World Bank) for their active help and support with international projects and their active participation as a speaker and panelist during ISWA-SWIS Winter School (2016–2020). Tom and Silpa are active executive board member of SWIS.
- Dr. Eshetu, Solid Waste Director of City of Addis Ababa for helping us with the tour of Reppie WTE Plant.
- Aditi Ramola, Technical Director of ISWA General Secretariat, Bjorn Appelqvist, Chair of Scientific Technical Committee (STC) of ISWA for their active help and support during the review process of the proposed book outline.
- Dr. Prabesh Bhandari (Geosyntec Consultants), Sachini Madanayake (Ph.D. student), and Muhasina Manjur Dola (Ph.D. student) for their help with different aspects of this book. We are very thankful to them for their hard work, dedication, and great service. Dr. Naima Rahman (SCS Engineer), Dr. Rakib Ahmed (ECS Consultants), Mumtahina Binte Latif (Atwell LLC), Sehneela Sara Aurpa (Ph.D. student) for their contribution and help.
- Ms. Ginny Bowers, our official reviewer/editor, for checking grammar and other aspects of the book.
- Sarah Higginbotham, Senior Commissioning Editor, John Wiley & Sons, Oxford, UK, for her keen interest in the book.

MD Sahadat Hossain, Ph.D., P.E.  
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## Chapter 1

# Introduction

**S**ustainable solid waste management poses different challenges for developing and developed countries.

In developing countries, 1/3 to 2/3 of the solid waste is currently dumped indiscriminately in streets and drains, where it can breed insects and rodents that transmit communicable diseases such as dysentery, typhoid fever, cholera, yellow fever, and plague (Zhu et al. 2007). Waste is traditionally burned in the streets and fields in and around city centers, producing dioxin emissions and damaging the air quality through soot emissions and the

climate through carbon dioxide emissions. Poorly managed waste has an enormous impact on health, the local and global environment, and the economy, and improperly managed waste usually results in downstream costs that are higher than the cost of managing the waste properly in the first place. Traditionally, as solid waste management practices improve, waste will begin to be placed in open dumps or landfills, which still poses human health/safety threats via disease vectors, water pollution, and explosive conditions. Uncontrolled landfills emit one-third of the anthropogenic methane emitted globally (ISWA Report 2021). Some of the current waste crises in developing countries are presented in the following section:

### CRISIS 1

People have to cover their noses as they walk past the garbage that is piled up in and around city neighborhoods, residential areas, small businesses, and shopping complexes (Figure 1.1). In some places, dump trucks pick up the garbage once a



**Figure 1.1** (a)/(b) Roadside uncollected waste becomes a nuisance for passerby  
Source: (a) Fahim shaon/Wikipedia commons/Public Domain. (b) Courtesy of SWIS.

week, and in others, weeks go by without collecting it. An unfortunate but common practice is for people to burn their garbage in the corners of their neighborhoods and use it as a heating source during winter and/or just for fun. These practices can cause serious health and safety issues, and many times cause massive fires. Many airborne diseases are prevalent in these areas because of the open burning of garbage, but the residents are often unaware of them or their cause. Residents in the area are not happy about the practice, but the respective authorities are not taking any actions. It is essential that the practice of burning waste in open places as part of informal waste management system stops immediately.

**Questions:** (1) How can we stop this unhealthy and unsustainable social practice?  
(2) Why are the authorities not taking action?

## CRISIS 2

Many metropolitan cities in South Asia, Africa, and Latin America have unusual flooding events (Figure 1.2). The floods are not during the regular flooding season, and in many cases, they occur in areas that are above the 100-year flood level. The roads and other infrastructures become completely flooded due to the heavy, continuous rainfall for several days and cause a nightmare for the city residents because of the (i) disruption of school/colleges and workplace schedules; (ii) difficulty in moving in and around the city by car, buses, or other road vehicles; (iii) serious health effects of highly polluted water (mix of rainwater and sewer water and many unhygienic floating materials on the water); and (iv) most seriously, the outbreak of many airborne and waterborne diseases immediately after the flood water recedes.

(a)



(b)



**Figure 1.2** Flooding in cities disrupts life of residents. (a)/(b) Traffic flow through waterlogged roads.

Source: Palash Khan/The Daily Star. the city, Ronie/© Pixahive.com.

**Questions:** Why is this unusual flooding happening in the city? Can we avoid this situation?

### CRISIS 3

Garbage disposal and management are the responsibilities of both regulators and private citizens, and the public's participation is vital to successfully resolve the problem. Indiscriminately throwing away trash without considering others or the environment creates problems regardless of the regulations that are in place (Figure 1.3).

(a)



(b)



**Figure 1.3** (a) Trash adjacent to a garbage disposal container (Karthik 2018).  
Source: Ron Cogswell/Flickr. (b) Waste pickers collect trash from roadside.  
Source: Biswarup Ganguly/Wikipedia Commons/Public Domain.

### CRISIS 4

A trash truck enters the dumpsite and hundreds of people (in this case, waste pickers) run toward or along the sides of the dump truck. This is an unbelievable but common daily view in many open dumps around the world and is comparable to hordes of people chasing a limo to get a glimpse of the celebrity inside. Ironically, the “celebrity” for the waste pickers is the trash that was thrown away by people for whom it had no value. Why are they running and possibly risking their lives? Because they want to retrieve as many recyclables or materials of value as possible. In some cases, the waste pickers jump on the dump truck (as presented in a photo from Tanzania, Figure 1.4), or even let the trash be dumped



**Figure 1.4** Waste management hazards faced by waste pickers. Waste picker inside a collection truck in Tanzania.

*Source:* Courtesy of SWIS.

on them in order to get the most valuable items. Selling their collected trash in the market is their only means of making a living, and many of them are dying every day around the globe.

**Question:** How can we improve the waste pickers' deadly/unsustainable working conditions?

### CRISIS 5

News Flash!! "Lebanese protest against waste-disposal crisis" Al Jazeera News, 26 July 2015.

The Naameh landfill, which served as the trash disposal facility for half of Beirut, Lebanon's population, was closed because it reached its capacity, and Sukleen, the main waste management company, stopped collecting rubbish because it had nowhere to dispose it. After that, garbage had piled up on every street corner in Beirut, and the stench of uncollected refuse was becoming unbearable (Figure 1.5a). In many cases, residents were burning trash on the street corners, which was unhealthy, as well as a serious safety concern (Figure 1.5b).

(a)



(b)



**Figure 1.5** (a) Uncollected waste in the streets of Beirut.

Source: Dr. Amani Malaalouf, Winter School Participant from Lebanon. (b) Burning of trash during the Lebanon waste crisis. Source: Eliane Haykal/Adobe Stock.

Why were they in a situation like this? Primarily because the old dumpsites or landfills in many cities are reaching their maximum capacity, and the government or city officials are having difficulty finding a new location for a landfill. New landfill sites need to be identified by the city officials three to four years prior to the current site reaching its maximum capacity so that once the old dumpsite/landfill closes, the new landfill can begin accepting garbage. Finding a suitable location that is close to major metropolitan cities is becoming more challenging every year not only in Lebanon but also in many other developing/developed countries. *Space* is a big issue.

Questions: Why did not the authorities act ahead of time? How can we solve the major space problem?

## CRISIS 6

"Death toll rises in Ethiopian trash dump landslide" – CNN, 15 March 2017

In March 2017, Koshe, a very old dumpsite, collapsed in Addis Ababa, resulting in the deaths of more than 150 people who were living on or next to the dumpsite. The Koshe dumpsite started its operation outside the city almost 50 years ago; however, with time and expansion of the city's boundaries, the dumpsite was well within the city limits and became the home of many people who lived on or very close to the base of the dumpsite. The dumpsite reached

(a)



(b)



**Figure 1.6** Landslide at the Koshe dumpsite in Addis Ababa. (a) Slope failure at Koshe. *Source:* Photo taken by author from site visit by SWIS. (b) Residential houses next to the failure site. *Source:* Photo taken by author from site visit by SWIS.

its maximum capacity and was closed in 2016, when the Sendafa Landfill, the first engineered sanitary landfill in Ethiopia, began operating just outside Addis Ababa. The new landfill ceased its operation after six months (July 2016) due to sociopolitical issues, however, and the city resumed dumping its trash at Koshe, which eventually caused a catastrophic failure and cost many lives (Figure 1.6a, b). Similar dumpsite failures cost lives in Sri Lanka, China, and Indonesia in recent years.

**Questions:** How can catastrophic failures such as the one that occurred at the Koshe dumpsite be avoided? What is the best way to close existing dumpsites without causing sociopolitical problems or creating a situation like the one in Lebanon in 2015? Can a waste management facility operate in one place perpetually for a long time?

### CRISIS 7

A woman carries her little child on her back while she works at a dumpsite (Figure 1.7a). Many women and children like her work at dumpsites to collect bits and pieces from the pile of trash so that they can sell them in the market and make money for their families. Many of them also live on (Figure 1.7b) or next to the dumpsite, which is common and considered normal for people like her and millions of others around the world.

(a)



(b)



**Figure 1.7** People living in dumpsites and making a livelihood from waste picking. (a) Children collecting waste. *Source:* Courtesy of SWIS, (b) young waste collectors taking a break while waiting for the next dump truck. *Source:* Toon van Dijk/Flickr.

**Questions:** Is it normal and healthy for anyone to live on or next to a dumpsite, especially with kids? How can we improve their lives or livelihoods?

### CRISIS 8

Many children are jumping into, swimming, and playing in a small pond (Figure 1.8a,b). They are having a great time during the summer heat where getting water to swim and play is not readily available to many in the world. Another group of kids is running around and playing next to the pond, and many of their friends are cheering them on. This seems like the perfect entertainment for the children, but the pond where they are playing is a leachate pond that is located at a dumpsite, where leachate and the surface runoff from rainwater are mixed. The playground is one corner of an open dump, and the children nor their parents have any idea about the serious health hazards that are present for those swimming in highly contaminated water and playing on and/or near an open dump.



**Figure 1.8** Children near open dump of garbage: (a) people swimming in water polluted with trash. *Source:* Bibek2011/Wikipedia Commons/Public Domain, (b) girls playing with waste. *Source:* John Christian Fjellestad/Flickr. (c) A small boy playing in the landfill. *Source:* pxfuel. (d) A little boy looking towards the landfill. *Source:* <https://www.pxfuel.com/en/free-photo-elam>

**Questions:** Can we cast our cares aside and allow the practice to continue because they are not our kids, and does it not affect us when we are aware of the seriousness of the problem and the children's and parents' ignorance?

### CRISIS 9

The news of China's restrictions on importing recyclables from foreign countries that became effective in January 2018 affected the waste recycling and waste management practices around the globe (Figure 1.9a).

Communities across the United States curtailed or halted their recycling programs, as the market for recycling products declined and the costs associated with recycling rose (Figure 1.9b). Many cities are sending their plastic waste and recyclables directly to the landfills, which are putting extra pressure on landfill operators as the increase in plastic waste, which consumes a higher volume of space in the landfill, will cause the landfill life to decrease significantly.



**Figure 1.9** Effect of China ban. (a) China bans plastic waste.

Source: RTM World., <https://www.rtmworld.com/news/china-to-ban-solid-waste-imports>.

(b) Stacks of Plastic. Source: Hans/Pixabay.

**Questions:** How can we manage plastic waste sustainably? How can we create local markets for recyclables and avoid sending plastic waste to landfills so that we can benefit from a circular economy path?

All these waste crises are still happening in many developing countries around the world, and the questions raised are still unanswered. It is the intention of this book to raise awareness among the readers and to discuss some potential feasible and applicable solutions to these waste crises throughout the remaining chapters. And finally, for interested stakeholders and decision making around the world, answers to these questions are summarized in the last chapter of the book as a reference and starting point to solve their own issues and problems regarding better waste management practices for their own communities they live in.

**In Developed Countries:** Landfills typically occupy an area from several to hundreds of acres, and the current lack of available space for new landfills is a real problem for future waste management. Due to rapid growth and urbanization of cities beyond their current limits, many previously closed landfills, which were outside the city limit during