WORKER AT A RECYCLING BUSINESS: A FEMALE WORKER POSES AT A RECYCLING BUSINESS THAT RECEIVED A GRANT THROUGH A USAID-FUNDED BUSINESS PLAN COMPETITION (MAY 21, 2013, PORT-AU-PRINCE, HAITI). PHOTO CREDIT: KENDRA HELMA

SECTOR ENVIRONMENTAL GUIDELINE: SOLID WASTE

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ABOUT THIS DOCUMENT AND THE SECTORAL ENVIRONMENTAL GUIDELINES

USAID has developed sector-specific environmental and social guidance to support activity design, pre-implementation environmental review (including the identification of potential impacts and the design of mitigation and monitoring measures), and the development of environmental mitigation and monitoring plans. **This document presents USAID's *Sector Environmental Guideline – Solid Waste.*** The Sector Environmental Guidelines for all sectors are accessible at USAID's Sector Environmental Guidelines & Resources webpage.

Purpose. The purpose of this document is to support the environmentally and socially sound design and management of common USAID sectoral development activities by providing concise, plain-language information regarding:

- The typical, potential adverse impacts of activities in these sectors, including the impacts related to environmental, social, and climate change;
- How to prevent or otherwise mitigate these impacts, both in the form of general design guidance and specific design, construction, and operating measures;
- How to minimize the vulnerability of activities to climate change, as well as the contributions of activities to climate change;
- How to minimize social impacts and maximize the benefits to beneficiaries and the local community in an equitable manner; and
- More detailed resources for further exploration of these issues.

Environmental Procedures. USAID's mandatory environmental procedures, as described in Automated Directives System (ADS) 204, require that the potential adverse impacts of USAID-funded and managed activities be assessed prior to implementation via the Environmental Impact Assessment (EIA) process defined by Title 22, Code of Federal Regulations (CFR), Part 216 (Reg. 216)[1]. They also require that the environmental management and mitigation measures identified by this process be written into award documents, implemented over the life of the project, and monitored for compliance and sufficiency.

The procedures are USAID's principal process to ensure environmentally sound design and management of USAID-funded activities and, thus, protect environmental resources, biodiversity, ecosystems, ecosystem services, and the health and livelihoods of beneficiaries and other groups. The procedures strengthen and sustain development outcomes and help safeguard the good name and reputation of USAID.

The *Sector Environmental Guidelines (SEGs)* directly support environmental compliance by providing information that is essential to assessing the potential impacts of activities and helping

[1] USAID. 1980. Reg. 216 (22 CFR 216). https://www.usaid.gov/environmental-procedures/laws-regulations-policies/22-cfr-216.

identify and design appropriate mitigation and monitoring measures, as necessary and appropriate based on capabilities.

However, they are **not** specific to USAID's environmental procedures. They are generally written and are intended to support environmental impact assessment of these activities by all actors, regardless of the specific environmental requirements, regulations, or processes that may apply.

Limitations. This document serves as an introductory tool for Agency staff for solid waste sector projects, programs, and activities. This document is not intended to act as a complete compendium of all potential impacts because site-specific context is critical to determining these impacts. Furthermore, the Guidelines are not a substitute for detailed sources of technical information or design manuals. Users are expected to refer to the accompanying list of references for additional information.

USAID Guidelines Superseded. This Sector Environmental Guideline replaces Sector Environmental Guideline: Solid Waste, Full Technical Update (December 2018).

Comments and Corrections. Each sector of these guidelines is a work in progress. Comments, corrections, and suggested additions are welcome. Email: environmentalcompliancesupport@usaid.gov.

Advisory: The Sector Environmental Guidelines are advisory only. They are not official USAID regulatory guidance or policy. Following the practices and approaches outlined in the Sector Environmental Guidelines does not necessarily ensure compliance with USAID environmental procedures or host country environmental requirements.

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ACRONYMS

AD	Anaerobic Digestion
ADS	Automated Directives System
BOD	Biological oxygen demand
CBO	Community-based Organization
CDE	Construction, Demolition, and Excavation
CDR	Compulsory displacement and resettlement
CEMS	Continuous Emission Monitoring System
CFR	Code of Federal Regulations
CH_4	Methane
CHP	Combined heat and power
CO_2	Carbon Dioxide
COD	Chemical oxygen demand
CRM	Climate Risk Management
CY	Cubic Yards
DBO	Design, Build, Operate
E&S	Environmental and Social
EA	Environmental Assessment
EIA	Environmental Impact Assessment
ECSSA	Environmental Cleaning Solutions S.A.
EIS	Environmental Impact Statement
EJ	Environmental Justice
ELV	End-of-Life Vehicle(s)
EMMP	Environmental Mitigation and Monitoring Plan
EOL	End of Life
ESIA	Environmental and Social Impact Assessment
ESS5	Environmental and Social Standard 5
GBV	Gender-Based Violence
GDA	Global Development Alliance
GHG	Greenhouse Gas
GPS	Global Positioning System
GRM	Grievance redress mechanism
HAZMAT	Hazardous Materials
HC	Hydrocarbon
HGV	Heavy goods vehicles
ICOMOS	International Council on Monuments and Sites
IP	Implementing Partner
IEE	Initial Environmental Examination
IFC	International Finance Corporation
IPCC	International Panel on Climate Change
IVC	In-Vessel Composting
LAP	Livelihood Action Plan
LCA	Life-Cycle Analysis
LDPE	Low-density Polyethylene

LED	Light-Emitting Diode
LEAD	Leveraging Effective Application of Direct Investments
LFG	Landfill Gas
MRF	Materials Recovery Facility
MSW	Municipal Solid Waste
NGO	Nongovernmental organization
NMOC	Non-Methane Organic Carbon
O&M	Operations and Maintenance
OECD	Organization for Economic Cooperation and Development
PAD	Project Appraisal Document
PADF	Pan American Development Foundation
PiP	Person-in-the Port
PM	Particulate Matter
PPE	Personal Protective Equipment
POPs	Persistent organic pollutants
PPP/P3	Public-Private Partnership
PPS	Pollution Prevention Systems
PS	Polystyrene
PVC	Polyvinyl Chloride
RAP	Resettlement Action Plan
RCV	Refuse Collection Vehicle
RDF	Refuse Derived Fuel
RFID	Radio-Frequency Identification
SEG	Sector Environmental Guidelines
SEP	Stakeholder Engagement Plan
SOP	Service Operational Plan
SPV	Special-purpose vehicle
SWM	Solid Waste Management
TIA	Traffic Impact Assessment
TPM	Total particulate matter
TS	Total Solids
UNEP	United Nations Environment Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
US EPA	United States Environmental Protection Agency
USAID	United States Agency for International Development
VOC	Volatile Organic Compound
WEEE	Waste from Electrical and Electronic Equipment (e-Waste)

1. CONTEXT AND INTRODUCTION

1.1 OVERVIEW

According to UNEP, the world generates 2.31 billion tons (2.1 billion metric tonnes) of municipal solid waste annually. This number is expected to grow to 4.19 billion tons (3.8 billion metric tonnes) by 2050[2,3], with waste generated in low-income countries expected to increase more than threefold.[4] At the same time, shifting patterns of production and consumption are leading to greater complexity in managing waste. Faced with such trends and the lack of funding and capacity, many solid waste management authorities in such areas will find it increasingly challenging to provide the necessary services, infrastructure, and facilities while addressing the associated threats to public health, society, and the environment. In this context, the United States Agency for International Development's (USAID) role in supporting the development of sustainable waste management projects, programs, and activities offers significant potential for achieving a wide range of benefits, including minimizing public health risks and environmental impacts and enhancing sustainability.

This Sector Environmental Guideline (SEG) provides an overview of the solid waste management sector; types of waste; systems for reducing, collecting, treating, and disposing of waste; and the planning and implementing of such systems. Additionally, this SEG introduces and outlines potential environmental and social impacts and the climate change risks associated with the solid waste management sector and discusses potential mitigation and management measures to address these impacts and risks. As the SEG is not comprehensive, suggested additional reading is provided in Section 10 *Additional Reading.*

1.2 THE SOLID WASTE MANAGEMENT SECTOR AND DEVELOPING COUNTRIES

The solid waste management sector consists of public and private entities and informal groups delivering or supporting waste services at all levels of production and consumption. This sector employs a wide range of methods for collecting, handling, storing, transporting, treating, and disposing of waste, and recovering materials and energy-from-waste, including developing laws, policies, infrastructure, and technologies, and undertaking activities and operations. Solid waste management is a public benefit; however, inadequate management has the potential to cause environmental pollution and can affect the health, safety, and quality of life of workers and communities. For example, decomposing organic waste attracts disease vectors such as insects, rats, and other vermin, and the products of decomposition can leach into the ground and watercourses, making them polluted and no longer safe; open burning of waste leads to air pollution; and improper handling of hazardous materials can lead to both acute and long-lasting risks to public health and the environment. Solid waste treatment and disposal also are major contributors to the greenhouse gas (GHG) emissions that are causing global climate change,

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[2] UNEP. 2024. "Global Waste Management Outlook 2024: Beyond an age of waste - Turning rubbish into a resource." Nairobi. https://wedocs.unep.org/20.500.11822/44939.
[3] Note that this SEG makes reference to "tons," which refers to US short tons. This differs from metric tonnes as 1 metric tonne = 1.1 U.S. short tons.
[4] World Bank. 2018. What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050. https://openknowledge.worldbank.org/entities/publication/d3f9d45e-115f-559b-b14f-28552410e90a.

principally through patterns of resource use, transportation, and direct emissions from waste decomposition in landfills. Post-consumer waste is estimated to account for about 5% (equivalent to 1.76 billion tons [1.6 billion metric tonnes] of carbon dioxide [CO_2] equivalent) of total annual global GHG emissions.[5]

In developing countries, technical and financial resources limitations can adversely influence solid waste management practices, magnifying the associated risks to public health and the environment. In many areas of developing countries, organized waste management activities can be extremely limited, leading to extensive littering of public areas, uncontrolled dumpsites and landfills, open burning of waste, and little differentiation between domestic and hazardous waste. High population growth and increased consumption of single-use products in urban areas can put intense pressure on available waste management infrastructure and resources and, in the worst affected areas, this situation may create near intolerable conditions for communities.

Informal participation (i.e., unofficial employment and economic activity) also makes a significant contribution to waste management in many countries, including “picking” or “reclaiming” recyclables at households, businesses, in streets, and at dumpsites or landfills, and in waste collection/carting, trading, and reprocessing.[6, 7] Many marginalized and underrepresented groups and/or people in vulnerable situations are dependent upon these activities for their livelihoods and they make an important contribution to the sector, reducing costs for public authorities; however, they also can be associated with economic insecurity, social problems in a local community (e.g., people who scavenge in a quiet residential area for solid waste items that have a monetary value may cause debris to fall on the floor unintentionally, which, in turn, may interrupt the formal sector’s solid waste management process), and inadequate health and safety provision.[8] Any action affecting the informal sector can have a wide range of social, political, and economic implications. For example, due to a lack of “formal data” and recordkeeping, public authorities sometimes fail to recognize the role of informal workers in waste management systems, leading to a loss of livelihoods in the process of modernization. Therefore, more data may be needed to assess the extent of the informal sector as part of waste planning activities. The informal sector also can represent a significant resource if incorporated into waste projects and programs, and this should not be overlooked.

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[5] World Bank. 2018. What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050. https://openknowledge.worldbank.org/entities/publication/d3f9d45e-115f-559b-b14f-28552410e90a

[6] Scheinberg et al. (2010) define the informal solid waste sector as “"individuals or enterprises who are involved in private sector recycling and waste management activities which are not sponsored, financed, recognized, supported, organized or acknowledged by the formal solid public waste management authorities, or which operate in violation of or in competition with formal authorities.”

[7] This activity is also widely referred to as “scavenging”; however, the term can have derogatory connotations.

[8] The number of informal waste workers is difficult to calculate with accuracy as they are largely undocumented and difficult to generalize. However, it is estimated that there are between 5 million and 56 million people worldwide working in the informal sector in waste management. (Ramusch et al., 2013)

International trade in wastes, including recyclables, e-waste, and hazardous materials, also can place an increased burden on the environment and infrastructure of developing countries.[9] Developing countries often lack the ability to adequately manage imported solid waste, and a substantial amount is also illegally diverted to unregulated markets where treatment and disposal occurs in the informal sector, both of which can cause significant environmental pollution and public health risks. Widely cited examples include ship-breaking (i.e., the dismantling and scrapping of large commercial vessels) in Bangladesh and e-waste processing in West Africa. Although the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal prohibits international trade in hazardous waste that does not comply with its strict environmental regulatory system, such practices are widely reported in the international media, particularly in relation to the trade in e-waste (see Section 2.7 *Waste from Electrical and Electronic Equipment*).

Given the above issues, there are significant opportunities for improving solid waste management in developing countries. Priorities for sustainable waste management systems include minimizing or eliminating uncontrolled dumping and burning of waste; providing proper treatment and disposal of non-hazardous and hazardous waste; reducing health and safety risks, as well as social and economic vulnerability, for the public, workers, and the informal sector; maximizing the recovery of energy and resources; and providing efficient, effective, and inclusive services for all. Key principles for developing and implementing sustainable waste management systems include the following:

- **The Proximity Principle:** Waste should be managed close to where it originates.

- **The Polluter Pays Principle:** The producer should pay the full cost of managing waste sustainably, as well as the cost of managing any associated environmental impacts.

- **The Waste Hierarchy:** The priority by which resources should be managed to reduce waste from the most sustainable to the least sustainable waste management practices (see Section 3.2 *Waste Reduction and the Waste Hierarchy*).

The provision of sustainable waste management systems requires building the capacity of public waste management authorities; investing in infrastructure; supporting the private sector; and the development and implementation of robust laws, regulations, and standards. Investments in solid waste management systems should be integrated in line with strategic plans and based on robust data and the assessments of risk, cost-benefit, social return on investment, environmental and social impacts, sustainability, life-cycle analysis (LCA) and others, as necessary.

1.3 USAID INTERVENTIONS IN SOLID WASTE MANAGEMENT

USAID's development and humanitarian interventions targeting the solid waste management sector help public authorities and communities in the developing world to improve the capacity, systems, and infrastructure needed to manage solid waste through financial and technical

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[9] Trade in hazardous waste includes such wastes originating in developed countries, where strict regulations incentivize generators to take advantage of looser regulations and lower costs in developing countries. However, a significant amount of waste trade is among developing countries.

assistance and partnerships. Although USAID does not categorize waste management as a “technical sector” per se, such projects, programs, and activities contribute to development objectives across all sectors through improvements to public health, the environment, livelihoods, and resource conservation, as well as the mitigation of climate change risks and improved resilience to disasters.

USAID interventions could include the following:

- Strengthening local actors through capacity-building activities for public authorities and services providers.
- Developing and implementing policy and guidelines and improving regulatory enforcement.
- Raising awareness of issues and encouraging behavioral change in communities and businesses.
- Developing and testing/piloting of locally appropriate, innovative waste management technologies and processes and approaches to minimization, reuse, recycling, and waste management.
- Improving communication and coordination among government institutions, civil society, researchers, and private sector entities.
- Promoting social inclusion in solid waste management by engaging groups that are underrepresented in local power structures, such as women, youth, and informal waste workers.
- Undertaking applied research to identify locally appropriate technology and improve decision-making, gaps, or obstacles in solid waste management systems.
- Enabling the private sector and markets to develop and implement market-driven solutions, and facilitating new partnerships, including between the public and the private sector.

Illustrative examples of USAID waste interventions:

- The Clean Cities, Blue Ocean Program aims to reduce plastic pollution in the oceans, directly at its source, in more than 25 cities in Asia, the Pacific Islands, Latin America, and the Caribbean.[10]
- The Municipal Waste Recycling Program to Reduce Plastics Pollution of the Oceans in Indonesia, The Philippines, Sri Lanka, and Vietnam.[11]
- Facilitating the privatization of solid waste management services in Egypt.[12]

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[10] USAID. n.d.(a). Clean Cities, Blue Ocean. Accessed 2024. https://urban-links.org/project/ccbo/.https://urban-links.org/project/ccbo/.
[11] USAID. 2018a. "Municipal Waste Recycling Program (MWRP) to Reduce Plastics Pollution of the Ocean - Indonesia, Philippines, Sri Lanka, and Vietnam." Annual Program Statement. https://www.usaid.gov/sites/default/files/2022-05/MWRP_APS_as_Amended_2018_01.pdf.
[12] USAID. n.d.(b). "Privatizing Solid Waste Management Services Challenge." Case Study. https://www.usaid.gov/sites/default/files/success/files/cs_egypt_waste.pdf.

- Capacity-building, including the provision of a waste strategy, implementation plans, and training for public authorities under the Government of Armenia support program.[13]
- Community-Based Solid Waste Management programs in Indonesia under the Environmental Services Program and in Mozambique under the Coastal City Adaptation Project.[14, 15]

[13] Vanoyan, Mayis, Armen Varyosyan, and Armine Petrossian. n.d. "Solid Waste Management in Armenian Cities." USAID. https://www.pf-armenia.org/sites/default/files/uploads/pfa_uploads/tasima15_beitrag_USAID_2010_08-26.pdf.
[14] USAID. 2022a. GlobalWaters.org. https://www.globalwaters.org/HowWeWork/Activities/environmental-.
[15] USAID. 2015. "Coastal City Adaptation Project Initial Environmental Examination." Approval Fact Sheet. https://ecd.usaid.gov/repository/pdf/43811.pdf.

2. SOLID WASTE TYPES AND STREAMS

What constitutes a solid waste is generally determined by host country legislation or, in the absence of a legal definition, a relevant internationally accepted definition; however, it usually includes solid or semi-solid materials that have been discarded (i.e., abandoned), disposed, stored in lieu of being disposed, or are "inherently waste-like." Solid waste can be further classified by the overlapping categories of origin, constituent materials, and methods of management. For this SEG, descriptions of common categories of solid waste are provided below. It should be noted that these categories are not rigidly defined, mutually exclusive, or comprehensive, and may vary according to local conventions or regulations.

2.1 MUNICIPAL SOLID WASTE

Municipal solid waste (MSW) is solid waste generated by households, businesses, and public institutions (e.g., schools, ministries, government offices); litter and refuse collected from street cleaning services; gully detritus; and beach cleansing. MSW is normally collected by municipal authorities but also can be undertaken on their behalf by the private sector (e.g., business or private nonprofit institutions).[16] MSW sometimes includes bulky waste but excludes wastewater from municipal sewage networks and construction and demolition waste. Household hazardous waste may (or may not) be included; however, industrial and other hazardous waste is not included. Waste generated at the household level is often referred to as "residential" or "domestic" waste.

The composition of MSW is highly variable and is influenced by many factors. Urbanization and development lead to increased consumption of inorganic materials (such as plastics and metals), while the relative organic fraction decreases. According to the World Bank, developing countries have a high percentage of organics in the waste stream, ranging from 40% to 85%.[17]

In 2016, high-income countries, although they only made up 16% of the world's population, accounted for the greatest portion of generated MSW (34%). In contrast, low-income countries made up 9% of the world's population but generated only about 5% of global waste. The East Asia and Pacific region was the largest generator of MSW, producing 516 million tons in 2016[18]. As of 2024, MSW production in the East and South-East region has grown to 628 million tons, with the region still generating the largest amount of MSW[19].

UNEP estimates that the average per capita generation of MSW in 2024 is 0.75 kg of waste per capita per day; however, this varies widely by location from 0.4 to 2.3 kg per capita per day. Generation rates are highly correlated with economic development. Sub-Saharan Africa averages 0.5 kg per capita per day, Central and South Asia averages 0.4 kg per capita per day,

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[16] See glossary.
[17] World Bank. 2018. What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050. https://openknowledge.worldbank.org/entities/publication/d3f9d45e-115f-559b-b14f-28552410e90a.
[18] World Bank. 2018. What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050. https://openknowledge.worldbank.org/entities/publication/d3f9d45e-115f-559b-b14f-28552410e90a.
[19] UNEP. 2024. "Global Waste Management Outlook 2024: Beyond an age of waste - Turning rubbish into a resource." Nairobi. https://wedocs.unep.org/20.500.11822/44939.

and East and South-East Asia averages 0.7 kg per capita per day, compared with 2.3 kg per capita per day in the high-income countries of North America.[20]

As previously noted, MSW generation is expected to rise to 4.2 billion tons by 2050 in the business-as-usual scenario, with much of this growth coming from low- and lower middle-income countries due to rapid population and economic growth. In Sub-Saharan Africa, Central and South Asia, and East and South-East Asia, for example, waste generation in 2050 would be roughly twice as high as 2020 levels in this scenario.[21]

In most parts of the world, it is the role of public authorities (e.g., municipalities) to collect and manage MSW, and the costs of this service often account for a considerable proportion of their budgets. In some cases, private haulers are contracted to collect the waste or implement treatment/disposal. However, services are often sporadic, leading to informal dumpsites, open burning, and litter. Materials that have value are generally removed by informal waste pickers prior to disposal or after disposal at landfills and dumpsites.

2.2 COMMERCIAL AND INDUSTRIAL WASTE

Commercial and industrial waste are part of the MSW stream and are often grouped together; however, there are key differences in composition and characteristics between them. Both are highly variable and can be grouped into many subcategories.

Commercial waste is generated from a wide range of sources, including offices, retail, hotels, restaurants, markets, and other light industries. Construction, demolition, and excavation (CDE) waste and agricultural waste are also sometimes considered to be commercial waste, although these are usually managed separately. The composition of commercial waste depends on the source. Markets and supermarkets produce large quantities of organic waste and corrugated cardboard, whereas waste from offices usually includes high-quality paper and plastics. Some commercial activities generate small quantities of hazardous waste, such as laundries and vehicle servicing/repair shops.

Industrial waste is typically produced by manufacturing activities and heavy industry (e.g., power stations, processing plants). The composition of the waste stream is dependent upon the industry or individual facility (e.g., vegetable waste from a food preparation factory, metal shavings from an engineering plant, and a wide range of metal, plastic, and chemical waste from automotive manufacturing). Many industrial processes have specific waste and byproducts, some of which require special treatment due to their properties (e.g., hazardous, bulky), while others are readily recycled or reused as they have economic value (e.g., waste vegetables for animal feed, waste metals for reprocessing, wooden pallets for reuse) and because quality and reliability are easier to control. Industrial waste also may be treated on-site (e.g., incineration or anaerobic digestion of homogenous feedstocks for power generation).

[20] UNEP. 2024. "Global Waste Management Outlook 2024: Beyond an age of waste - Turning rubbish into a resource." Nairobi. https://wedocs.unep.org/20.500.11822/44939.
[21] UNEP. 2024. "Global Waste Management Outlook 2024: Beyond an age of waste - Turning rubbish into a resource." Nairobi. https://wedocs.unep.org/20.500.11822/44939.

Certain types of waste may be suitable for beneficial uses, such as fertilizers (e.g., brewery waste); however, this should be subject to strict regulatory control.

2.3 AGRICULTURE, FISHING, AND FORESTRY WASTE

Agriculture, fishing, and forestry waste come from a branch of manufacturing and trade based on the growing and harvesting of organic commodities. This includes the production of agricultural crops and livestock; agro-industrial production; hunting, trapping, and fishing; fish farming; and forestry. Lumber and wood products may not be included if they are classified as an industrial or a commercial waste. Agriculture, fishing, and forestry produce significant quantities of organic waste (e.g., manure/slurry, crop biomass, animal remains), potentially hazardous chemical waste (e.g., herbicides, pesticides, fertilizers and ripeners), and used oil.

Organic waste can often be managed effectively where it is produced. Applying animal manure and crop residue on land to improve soil is practiced worldwide. Regulating where, when, how, and how much manure is added to the land at one time reduces the risk of nutrient-rich materials contaminating surface water or groundwater. The reuse of animal waste can be linked to disease outbreak (e.g., contaminated animal feed from waste causing Foot and Mouth Disease). The movement of agriculture and forestry waste also may need to be controlled to prevent the spread of pests and tree diseases.

Agricultural waste supplies a sizable proportion of the total biofuel used in developing countries. Dried animal dung and crop products are an important fuel for cooking or heating in many areas. However, uncontrolled burning in homes can lead to serious health effects. On-farm composting and anaerobic digestion of organic waste can provide financial benefits for producers from use or sale of products. For example, in the dairy industry, manure from cows can be digested and the produced biogas can then be used to power milking sheds. Although such systems can be capital intensive, many opportunities exist for smallholders and cooperatives to use residual products for waste-to-energy and composting (e.g., the utilization of crop residues instead of burning them in fields, which is common in many rural areas).

Despite the persistence of food insecurity in some regions, more than a third of total food production is wasted globally. As agricultural production in developing countries becomes commercialized, food production industrialized, and consumption patterns intensified, food losses and waste are likely to become a more significant issue.

2.4 CONSTRUCTION, DEMOLITION, AND EXCAVATION WASTE

Construction, demolition, and excavation (CDE) waste arises from activities related to the construction or demolition of buildings and infrastructure, infrastructure maintenance, and spoils from civil engineering works. CDE waste includes materials such as excavated soils, bricks, insulation, ceramics, glass, wood, and sand aggregates, which have high potential for reuse and recycling, and technology for the recovery of CDE waste is well established. Aggregates are increasingly used in construction (e.g., as an additive in concrete or as a road base) and the beneficial use of uncontaminated excavation waste as fill material can lead to significant cost savings on construction projects.

Other materials generated during construction include empty containers and packaging (e.g., from chemicals, paints and fuels, cement packaging), and used formwork, pallets, and oily rags, which may be tainted with hazardous materials. Increasingly, plastics (e.g., polyvinyl chloride [PVC]) and composite materials are used in construction, some of which may be difficult to recycle. Demolition waste can contain a range of materials, which could include hazardous materials such as asbestos, decommissioned chemical or fuel tanks, and lead. Excavated soils may be contaminated, depending on previous site or upstream usages (e.g., hydrocarbons at a vehicle depot), or from natural sources (e.g., naturally occurring radioactive materials).

Construction consumes a sizable proportion of available raw materials, including virgin wood, sand aggregate, and other building materials. Many environmental and social impacts occur from the extraction of these materials, especially where they are scarce or form sensitive habitat. Transportation of waste is often expensive and can have significant effects on traffic and the road network due to the large mass and volume of materials. Furthermore, transportation of waste contributes to GHG emissions. CDE waste disposed of in landfill occupies valuable airspace and increases the use of new and virgin materials. Consequently, there is a growing drive to manage resources more effectively and reduce costs in the construction sector by reducing CDE waste generation and increasing reuse and recycling.

In developing countries, the high cost of building materials compared with labor can serve as an incentive to reduce waste. However, the management of waste is sporadic, with materials often illegally dumped. Legislation, penalties, pricing controls and effective enforcement, and the availability of formal collection and disposal systems may be required to control illegal dumping of CDE waste.

CDE is often a major source of the total waste requiring management, particularly in growing urban areas. Therefore, there is a need to reconcile economic progress with sustainable construction and demolition waste management.

2.5 HAZARDOUS WASTE

Although the definition of "hazardous waste" will depend on the host country's legislation, in general, hazardous waste has properties that make it dangerous or capable of having a harmful effect on human health or the environment. Hazardous waste is generated from many sources, ranging from industrial process byproducts and mining waste to batteries and common household cleaners, and can come in different forms, such as solids, liquids, and sludge (United States Environmental Protection Agency [EPA]).[22] US law categorizes hazardous waste based on it having one or more of the following characteristics:

- **Ignitability:** It is flammable.
- **Corrosivity:** It can eat away its container or has a pH that is less than or equal to 2 or greater than 12.5.

[22] US EPA. 2024b. Hazardous Waste. https://www.epa.gov/hw.

- **Reactivity:** It is unstable, potentially explosive, or can release toxic gases or result in violent explosions when mixed with water.

- **Toxicity:** Toxic materials are those that are poisonous and can potentially have long-term effects on human health and the environment. Some toxic materials can cause cancer as a result of long-term exposure.

In some countries, waste can be predefined or listed as hazardous if it is a byproduct associated with a specific industry or manufacturing process or contains particular chemical elements or compounds.

Examples of hazardous waste include asbestos, chemicals such as brake fluid or printer toner, batteries, solvents, pesticides, oils (except edible ones), equipment containing ozone-depleting substances (e.g., refrigerators), and hazardous waste containers. Hazardous materials will normally be present in small quantities in MSW; however, significant volumes can be generated from industrial activities, construction, demolition, contaminated land remediation, mining, and agriculture.

Hazardous waste can cause significant environmental pollution and risks to public health and must be managed appropriately using trained/qualified personnel, licensed or registered contractors, and appropriate equipment and facilities. Each waste will need to be identified, classified, stored, and either recycled, recovered, treated, destroyed, or disposed of using the appropriate specialized methods. In developing countries, the management of hazardous waste is often deficient, with such materials being disposed of with MSW at landfills and dumpsites. Disposal of hazardous waste on land without detailed knowledge of the waste can significantly increase the risks to public health and the environment. The introduction, management, and enforcement of a regulatory process that tracks waste from the producer to final disposal is an important aspect of managing hazardous materials effectively.

2.6 HEALTHCARE WASTE

Healthcare waste (HCW) includes all the waste generated within healthcare facilities, research centers, and laboratories. Approximately 85% of the waste produced by healthcare providers is considered nonhazardous or general waste. The remaining 15% of HCW is regarded as hazardous[22].

Nonhazardous waste, also known as non-infectious, non-toxic, or non-radioactive waste, does not require special handling. It includes items such as packaging, unwanted paper, and food waste.

Hazardous waste includes infectious, sharp, pathological, pharmaceutical, and chemical waste. It must be specially treated and disposed of to prevent adverse impacts on human health and the environment.

Pharmaceutical waste is a growing source of water pollution as pharmaceutical chemicals entering domestic sewers can bypass municipal wastewater treatment systems and enter the environment via the discharge and reuse of effluents. The introduction, management, and enforcement of a regulatory process that tracks the waste from the producer to the ultimate point of disposal is an important feature for managing medical and healthcare waste effectively.

The USAID Healthcare Waste SEG (2024 Partial Update) has additional details on healthcare waste impacts and mitigation options.[23]

2.7 WASTE FROM ELECTRICAL AND ELECTRONIC EQUIPMENT

Waste from electrical and electronic equipment (WEEE, or e-waste) covers a range of equipment containing electrical parts (e.g., they require an electrical source to operate), which has come to the end of its useful life. Examples of WEEE include used white goods (e.g., refrigerators, washing machines), kitchen appliances, power tools, air conditioning units, TVs, mobile phones, lighting and lightbulbs, and many other devices. Other less obvious items, such as electrical cables, radio-frequency identification (RFID) tags, batteries, and solar panels, may (or may not) be included in the definition, depending on the applicable regulations. The quantity of WEEE generated is increasing in most regions due to the growing consumption of electronic products, particularly in the urban areas of developing countries with fast-growing economies.

WEEE can contain hazardous materials such as heavy metals, batteries, and persistent organic pollutants, which can be released to the environment if not appropriately handled and managed. WEEE also includes materials that can be profitable when recovered, including small quantities of precious and rare earth metals, as well as plastic, metals, and glass. The recovery of these materials can present economic opportunities and is widely carried out in developing countries such as China, India, Ghana, and Nigeria. In some developing countries, much of the WEEE recycled is managed in the informal sector or in small-scale reprocessing facilities. Technical, environmental, and infrastructure conditions in such countries are often highly inadequate.[24] The environmental and social consequences are well publicized in the international media.[25, 26]

According to the World Health Organization, in 2019, some 59 million tons of electronic and electrical waste (e-waste) were generated worldwide. This represented a 21% increase over the previous five years. Only about 17% of the 59 million tons reached formal recycling or waste management systems. The remainder was either disposed of illegally or recycled by informal workers at domestic or international locations. Global e-waste generation is projected to increase to more than 82 million tons by 2030.

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[23] USAID's Healthcare Waste SEG can be found on USAID's Sector Environmental Guidelines & Resources page, located at https://www.usaid.gov/environmental-procedures/sectoral-environmental-social-best-practices/sector-environmental-guidelines-resources.

[24] Perkins, Devin N., Marie-Noel Brune Drisse, Tapiwa Nxele, and Peter D. Sly. 2014. "E-Waste: A Global Hazard." Annals of Global Health 80 (4): 286-295. https://www.sciencedirect.com/science/article/pii/S2214999614003208.

[25] The Guardian. 2014. "Agbogbloshie: The World's Largest E-Waste Dump-In Pictures." https://www.theguardian.com/environment/gallery/2014/feb/27/agbogbloshie-worlds-largest-e-waste-dump-in-pictures.

[26] Ellis-Petersen, Hannah. 2018. "Deluge of electronic waste turning Thailand into 'world's rubbish dump'." The Guardian. https://www.theguardian.com/world/2018/jun/28/deluge-of-electronic-waste-turning-thailand-into-worlds-rubbish-dump.

Based on informal waste worker estimates worldwide (between 12.5 and 56 million people) and women laborer estimates in the industrial sector (23% of the workforce), between 2.9 and 12.9 million women may be at risk from toxic e-waste exposure as informal waste sector workers.

Despite regional and international agreements related to sound, cradle to grave e-waste management, including the Basel Convention and the Stockholm Convention on Persistent Organic Pollutants, transport of e-waste from some high-income countries to some low-income countries remains high. Consequently, United Nations agencies, programs, and experts have called for stronger actions based on the growing threat that improperly managed e-waste represents to human health and the environment.[27]

Some developing countries have introduced legislation for proper management of WEEE; however, compliance and enforcement are usually low. Improving the management of WEEE in developing countries requires the development of a robust legislative and regulatory framework, infrastructure, and management systems based on the principle of Extended Producer Responsibility,[28] as well as engagement with the private and informal sectors.

US EPA works with international governments and intragovernmental agencies to support the US Government's National Strategy for Electronics Stewardship, which plans to enhance the management of electronics throughout the product life cycle, and to exchange best management practices in e-waste management (see Box 1).

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[27] World Health Organization. n.d. E-waste and children's health. https://www.who.int/teams/environment-climate-change-and-health/settings-populations/children/e-waste.

[28] The producer, importer, or seller is responsible for appropriate handling of equipment throughout its life cycle, including post-consumer recycling and final disposal.

USAID developed the Managing Electronic Waste in USAID Activities Factsheet to provide an overview of WEEE and a guide on how to best manage WEEE at the activity level in developing countries.

BOX 1. CASE STUDY: US EPA PARTNERS WITH DEVELOPING COUNTRIES TO PROMOTE SUSTAINABLE E-WASTE MANAGEMENT

Cleaning Up Electronic Waste (e-Waste)

In support of the goals of the National Strategy for Electronics Stewardship, US EPA works with partners in Asia/Pacific, Latin America and the Caribbean, the Middle East, and Africa to develop and support projects on the sustainable management of e-waste. In Africa, EPA is engaged in numerous partnerships, including in the following:

Ethiopia: Through cooperation with the United Nations University Solving the e-Waste Problem (UNU-Step), EPA worked in Ethiopia with government officials, as well as industry and nongovernmental organization stakeholders, to strengthen the capacity of a de-manufacturing facility that can safely recycle end-of-life used electronics.

Nigeria: In 2015, the UNU-StEP Initiative, with financial support from EPA and the German Senior Expert Service, launched a Person-in-the Port (PiP) Project in Lagos, Nigeria. Through the PiP Project, a Nigerian e-waste expert collected qualitative and quantitative information on imports of electronics into the Port of Lagos over a period of 6 months. This effort could serve as a model for countries with e-waste import problems that wish to gain a better understanding of the flows of used electronics and e-waste.

Source: US EPA. 2024a. *EPA Collaboration with Sub-Saharan Africa.* https://www.epa.gov/international-cooperation/epa-collaboration-sub-saharan-africa.

2.8 FECAL WASTE AND SEWAGE SLUDGE

Management and disposal of fecal waste from humans and treated sewage sludge is a key issue in areas where sanitary infrastructure is inadequate.[29]

[29] Please refer to the USAID Water Supply and Sanitation SEG, which can be found on USAID's Sector Environmental Guidelines & Resources page, located at https://www.usaid.gov/environmental-procedures/sectoral-environmental-social-best-practices/sector-environmental-guidelines-resources..

2.8.1 HUMAN AND ANIMAL WASTE

Pit latrines, septic tanks, and unsewered public toilets or open defecation give rise to human fecal waste that can cause localized pollution and represent a significant risk to public health. Despite considerable progress, in recent times, only around 39% of the world's population has access to safe sanitation, while 12% still practice open defecation.[30] Fecal waste also is used by farmers as fertilizer for crops, which risks spreading pathogens on land, water, and the food chain. Human waste also can enter the MSW stream, where both waste and wastewater management systems are underdeveloped, leading to significant cross-contamination. Conversely, when domestic waste collection services are unavailable, solid waste is often disposed of in latrines or wastewater infrastructure (up to 25% of pit latrine content by volume may be solid waste).

Management of human waste requires safe storage, collection, transport, treatment, and end use or disposal of sewage to protect public health and the environment. Critically, open defecation should be eliminated, where possible, and proper sanitary systems developed.[31] Where human waste needs to be recovered from latrines and unsewered toilets, this should be done using appropriate equipment (e.g., vacuum tanker) and the waste should be disposed of at a municipal sanitary facility.

2.8.2 SEWAGE TREATMENT SLUDGE

Sewage sludge is generated as a byproduct of wastewater treatment. It is often used as a soil conditioner in developed and developing countries. Similar considerations must be given to fecal waste to ensure that it is suitably treated before its end use or disposal.

When properly managed, sewage sludge has the potential for reuse and resource recovery. However, if this is not feasible or cost effective, incineration or disposal in landfills also are potential management options. When designing fecal waste management systems, the end use or disposal option of sludge should first be determined so that the treatment can be designed accordingly. In many developing countries, the status of sanitation systems is inadequate. Therefore, the focus in the short term should be on critical interventions that have an immediate impact on human health and environmental protection. In the long term, markets for resource recovery and reuse products can be developed.

2.9 PLASTIC WASTE

Plastic waste forms a relatively substantial proportion (up to around 20%) of household waste in many urban areas of developing countries. Many developing countries import post-consumer plastics from other countries for reprocessing, most of which end up as waste. In the absence of proper waste management systems, much of the plastic waste is improperly disposed of in informal dumpsites or as litter. Because they are uncontained, most plastics eventually end up

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[30] WHO/UNICEF Joint Monitoring Program (JMP) for Water Supply, Sanitation and Hygiene. 2022. People Practicing open defecation (% of population). https://data.worldbank.org/indicator/SH.STA.ODFC.ZS.

[31] Please see the USAID Water Supply and Sanitation SEG, which can be found on USAID's Sector Environmental Guidelines & Resources page, located at https://www.usaid.gov/environmental-procedures/sectoral-environmental-social-best-practices/sector-environmental-guidelines-resources

in watercourses and the ocean, washing up on river banks and beaches and affecting ecologically sensitive areas such as coral reefs. This is a major and persistent problem for many developing countries. The Organization for Economic Cooperation and Development (OECD) estimates that the life-cycle emissions of plastics in 2019 was 1.8 billion tonnes of CO_2 equivalent, accounting for approximately 3.3% of global emissions, with around 90% coming from the production stage.[32] Other studies estimate that plastics are responsible for approximately 4.5% of global GHG emissions.[33]

As illustrated in the case study provided in Box 2, local entrepreneurial initiatives with international development support, such as Environmental Cleaning Solutions S.A. in Haiti, can play a key role in preventing and cleaning up plastic waste while supporting local employment and potentially reducing GHG emissions from plastic waste as well. While most USAID waste activities are centered around plastic waste, improvements in the prevention and handling of plastic waste also can benefit other waste streams.

BOX 2. CASE STUDY: PREVENTING PLASTIC WASTE THROUGH ENTREPRENEURSHIP IN PORT-AU- PRINCE, HAITI[34]

Haiti has been struggling with ever increasing quantities of untreated waste, including plastic waste, which is polluting the streets, parks, rivers, and the ocean. The plastic is clogging sewage systems, especially in the capital, Port-au-Prince, causing additional environmental concerns.

In 2010, Edouard Carrié, a Haitian entrepreneur, created a recycling business, Environmental Cleaning Solutions S.A. (ECSSA) to keep the streets, canals, and vacant lots of Port-au-Prince clean, as well as to provide income to Haiti's poorest households. The scheme provides cash to people depositing bags of discarded plastic bottles at 65 collection points throughout the Port-au-Prince region. In 2012, ECSSA collected, compacted, and shipped nearly 300 million bottles, close to 1 million bottles every day, for further processing into recycled plastic pellets that are used in more than 120 countries to make everything from T-shirts to tables.

To raise capital for the next phase of business expansion, Carrié applied for a matching grant through the Leveraging Effective Application of Direct Investments (LEAD) Business Plan Competition, funded by USAID and implemented by the Pan American Development Foundation (PADF). Carrié says that "*USAID and PADF's LEAD investment is allowing ECSSA to ramp up collection and provide more Haitian households with the opportunity to earn income. My company now has the capacity to increase its individual collectors from 6,000 people to up to 20,000. Additionally, the increase in collection points and processing capacity provide entrepreneurs the opportunity to grow their own businesses by serving as intermediary plastic collectors and suppliers for ECSSA*."

The use of plastics has consistently grown over the past 50 years, from 1.6 million tons per year in 1950 to more than 355 million tons per year in 2015.[35] Within this timeframe, it is estimated that,

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[32] Ritchie, Hannah. 2023. How much of global greenhouse gas emissions come from plastics? https://ourworldindata.org/ghg-emissions-plastics.

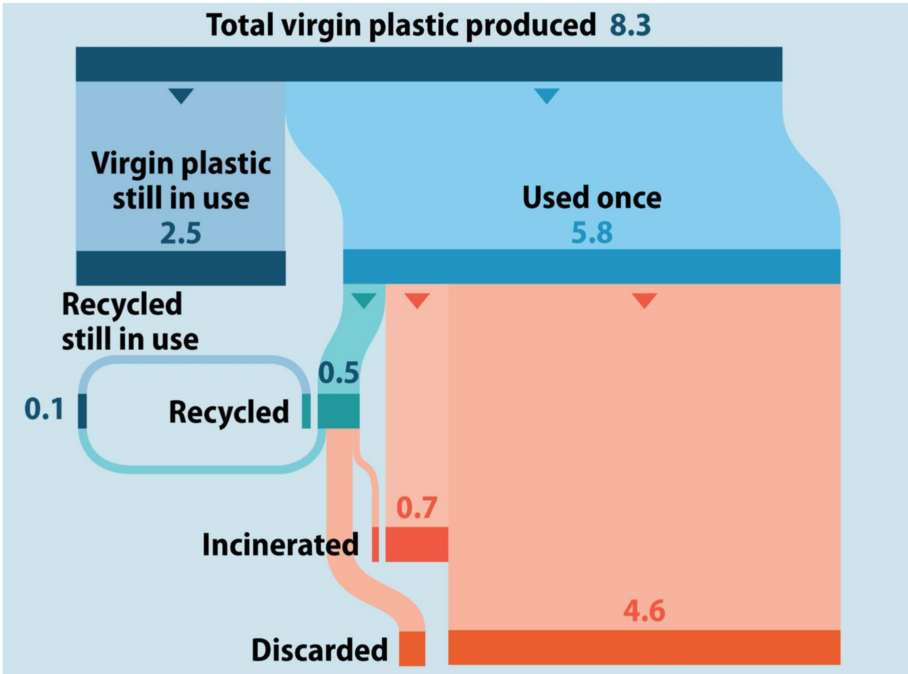
[33] Stegmann, Paul, Vassilis Daioglou, Marc Londo, Detlef P. van Vuuren, and Martin Junginger. 2022. "Plastic futures and their CO2 emissions." Nature 272-276. https://www.nature.com/articles/s41586-022-05422-5.

[34] USAID. 2017a. "Generating Income While Keeping Streets Clean in Haiti." https://2012-2017.usaid.gov/results-data/success-stories/generating-income-while-keeping-streets-clean-haiti.

[35] Association of Plastics Manufacturers. 2017. *Plastics - the Facts 2017*. PlasticsEurope. https://plasticseurope.org/wp-content/uploads/2021/10/2017-Plastics-the-facts.pdf.

cumulatively, around 9.1 billion tons of plastic have been produced, most of which was used only once before being discarded, as illustrated in Figure 1.[36,37]

FIGURE 1. GLOBAL PLASTIC PRODUCTION AND USE, 1950-2015 (BN TONNES)[38]



Plastics recovered in the recycling programs of major economic centers, such as North America and Europe, established a system of shipping bales of sorted post-consumer plastics for reprocessing in developing countries—predominantly China, and to a lesser extent India, Vietnam, and Indonesia (where they are made into consumer products and often shipped back to the same markets). A sizable proportion of the material has been disposed of in their landfills or, due to poor regulatory, infrastructural, and environmental controls, has ended up polluting land and waters. Poor waste management, combined with the domestic production of plastic waste, means that the developing world is a major source of marine plastic pollution. According to a paper by the Helmholtz Centre for Environmental Research in 2017, up to 90% of the

[36] Geyer, Roland, Jenna R. Jambeck, and Kara Lavender Law. 2017. "Production, use, and fate of all plastics ever made." *Science Advances.* https://www.science.org/doi/10.1126/sciadv.1700782.
[37] UFZ. 2017. "Rivers carry plastic debris into the sea." https://www.ufz.de/index.php?en=36336&webc_pm=34/2017.
[38] The Economist. 2018. *The known unknowns of plastic pollution.* https://www.economist.com/international/2018/03/03/the-known-unknowns-of-plastic-pollution. adapted from Geyer, Roland, Jenna R. Jambeck, and Kara Lavender Law. 2017. "Production, use, and fate of all plastics ever made." Science Advances. https://www.science.org/doi/10.1126/sciadv.1700782.

estimated 11 million tons per year of marine plastic pollution is said to reach the ocean via 10 rivers, 2 of which are in Africa and the rest are in Asia.[39]

When dispersed by ocean currents, plastics are difficult to retrieve and can be found everywhere, from the remote shores of uninhabited islands, in Arctic ice, the deep ocean, and in vast areas of ocean waste fed by currents. Plastics do not decompose like organics and accumulate in the environment for many hundreds or thousands of years. Instead, salt, sunlight, and physical action cause plastics to degrade into smaller and smaller pieces, eventually becoming microplastics.[40]

The harmful effects of plastic on aquatic organisms include physical hazards from ingestion and entanglement and toxicological threats from the ingestion of contaminants in plastic particles. It is estimated that 17% of species affected by plastic marine debris are on the International Union for Conservation of Nature Red List of Threatened Species.[41] Furthermore, research indicates that half of sea turtles worldwide have ingested plastic, up to a million seabirds are killed each year from plastic waste, and corals that come into contact with plastic have an 89% chance of contracting disease, compared with a 4% likelihood for corals that do not have such contact.[42]

A 2020 Joint Initiative on Sustainable Humanitarian Assistance Packaging Waste Management (a collaborative effort co-led by USAID and the United Nations [UN] Environment/Office for the Coordination of Humanitarian Affairs' Joint Environment Unit) begins to address the need for more sustainable packaging building "a greater understanding of the packaging waste challenge among the humanitarian sector and brings stakeholders together to find and implement creative, collective solutions."[43] The Joint Initiatives program is based on circular economy principles and intends to mobilize partner organizations to reduce packaging waste by (1) reducing the problem at the source, (2) looking for ways to reuse and repurpose, and (3) developing new ways to manage packaging waste. The Environmental Emergencies Centre (EEC) Website provides additional information on management of packaging wastes.[44] The Environmental Emergencies Centre (EEC)Website provides additional information on management of packaging wastes.[45]

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[39] UFZ. 2017. "Rivers carry plastic debris into the sea." https://www.ufz.de/index.php?en=36336&webc_pm=34/2017.

[40] It is estimated that as much as 51 trillion microplastic particles are contained in the oceans, including degraded plastics, fragments of polyester caused by washing clothing, industrial spills, and microbeads intentionally added to consumer products (The Economist, 2018).

[41] Fava, Marta. 2022. Ocean plastic pollution an overview: data and statistics. UNESCO. https://oceanliteracy.unesco.org/plastic-pollution-ocean/.

[42] Reddy, Simon. 2018. "Plastic Pollution Affects Sea Life Throughout the Ocean." *Pew*. https://www.pewtrusts.org/en/research-and-analysis/articles/2018/09/24/plastic-pollution-affects-sea-life-throughout-the-ocean.

[43] USAID. 2020a. "Joint Initiative for Sustainable Humanitarian Packaging Waste Management." https://www.usaid.gov/sites/default/files/2022-05/Fact-sheet-Joint-Initiative-On-Sustainable-Humanitarian-Packaging-Waste-Management.pdf.

[44] The Environmental Emergencies Centre (EEC) website provides information on management of packaging wastes, located at https://eecentre.org/2019/07/15/https-www-eecentre-org-2019-07-15-sustainable-humanitarian-packaging-waste-management/.

[45] For additional information see: https://eecentre.org/2019/07/15/https-www-eecentre-org-2019-07-15-sustainable-humanitarian-packaging-waste-management/

2.10 OTHER WASTE

2.10.1 TIRES

Tires are produced in vast quantities globally and the safe and sustainable storage and disposal of end-of-life (EOL) tires are a significant issue. Up to four billion tires are estimated to be held in stockpiles and landfills.[46] In some developing countries, growing automobile use and waste tire imports from developed countries, coupled with poor management and illegal dumping, mean that this aspect of waste management requires urgent attention. For example, in Thailand, it has been estimated that up to 40% of EOL tires were dumped in the open environment in 2012.[47]

Tires degrade slowly, remaining substantially intact for decades, and have a large volume and void space so they can consume valuable space in landfills. Additionally, some of their components can release pollutants, such as zinc, chromium, lead, copper, cadmium, and sulfur, into the ground and waters as they degrade. They often are stored in large piles, which can cause fires that are difficult to control. Fires involving waste tires cause significant atmospheric pollution, which can be harmful to human health. GHG emissions also can result from the combustion of tires, from both the combustion process and the transportation of tires to the combustor.[48]

Landfilling of whole tires is banned in some countries (e.g., most states in the United States) and recycling is mandatory. Tires can be successfully recycled or recovered in several ways. The steel they contain can be removed and recycled, the tires can be combusted in a controlled manner for energy generation or shredded for reuse in new tires or road aggregate. Tire-derived fuels also are commonly used in cement kilns and other industrial processes.

2.10.2 WASTE OIL

Waste oil, such as spent engine oil, which has been removed from combustion engines during periodic maintenance, mineral oil, and waste cooking oil, is a valuable resource. Waste oil can be collected through interceptors in garages and storage tanks, which is normally contaminated with water and requires treatment for separation. These waste oils are typically recycled as a heating boiler fuel following filtering and analysis to ensure that their combustion would not cause pollution. Where the oils are too contaminated, they are typically burned for heating in more advanced systems, which can reduce/capture the pollutants produced. If the oils are heavily contaminated, they may be disposed of in an incinerator with the appropriate emission controls.

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[46] World Business Council for Sustainable Development. 2018. "Global ELT Management – A global state of knowledge on collection rates, recovery routes, and management methods." https://docs.wbcsd.org/2018/02/TIP/WBCSD_ELT_management_State_of_Knowledge_Report.pdf.

[47] World Business Council for Sustainable Development. 2018. "Global ELT Management – A global state of knowledge on collection rates, recovery routes, and management methods." https://docs.wbcsd.org/2018/02/TIP/WBCSD_ELT_management_State_of_Knowledge_Report.pdf.

[48] EPA. 2019. *Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM): Tires.* ICF, EPA Office of Resource Conservation and Recovery. https://www.epa.gov/sites/default/files/2019-06/documents/warm_v15_tires.pdf.

2.10.3 END-OF-LIFE VEHICLES AND SCRAP

End-of-life vehicles (ELVs) are vehicles such as cars, light commercial vehicles, trucks, buses, and mobile plants (e.g., off-road construction vehicles and equipment) that have come to the end of their useful life. Materials and components in ELVs have economic value, and typically around 80% or more can be salvaged for spare parts or recycled (mostly metals, rubber, glass, and plastics). ELVs also contain fluids (e.g., petrol and diesel fuels, oils, brake fluid, coolant, anti-freeze) and components (e.g., batteries, gearboxes, mercury switches, catalytic converters, airbags), which are hazardous or potentially polluting, and require special storage, handling, and disposal at appropriate facilities. Good practices during recovery include draining fluids and removing hazardous parts from ELVs in a covered hard-standing, then storing them in a separate dedicated and controlled area, prior to recovery or disposal at an appropriate facility (such as a double-lined landfill).

In developing countries, the recovery of ELVs usually takes place at small workshops and scrap yards or in the informal sector (e.g., at dumpsites). Governance issues and lack of resources mean that activities may take place using substandard processes and equipment in the absence of environmental controls and worker welfare provisions. In this situation, the recovery and disposal of ELVs can represent a significant risk to public health and the environment. Hazardous materials can leak directly into the ground during breaking, when abandoned, or when disposed of at uncontrolled dumpsites. The exposure of workers to hazardous materials and physical injuries due to poor health and safety provisions also can lead to occupational health and safety impacts for workers, while unregulated use of salvaged parts can cause traffic accidents.

Due to a growing population and increasing per capita ownership of vehicles, the requirements for the management of ELVs are rapidly expanding, leading to increasing pressure on public waste management authorities and environmental risks.

3. WASTE MANAGEMENT SYSTEMS: REDUCTION, REUSE, COLLECTION, SEGREGATION, RECYCLING, ENERGY RECOVERY, TREATMENT, AND DISPOSAL

Waste generation is increasing rapidly due to globalization, unsustainable consumption and production patterns, economic development, and population growth. UNEP estimates that the amount of MSW will rise from 2.3 billion tons per year in 2020 to 4.2 billion tons by 2050.[49] Its long-term forecast is for waste volumes to triple by the end of the century. The greatest proportion of the average annual increase will come from rapidly growing cities in developing countries. Urbanization also is resulting in increasing CDE waste being generated from the development of new buildings and infrastructure, as well as a greater number of waste tires and ELVs from an increasing number of vehicles and industrial waste from the growth in manufacturing.

Infrastructure for the managing and disposing of waste in some developing countries is often inadequate and developing new infrastructure is expensive. Budgetary and capacity constraints can affect the ability of waste authorities to respond to population growth and development by expanding and modernizing their waste systems and assets, leading to environmental and social consequences. Reducing the waste at the source, including difficult-to-manage waste such as hazardous waste, tires, and CDE waste, is therefore a vital strategy for reducing waste impacts under these circumstances.

3.1 WASTE REDUCTION AND THE WASTE HIERARCHY

Waste reduction typically sits at the top of the waste hierarchy in regulatory and planning frameworks, as shown in Figure 2.[50] This is because reducing waste saves natural resources, conserves energy, reduces pollution and GHG emissions, and saves money for consumers and businesses alike. Reducing the quantity of waste generated also lowers the demand for land, hazardous waste generation, and the associated waste management impacts (see Section 6 *Environmental Impacts* and Section 7 *Social Impacts*).

[49] UNEP. 2024. "Global Waste Management Outlook 2024: Beyond an age of waste - Turning rubbish into a resource." Nairobi. https://wedocs.unep.org/20.500.11822/44939.
[50] US EPA. 2020. *Best Practices for Solid Waste Management: A Guide for Decision-Makers in Developing Countries.* US EPA Office of Resource Conservation and Recovery. https://www.epa.gov/sites/default/files/2020-10/documents/master_swmg_10-20-20_0.pdf.

FIGURE 2. THE WASTE HIERARCHY[51]

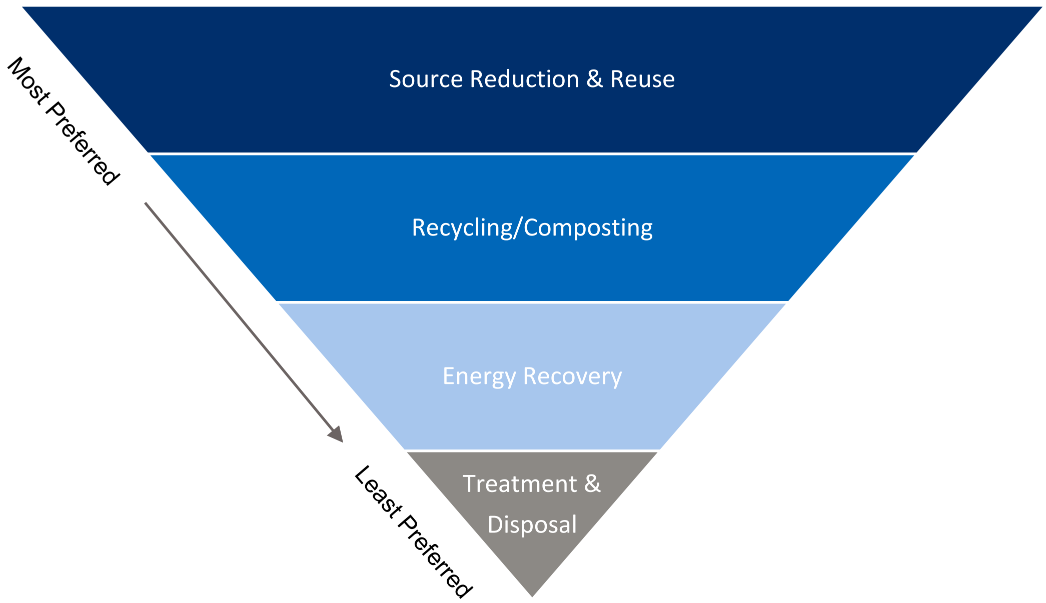

Table 1 describes some of the key elements that can be considered when developing strategic plans for waste reduction.

TABLE 1. KEY ELEMENTS TO CONSIDER WHEN DEVELOPING STRATEGIC PLANS FOR WASTE REDUCTION

KEY ELEMENT	DESCRIPTION
Decoupling Economic Activity and Waste Generation, and The Circular Economy	Historical trends in most industrial economies suggest that resource use and the resulting waste generation are linked to economic activity. However, it is possible to decouple economic growth from resource use through resource efficiency by "doing more with less." Decoupling implies using fewer resources and generating less waste per unit of economic activity. Effective decoupling can only be achieved by understanding the drivers for waste generation (e.g., lifestyle, household size, waste management costs, population, consumption). Several measures can be employed to enhance decoupling, such as economic instruments (e.g., taxes, fees, extended producer reliability schemes), cooperation (e.g., voluntary and government agreements), and information-based instruments (e.g., ecolabels). The concept of a circular economy is defined as "a regenerative system in which resource input and waste, emission, and energy leakage are minimized by slowing, closing, and narrowing energy and material loops; this can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, recycling,

[51] US EPA. 2020. *Best Practices for Solid Waste Management: A Guide for Decision-Makers in Developing Countries.* US EPA Office of Resource Conservation and Recovery. https://www.epa.gov/sites/default/files/2020-10/documents/master_swmg_10-20-20_0.pdf.

KEY ELEMENT	DESCRIPTION
	and upcycling."[52] Its application is based on business models that can achieve both financial benefits and resource efficiencies at various stages of the production cycle. In a circular economy system, producers are responsible for the life-cycle management of their products and packaging. This is in comparison with the traditional linear approach where producers handle only production and distribution.[53] In a circular economy, there is a need for enforceable laws that will spur appropriate action.
Residential Organics Management	Implementation of home composting (e.g., food and yard waste) and waste reduction programs can significantly reduce the overall tonnage of waste generated within a community. Home composting programs can be facilitated by providing equipment to residents (e.g., food scrap containers, composting bins). In areas where economic activity is more prevalent and agricultural and livestock programs have been further developed, composting programs can be implemented at a much larger scale.
Materials Reuse Programs	Materials reuse programs, intended to continue the utility and life span of lightly used goods, such as electronics, construction materials, and clothing, can reduce the generation of waste. These programs provide the availability of products that may no longer be of use to one group but can have ample utility for others. For example, there are markets where used household furnishings, appliances, and unused but serviceable construction materials are available free, or at a significantly reduced price. There also are electronics and computer recycling programs where serviceable yet unwanted or refurbished equipment is donated to developing countries for educational programs.

3.2 MINIMIZING FOOD LOSS AND WASTE

According to estimates compiled by the Food and Agriculture Organization (FAO) of the United Nations (UN), approximately 14% of the world's food, valued at $400 billion, is lost on an annual basis between harvest and the retail market and an estimated 17% of food is wasted at the retail and consumer levels.[54] Food losses and waste occur in the process of harvesting, transporting, storing, and retailing (e.g., supermarkets), and during consumption and post-consumption. It is estimated that food loss and waste account for 8% to 10% of global GHG emissions, contributing to climate change impacts that negatively affect crop yields, such as potentially reducing the nutritional quality of crops and causing supply chain disruptions.[55]

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[52] Geissdoerfer, Martin, Paulo Savaget, Nancy M. P. Bocken, and Erik Jan Hultink. 2017. "The Circular Economy - A new sustainability paradigm?" *Journal of Cleaner Production* 143: 757-768. https://www.sciencedirect.com/science/article/abs/pii/S0959652616321023.

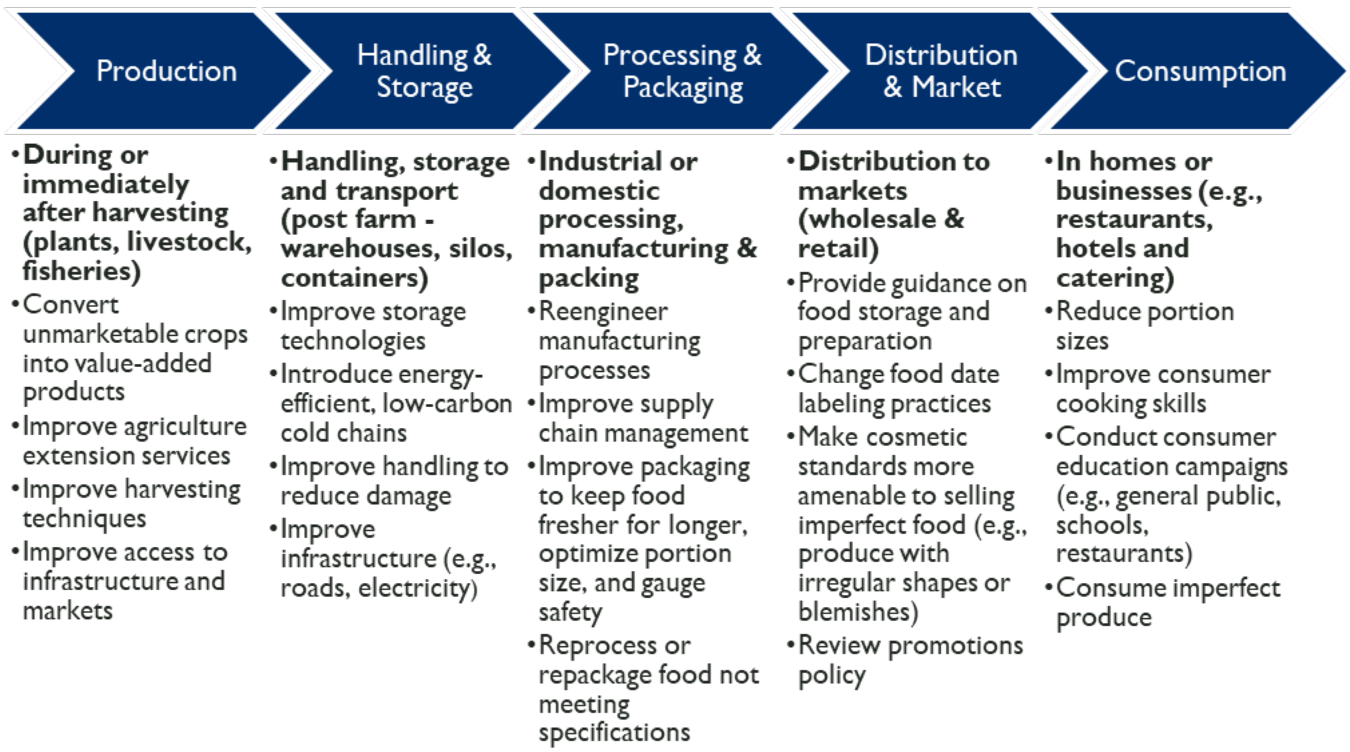
[53] Product Stewardship Institute. 2024. What is extended producer responsibility (EPR)? https://productstewardship.us/what-is-epr/.

[54] FAO. 2024. *Capacity Development: Food Loss and Waste*. https://www.fao.org/nutrition/capacity-development/food-loss-and-waste/en/.

[55] FAO. 2022. *Tackling food loss and waste: A triple win opportunity*. https://www.fao.org/newsroom/detail/FAO-UNEP-agriculture-environment-food-loss-waste-day-2022/en.

Furthermore, food that is harvested but ultimately lost or wasted consumes an estimated 250 cubic kilometers, or three times the volume of Lake Geneva, every year.[56] Reducing food loss and waste can save money for farmers, companies, and households; it can help feed more people; and it can alleviate the negative impacts on water, land, and climate. In recognition of these benefits, the UN has called for the halving of per capita global food waste at the retail and consumer levels and reducing food losses along production and supply chains (including post-harvest losses) by 2030 under its Agenda for Sustainable Development's Sustainable Development Goals (SDGs).[57] Examples of reducing food waste and losses at each stage in the production/supply chain are shown in Figure 3.

FIGURE 3. FOOD VALUE CHAIN AND EXAMPLES OF REDUCING WASTE



3.3 SEGREGATION, COLLECTION, TRANSFER, AND TRANSPORTATION SYSTEMS

Public waste management authorities are typically responsible for managing the collection of solid waste and recyclables that are generated within a city or region. Waste collected may be transported directly to treatment or disposal destinations, or through transfer stations for more efficient bulk transportation of waste to distant sites. Recyclables are transported to material recovery and processing facilities prior to delivery to markets. Proper waste stream segregation

[56] FAO. 2017. "Water for Sustainable Food and Agriculture: A Report Produced for the G20 Presidency of Germany." Rome. https://www.fao.org/3/i7959e/i7959e.pdf.

[57] In September 2015, the UN General Assembly adopted a set of 17 sustainable development goals (SDGs) as part of the 2030 Agenda for Sustainable Development. SDG No. 12 seeks to promote sustainable consumption and production patterns. Cutting food loss and waste falls under Target 12.3.

(e.g., recyclables from solid waste) is key to saving money and minimizing exposure to hazardous materials.

In many developing countries, these activities may be challenging due to lack of funding or technical capabilities, or other specific constraints (e.g., terrain or armed conflicts). The collection of waste and recyclables in urban areas is typically unreliable, irregular, and inefficient, whereas in rural areas it may be absent. Long-distance transportation of waste can be hampered by inadequacies in the transportation infrastructure, such as roads, rail, or ports. It is common practice in developing countries to co-mingle different waste streams in open dumps leading to adverse environmental and social impacts.

3.4 WASTE AND RECYCLABLES COLLECTION SYSTEMS

Timely, efficient, and regularly scheduled waste collection can protect human health and the environment because it minimizes the potential for attracting disease vectors and reduces the likelihood of contaminating nearby environmental receptors such as waterbodies, groundwater, and surface water.

Due to the availability of inexpensive labor, developing countries typically rely on labor-intensive methods for waste and recyclables collection. In these regions, waste and recyclables are usually collected by manually loading them on collection vehicles, which can be as basic as a small pickup truck or an open dump truck. Front-end loaders or other types of heavy equipment also may be used to remove trash collected in heaps in urban areas.

Waste collection services in developing countries are often only available in central or more affluent areas, and high-density, low-income housing areas are often neglected. While services provision in some areas of major cities may reach 30% to 50% or more of the population, in smaller provincial towns, coverage is likely to be much lower. In areas without services provision, waste is often dumped or burned as described in Section 3.7 *Thermal Treatment* and Section 3.8 *Land Disposal*.

Many types of storage containers are used in developing countries. Some examples of commonly used containers are provided in Figure 4. Storage containers should be selected that allow ease of loading onto collection vehicles and are safe, hygienic, and appropriately sized for the frequency of collection. While household containers often can be lifted and emptied manually, community bins may require mechanical emptying systems (e.g., roll-on/roll-off containers).

FIGURE 4. EXAMPLES OF HOUSEHOLD AND COMMUNITY WASTE STORAGE[58]

(a) Halved drum

(b) Wheeled bin

(c) Plastic bags

(d) Reused steel drum

(e) Thin galvanized bins

(f) Plastic bin with liner

(g) Movable skip

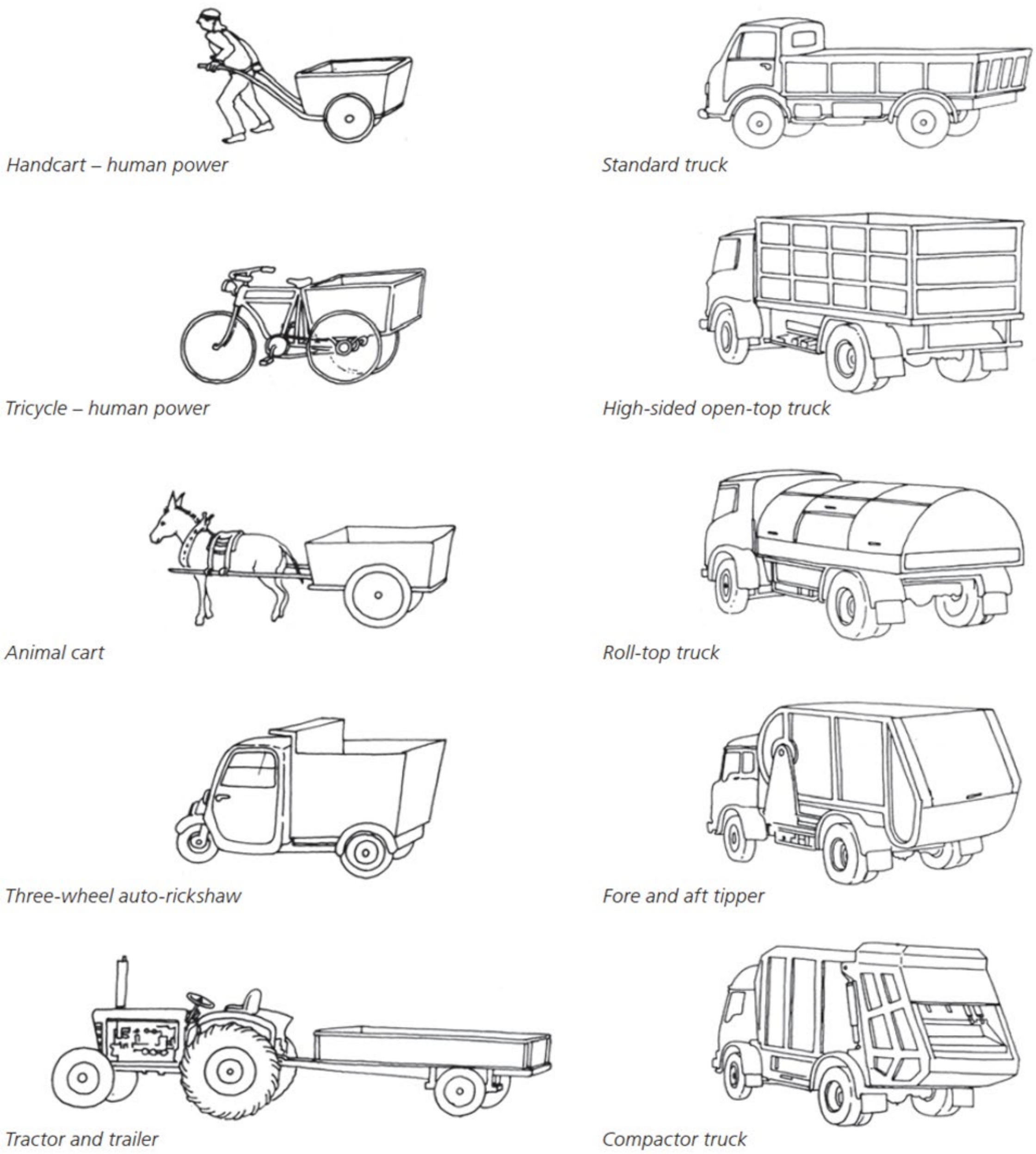
(h) Community bunker

(i) Wheeled container

[58] Coffey, Manus, and Adrian Coad. 2010. *Collection of Municipal Solid Waste.* United Nations Human Settlements Programme (UN-HABITAT), Malta: Gutenberg Press. https://unhabitat.org/sites/default/files/2021/02/2010_collection-msw-developing-countries_un-habitat.pdf.

Figure 5 illustrates typical types of vehicles that make up the majority of those used by public waste management authorities and the private sector for waste and recyclables collection in developing countries.

FIGURE 5. EXAMPLES OF WASTE COLLECTION VEHICLES AND CARTS[59]



[59] Coffey, Manus, and Adrian Coad. 2010. Collection of Municipal Solid Waste. United Nations Human Settlements Programme (UN-HABITAT), Malta: Gutenberg Press. https://unhabitat.org/sites/default/files/2021/02/2010_collection-msw-developing-countries_un-habitat.pdf.

Collection programs can vary based on many factors, including community size, space availability, climate, and behavioral factors. Some examples of collection programs are outlined as follows:

- **Community programs:** Community collection programs are geared toward multifamily dwellings (e.g., apartment buildings, townhomes) where it is impractical for all residents to stage their individual waste and recyclables containers in preparation for collection. These programs typically involve a shared area where large (e.g., 20 cubic yards) waste and recyclables containers, provided by the complex management, are stored. The residents manually carry their waste and recyclables to these areas for deposit into the appropriate container.

- **Convenience centers:** These are designated areas in public spaces where public authorities or third parties install and operate separate containers in which the public may deposit recyclables.

- **Non-containerized collections:** For bulky materials (e.g., white goods, mattresses, carpets, small CDE quantities) or WEEE, which cannot be containerized or collected by compactor trucks, collectors can offer special collections with tipper trucks, either on call or scheduled.

- **Self-service schemes:** The generators transport and deposit the waste and recyclables themselves at designated sites, such as disposal, civic amenity, and transfer stations.

- **Contracted services:** Non-household waste streams, which also can include healthcare, industrial, large-scale commercial, and hazardous waste, are collected directly from the generators from appropriately equipped and permitted collectors.

- **Curbside programs:** A curbside collection program typically involves collection for single-family dwellings. Waste and recyclables generated within the dwelling are placed in secure containers. Municipal curbside recycling programs are not widely practiced in developing countries because recycling collection is usually carried out in the informal sector.

- **Underground waste storage systems:** These systems have been adopted to avoid the amenity impacts associated with storing refuse prior to collection in urban areas, especially in hot climates. These bins are emptied by collection vehicles after they are brought to ground level via hydraulic lifts.

Vehicles and collection programs should be chosen based on efficiency, cost minimization, the size of the population served and its material generation volume, the size of the collection area, and the accessibility constraints that could impede its maneuverability.

3.4.1 WASTE TRANSFER STATIONS

Waste management sites are often far from the residential areas they serve. Long distances to treatment and disposal destinations negatively affect the efficiency and economics of collection operations because waste trucks spend a significant amount of time carrying collected waste to waste receptors and returning empty. The longer the transport distance, the lower the utilization of trucks and operatives (as the operatives remain idle during transfer rather than collecting waste) and the greater the fuel consumption, GHG emissions, and cost per ton collected. When the break-even transfer distance threshold is reached, there is an operational and economic need for transfer station facilities that link collection, treatment, and disposal to achieve economies of scale.

There is a large variety of designs and functional options for transfer station facilities. The main types of transfer station facilities are outlined as follows:

- **Rural transfer stations:** These are typically smaller scale facilities in remote areas that are not enclosed in buildings. Typical layouts are split level with hoppers, where collection trucks empty directly into transfer truck containers.

- **Mobile transfer stations:** An alternative to split level for small-scale operations is the use of a mobile plant comprising a vertical hopper and a reclining conveyor belt, where waste is offloaded by the trucks into the hopper and then transported via the conveyor and loaded from the top into waste transfer vehicles.

- **Direct dump:** The smallest scale transfer option is the direct dump. Small and satellite collection trucks can dump their waste directly on the on-board hopper outlet in the rear of the transfer vehicles.

- **Tipping floor type:** This is a layout option widely employed in small- and medium-scale facilities. Waste is deposited by the collection trucks on a flat surface (yard or floor) and then loaded by wheel loaders onto transfer trucks.

- **Hopper with/without compaction:** Hoppers are widely used in transfer stations. These are typically built within large buildings and collection trucks empty waste into them directly to load transfer vehicles.

3.4.2 BULK AND LONG-HAUL TRANSPORTATION

Recyclables and waste need, in many cases, to be transported long distances to be correctly managed (e.g., at a materials recovery operation, treatment facility, or disposal site)[60]. Bulk and long-haul transportation via road, rail, or water is used to increase the efficiency of long-distance transportation and prevent the need for collection vehicles to travel long distances. In countries

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[60] The transport of wastes over long distances for proper disposal is important, and often necessary, but may conflict with the Proximity Principle discussed in Section 1.2 *The Solid Waste Management Sector and Developing Countries*. To reconcile the importance of processing wastes locally with the often considerable investments required to build new infrastructure to properly manage waste, a combination of actions can be helpful. These include the involvement and support of government entities (local, regional, state, and federal), financial incentives (e.g., in the case of an energy recovery facility, sustainable electricity tariff rates with the grid can help ensure stable project cash flow and make such projects viable and profitable), and working transparently with key stakeholders (e.g., public sector, private sector, informal sector) to acknowledge the growing social costs associated with improper solid waste management and the need for implementing modern solutions.

where roads are in poor condition, even short-distance travel can be slow and difficult. In such cases, the development of bulk transport links to facilities offers efficiency improvements, allowing collection vehicles to focus on core services and disincentivizing informal or illegal dumping. Key transport methods include:

- **Road:** Waste is transported by large heavy goods vehicles (HGVs) via road networks. Most transportation is undertaken using HGVs; however, the use of articulated vehicles, with or without draw-bar trailers, can increase vehicle capacity with potential cost savings.

- **Rail:** Waste is loaded on trains and transported via the rail network to destinations with appropriate loading facilities.

- **Water:** Waste is loaded onto ships or barges (the latter are preferred for inland waterways). Typically, they are containerized (standard shipping containers) and employed for very large quantities of hauled waste. This also is an extensively used method for international transport of recyclable waste from generation countries to reprocessors in Asia and Africa.

International transportation of hazardous waste, including several WEEE types, is regulated under the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal. International haulage of waste and recyclables, which are destined for recovery or processing, is controlled under OECD Decision C(2001)107/FINAL on the Control of Transboundary Movements of Wastes Destined for Recovery Operations.

3.4.3 RECYLING/MATERIALS RECOVERY

Recycling involves the collection and processing of materials that would otherwise be managed as waste and turning them into new products. At a materials recovery facility (MRF), the separate components of a mixed-waste stream are extracted using mechanical and manual separation. MRFs are operated and proven worldwide as governments and businesses seek to extract recyclable materials from the waste stream to recover value, manage waste in a more sustainable manner, and reduce the amount of residual waste that requires treatment or disposal. The viability of an MRF depends on the presence of sufficient markets for separated recyclables. Provided that the quality meets reprocessors' specifications, there are usually markets for plastics, metal, and paper.

Typically, MRFs are designed with the capacity to handle between 3,000 and 250,000 tons of input materials per year. The technologies and systems employed can be complex or simple, depending on the sophistication of the plant, the equipment employed, and the number of operational staff. In low-technology facilities, an MRF may consist of a warehouse or shelter with equipment for manual sorting, such as a conveyor, tables and bins, scales or a weighbridge, equipment to compress recyclables into bales, and handling vehicles such as front-end loaders or forklift trucks to move bales or other waste. In more technologically advanced MRFs, conveyors are used to move waste between a range of sorting equipment, such as magnets, eddy currents, and sieves. Such plants may have advanced automatic control systems and optics for separating different plastic resin types. High-tech facilities are capital intensive and in developing countries where labor costs are low, low-tech solutions are more common.

MRFs are sometimes referred to as “dirty” or “clean” facilities. Dirty MRFs are facilities that sort waste streams with little or no segregation (i.e., commingled MSW). They are often designed to sort high-value and relatively easy-to-sort materials from the waste stream (e.g., metals, cardboard) or to pre-process waste prior to it being used as a feedstock for waste-to-energy plants. Dirty MRFs typically recover between 5% and 45% of the incoming material as recyclables.[61] Any remaining non-organic waste is typically either treated by incineration or disposal in a landfill. Clean MRFs are facilities that sort recyclables that have been segregated at the source or mixed recyclables. Because the proportion of organic and non-recyclable waste in mixed recyclables is lower than in mixed general waste, it is easier to sort recyclables into separate streams with an acceptable level of contamination for the material pre-treatment or manufacturing sector. Depending on how materials are delivered to the facility, clean MRFs are capable of separating more than 95% of the materials received for recycling.[62] Nationwide estimates for MRF contamination rates (reflecting items not targeted by the recycling program or not allowable under the terms of the MRF processing agreement) are 25% to 35%.[63]

MRFs can be flexible in comparison with other waste processes because the cost and disruption to services of increasing capacity are relatively low. For example, throughput can be increased by the extension of shift time or patterns to use automated equipment or manually sort or re-configure and/or add to the sorting equipment and picking stations.

3.4.4 ORGANIC WASTE MANAGEMENT

Composting and anaerobic digestion (AD) are two widely used and proven methods for the treatment of organics from waste. Three main types of composting are windrow, in-vessel (see Figure 6), and vermicomposting. AD can be carried out on a small scale (perhaps on a single farm) or at large industrialized facilities processing more than a thousand tons of food waste per day.

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[61] Hosansky, David. n.d. "Materials Recovery Facility." Britannica. Accessed 2024. https://www.britannica.com/technology/materials-recovery-facility.
[62] MSW Consultants. 2018. "Measuring Composition and Contamination at the MRF." https://nerc.org/documents/conferences/Fall%202018%20Conference/Measuring%20Composition%20and%20Contamination%20at%20the%20MRF_John%20Culbertson.pdf.
[63] National Waste & Recycling Association. 2018. "Material Recovery Facilities Issue Brief." https://wasterecycling.org/wp-content/uploads/2020/10/Issue_Brief_MRFS.pdf.

FIGURE 6. IN-VESSEL AND WINDROW COMPOSTING SYSTEMS

In-vessel[64] Windrow[65]

Anaerobic digestion was developed primarily in the domestic wastewater treatment and farming industries for the safe and environmentally controlled treatment of animal and sewage waste. More recently, AD has become widely used to treat organic waste separated from MSW. AD is a complex biochemical process for the treatment of biodegradable waste that takes place in a tank in the absence of oxygen. It results mainly in the formation of a CO_2 and methane (CH_4) gas mixture known as "biogas," which is typically used to provide electrical power generation, heat, and a solid and liquid digestate.

AD is a more complex system to manage than either windrow or in-vessel composting. An important design parameter of an anaerobic digester is the total solids (TS) concentration in the digestion reactor, expressed as a fraction of the wet mass of the prepared feedstock. The remainder of the wet mass is water. AD systems vary by supplier; however, systems can be classified by the following categories:

- **Moisture content of feedstock:** Wet (< 20% TS) / Dry (20% to 40% TS)
- **Temperature in digester tanks:** Mesophilic (86°F to 95°F) / Thermophilic (113°F to 149°F)
- **Number of digestion stages**: Single or multi-stage
- **Input waste feedstock:** In batches or fed into the process continuously

The capital cost of building AD systems is greater than for in-vessel composting (IVC), while the operational costs would likely be less than for IVC systems if there is an income from the sale of gas/electricity. AD typically becomes financially viable where there is a robust market or on-site use for biogas/heat and power.

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[64] Green Mountain Technologies. n.d. "In-Vessel Systems." Green Mountain Technologies. https://compostingtechnology.com/in-vessel-systems/.
[65] Waste Treatment Technologies. 2019. "Windrow Composting." Waste Treatment Technologies. https://waste-technologies.co.uk/windrow-composting/.

3.5 ENERGY RECOVERY

Energy is a byproduct from waste treatment technologies such as AD and thermal treatment. Biogas from anaerobic digestion, landfill gas capture, gasification, or pyrolysis can be used in a gas engine (or turbine) to generate heat and electricity, injected into a gas distribution network, or compressed or liquified for use as transport fuel. For most uses, biogas must undergo a cleaning process to remove the moisture, trace gases, and CO_2, resulting in an increase of the calorific value of the gas. The source of the fuel being close to the end user reduces the transport burden commonly associated with fossil fuels. An advantage of collecting and burning biogas as a fuel is that it converts CH_4, the primary gas in biogas, into CO_2 and water vapor, which have considerably lower global warming potential.

Heat from the incineration of waste is used to generate electricity via steam turbines. The efficiency of energy generation increases with the use of combined heat and power (CHP) systems. For recovered energy to be utilized, it should be proximate to energy markets or complementary on-site uses. Many energy-from-waste operations generate electricity for a combination of on-site use and sale to the local grid. Typical end users of heat (hot water or steam) from CHP schemes include paper manufacturing, food processing, desalination plants, and hospitals. However, it is often challenging to find end users for heat, especially in warm climatic conditions.

3.6 THERMAL TREATMENT

Thermal treatment is widely used because it significantly reduces the mass and volume of the waste; allows a range of materials to be combusted, producing relatively consistent byproducts; and typically allows heat and/or power recovery. For waste to be suitable for thermal treatment, it needs to be combustible. This means that inert materials (e.g., concrete, steel) are not suitable (and they reduce the efficiency of the process), although sometimes they are recovered from the process. The main types of thermal treatment are the following:

- **Incineration:** Combustion of waste in the presence of oxygen. The byproducts of combustion include ashes and flue gases. Flue gases should be “cleaned” using emission control technologies and the hazardous residues removed require special handling.

- **Gasification:** The thermal treatment of waste in a depleted oxygen environment. Synthetic gas is produced that contains hydrogen, carbon monoxide (CO), and CH_4, which is cleaned and combusted to generate energy.

- **Pyrolysis:** The thermal treatment of waste in the complete absence of oxygen. The thermal decomposition of waste results in synthetic gas and/or liquid oil, depending on the temperature used. The process requires the temperature to be maintained and this is typically achieved by recirculating the exhaust gases from the combustion of synthetic gas and heat exchangers.

- **Autoclave:** A thermal technology that subjects waste to a high temperature and pressure inside a vessel. The high temperature and pressure require the vessel to meet stringent safety standards and the process is more suitable for medical waste where waste infrastructure is not fully established. The process also is energy intensive with little or no recovery when compared with the other thermal treatment technologies discussed above.

Pyrolysis and gasification are capital intensive and complex technologies requiring highly skilled operatives. These technologies also require a highly homogenous waste feedstock with low moisture content. Both processes are not well-proven at commercial scales and are generally absent from the waste management mix of developing countries.

3.7 LAND DISPOSAL

3.7.1 UNCONTROLLED OR LIMITED CONTROL OF WASTE DISPOSAL

In developing countries, technical and financial resource limitations can adversely influence solid waste disposal practices. In the least developed countries, the residents of central urban areas may be the only people to benefit from municipal waste collection and disposal services. Following collection, the waste is likely to be disposed of at sites that lack basic infrastructure, containment, and environmental controls. There is often little differentiation between MSW and hazardous waste, as these wastes may be combined in disposal sites and users may not separate wastes for collection. Waste is purposefully set on fire and the sites are frequented by informal waste pickers and animals. In marginal areas without access to basic sanitary services, solid waste is often dumped indiscriminately in public areas and waterways. A vast quantity of solid waste litter and debris enters, circulates, and accumulates in surface waterbodies, waterways, the ocean, and beaches. Waste often accumulates in areas that are ecologically sensitive, such as wetlands, swamps, and coral reefs. This system of waste disposal leads to many problems, including the pollution of air and surface waters/groundwaters, fires, litter, odor, and the proliferation of disease-carrying vectors.

Semi-controlled dumpsites may be in place in some areas as the primary disposal method. At such sites, incoming waste may be inspected and recorded, controlled and compacted at a tipping face, and there may be some application of daily soil cover to prevent animals and vermin. However, such sites typically do not use environmental control measures such as leachate and landfill gas[66] management systems. As cities grow and produce more waste and solid waste collection increases, the impacts from semi-controlled dumpsites, as well as open dumpsites, can become intolerable.

The photographs in Figure 7 show examples of an informal dumpsite in Aruba and an engineered land disposal site in Greece.

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[66] Landfill gas is a mix of gases created when organic waste decomposes anaerobically (i.e., without oxygen) in a landfill. It is approximately 50% to 55% CH_4 and 45% to 50% CO_2, with less than 1% non-methane organic compounds and trace amounts of inorganic compounds. See US EPA. 2024c. "LFG Energy Project Development Handbook." Landfill Methane Outreach Program. https://www.epa.gov/system/files/documents/2024-01/pdh_full.pdf.

FIGURE 7. EXAMPLES OF SOLID WASTE LAND DISPOSAL

Typical dumpsite in Aruba (left) and new engineered landfill site in West Macedonia, Greece (right). Source: Mott MacDonald.

BOX 3. CASE STUDY: CLEANING UP THE STREETS WITH SUSTAINABLE WASTE MANAGEMENT, GUAPI, COLOMBIA

Guapi is an isolated municipality on Colombia's Pacific coast with little waste infrastructure, landfill capacity, and recycling facilities. Waste is mostly disposed of, causing significant public health and environmental hazards, and affecting deforestation.

Colombia's Ministry of Housing, City and Territory, supported by the United Kingdom's Foreign, Commonwealth and Development Office, identified safe recycling and disposal considering the views of local waste management stakeholders. An assessment toolkit was developed to support other towns with similar issues.

Introducing sustainable waste management systems in Guapi will improve public health, safeguard the local environment, and boost economic prosperity for local communities that have been affected by a long-standing civil war.

Source: Mott MacDonald. n.d. "Cleaning up the Streets." Mott MacDonald. https://www.mottmac.com/article/40007/cleaning-up-the-streets.

3.7.2 SANITARY LANDFILLS

Landfilling may be suitable in some developing countries due to its relative simplicity and low cost if integrated with material recovery, environmental controls, and good management practices. The development or conversion of open or operated dumpsites to "sanitary landfills" is an essential step for many developing countries to prevent and reduce the impacts on the environment and human health.

The definition of a "sanitary landfill" can be specified in terms of engineering measures and performance requirements, with such sites typically satisfying the following conditions:

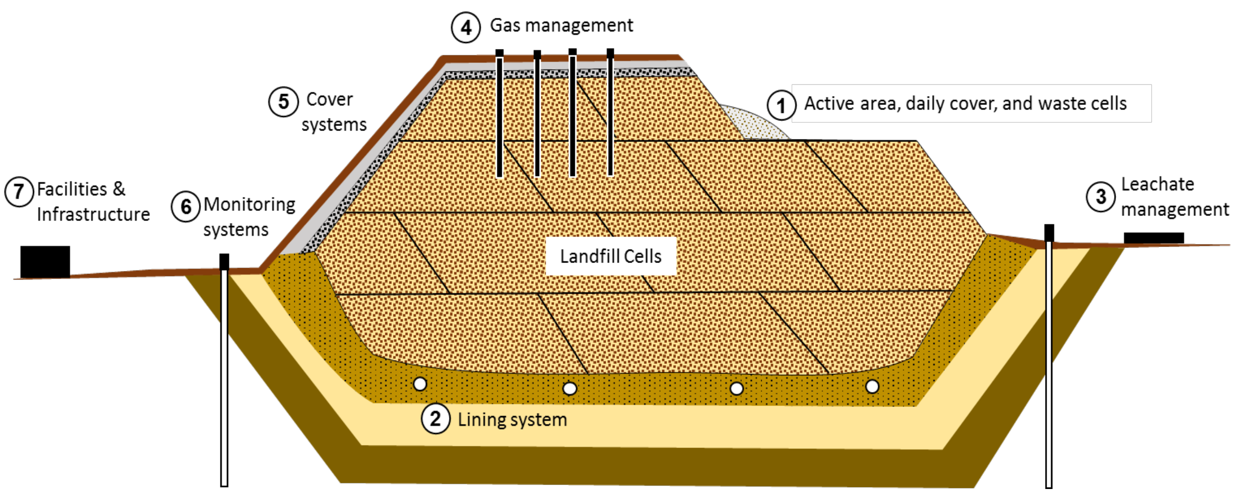
- Consolidation of waste into a working face and compaction to conserve land resources.
- Design and operation of the fill to control settlement and optimize chemical and biological processes.
- Control or prevention of adverse environmental impacts on land or soil, water, and air, and their impacts on public health and safety.

Meeting all conditions may be impractical in some developing countries due to a lack of resources and capacity. In such cases, the short-term or immediate goal should be to meet the conditions to the extent possible under the existing circumstances with the aim of full compliance in the long term.

There are several types of landfills and the complexity of their respective components (e.g., lining and environmental collection, treatment and monitoring systems) are driven by the types of waste each will receive. Landfills are usually categorized into inert (e.g., construction and demolition waste), non- hazardous (e.g., MSW), and hazardous (e.g., medical, industrial) but can include multiple designations within a single site. Substantial amounts of hazardous waste must be disposed of in specially designed hazardous waste landfills with robust management, containment, and monitoring systems.

A diagram showing a typical sanitary landfill cross-section and key aspects is shown in Figure 8 and discussed in elements 1 through 7 in Table 2.

FIGURE 8. SIMPLIFIED CROSS-SECTIONAL DIAGRAM OF A SANITARY LANDFILL



Source: Mott MacDonald.

TABLE 2. KEY ASPECTS OF A TYPICAL SANITARY LANDFILL

NO.	ELEMENT	DESCRIPTION
1	Active area, daily cover, and waste cells	The active area of a landfill, or tipping face, is where solid waste is tipped, spread, and compacted. Daily covering of soil is often used to minimize odor, litter, and vectors. Compacted waste is covered with soil, which is then compacted to form a cell. The cells are formed sequentially to create layers or "lifts," which form the landfill body. The sides are graded to provide a stable structure and drainage.
2	Lining system	Liners are used to protect groundwater from contamination.[67] The need for a bottom liner depends on hydrogeological and climatic conditions and the leachability of the contained waste. Liner systems may be single, double, or composite layers and are constructed from natural (e.g., soil, clay, gravel) and/or synthetic (e.g., plastic sheets, geotextiles) materials. The liner should impede leachate flow and provide a structurally stable base for overlying waste. The lining is sloped to collect leachate above it.
3	Leachate management	Leachate management is needed to prevent contaminants from entering groundwater or connected waterbodies, and sometimes to protect the integrity of the landfill lining. Leachate can be managed through reduction, containment, and treatment. Generation can be prevented or reduced by screening liquid and high-moisture waste, reducing infiltration of precipitation through the final and intermediate cover, and implementing drainage features.[68] A typical leachate collection system includes a drainage layer formed of sand or gravel and evenly spaced perforated pipes that collect the leachate and divert it to a low-lying collection point. Accumulated leachate is transferred for storage, treatment, or disposal. Leachate treatment methods include physical-chemical and biological treatment, evaporation, and recirculation of leachate within the landfill.
4	Gas management	When solid waste is buried, organic material decomposition occurs under anaerobic conditions, resulting in the generation of landfill gas. Provisions for managing landfill gas, which comprises mostly CH_4 and CO_2, should be considered by landfill designers and operators. If not managed properly, landfill gas migration can lead to nuisance odors, GHG emissions, and serious safety issues such as fires and the risk of explosion. Landfill gas collection and management systems typically consist of horizontal or vertical collection wells connected to a transfer piping system and blowers. Collected landfill gas can be used as a fuel source to generate electricity or burned (i.e., flared).

[67] Leachate is liquid discharged from a landfill that contains chemicals or constituents from the waste it has contacted. It is potentially a significant pollutant and is usually very odorous. The composition varies widely depending on the type and the age of the waste.
[68] Leachate treatment can be one of the most significant operating costs for a landfill. Therefore, minimizing the generation of leachate at the front-end can be an effective way to reduce costs.

NO.	ELEMENT	DESCRIPTION
5	Final cover	When the landfill cell or unit is filled, a final cover system (or "landfill cap") should be installed to provide secure, long-term storage. Final covers provide a physical barrier over buried waste, prevent human contact, minimize problems with vectors and odor, prevent erosion that could expose waste, reduce infiltration and the generation of leachate, and provide a foundation for the possible reuse of the landfill. Final cover systems range from simple to complex, and may include layers for vegetation, hydraulic barriers, drainage, filtration, and gas collection/ventilation.
6	Monitoring systems	Environmental monitoring systems are required to measure and evaluate impacts from landfills on the environment and human health so that they can be prevented, managed, or rectified. The scope of monitoring is site dependent but may include the installation of groundwater monitoring wells and the sampling of surface waters. Air quality (dust and gases), noise, and odor may be issues during operation, which should be monitored, depending on the proximity to people. Closed landfills may include the monitoring of landfill gas for fire prevention or as part of gas collection and management systems.
7	Facilities and infrastructure	Landfills contain a variety of infrastructure and facilities, which are vital to operations, including roads, drainage, utilities, buildings, fencing, industrial weighing scales, and other equipment and facilities. The maintenance of roads and drainage is a major activity for operators.

Sanitary landfills are operated as systems. Each element requires operation, maintenance, management, monitoring, and evaluation to ensure efficient, safe, and environmentally sound practices. Landfill operating procedures are determined by many site variables but typically include the following:

1. **Receipt of waste:** Waste is delivered to the site and inspected, weighed, and screened. Incoming waste details are recorded. Most formal landfills charge tipping fees; however, the charge is often below the operating cost. High tipping fees may incentivize the illegal dumping of waste.

2. **Handling and placement of waste:** Waste is processed, tipped, spread, compacted, and covered at a working face in a designated area. The recovery of recyclable materials is a good practice as it recovers revenue from the waste stream and reduces airspace in the landfill cells.

3. **Equipment operations and maintenance (O&M):** Landfills commonly employ heavy equipment and other mechanical, hydraulic, and electrical equipment. Such equipment should be properly operated and maintained. Procurement (and donations) of equipment must be accompanied by training and capacity-building, as well as a source of funds for maintenance.

4. **Infrastructure O&M:** Roads need to be constantly maintained to cope with heavy-wheeled and tracked machinery and provide access to a moving working face. Access to

landfills should be controlled to prevent unauthorized waste picking and illegal dumping. Drainage systems also require constant modification and maintenance to manage surface water in the dynamic landfill environment.

5. **Environmental control:** Collection (e.g., gas, leachate), monitoring (e.g., groundwater), and treatment systems (e.g., leachate) are installed (phased), operated, and maintained. Fires typically result from poor handling practices and are often set deliberately to create more space.

BOX 4. CASE STUDY: TRANSITIONING TO SANITARY LANDFILL IN DOMINICAN REPUBLIC

Since 2014, San Cristobal (population 250,000) operated a semi-controlled dumpsite (no liner, groundwater monitoring, soil cover) with uncontrolled access to the site, resulting in unsafe scavenging and fires.

Due to unsafe site conditions and associated health and aesthetics impacts, many resident complaints were registered. In response, San Cristobal reached out to Ministry of Environment and Natural Resources, USAID, and the US EPA to develop a plan for dumpsite improvement/closure and to transition to a sanitary landfill.

In 2017 and 2018, the city and its partners conducted multiple field data collection assessments on current SWM practices as well as stakeholder meetings. Based on this, the following recommendations were determined:

1) Improve current site operations (e.g., establish proper working face at current site)
2) Convert the site to an engineered landfill, including designing leachate treatment and LFG collection systems.
3) Contract the private sector.

In 2021, the city government ordered work on the landfill to start.

Source: U.S. EPA. 2020. "Best Practices for Solid Waste Management: A Guide for Decision-Makers

3.7.3 WASTE PICKING

Waste picking is a widespread occurrence at urban land disposal sites in developing countries and is to be expected at sites unless measures to prevent it are implemented. Waste pickers and informal workers at landfills and dumpsites can pose a safety hazard, interfere with operations, and start fires. The negative impacts of waste picking have been reduced in some places by formalizing this work, either by employing waste pickers directly or by engaging contractors to do their work. However, as pickers normally are part of the socioeconomic structure, their displacement from an existing disposal site can result in workers being made jobless and homeless and cutting off a valuable income for them and their families. Examples of programs aimed at formalizing the role of waste pickers through the establishment of cooperatives include the Linis Ganda (Clean and Beautiful) program in Metropolitan Manilla, The Philippines, and the EcoCitizen program in Curitiba, Brazil.[69, 70]

FIGURE 9. INFORMAL WORKERS AT WASTE SITES IN ARUBA

Lack of personal protective equipment (PPE) for informal waste workers at waste transfer sites and dumpsites.

Source: Mott MacDonald.

3.7.4 LANDFILL STABILITY AND LANDSLIDE RISK

Landfills are designed to clearly define gradients to ensure that the sites do not become unstable and collapse. While this is observed within the developed world, in other parts of the world, this is not adhered to, mainly because the sites have not been correctly engineered and thus the waste volumes continue to build up. Within these developments, informal settlements are frequently found at the edges of landfills as many members of the community work in the informal waste sector. The occupants of these settlements may be at risk from pollution, fires, and landslides. Figure 10 shows before and after images of the collapse of a dumpsite in Payatas, Quezon City, The Philippines, following a typhoon on July 10, 2000, which buried squatter houses and then went up in flames, reportedly killing more than 200 people and leaving many homeless.[71]

[69] WIEGO. 2024. Waste Pickers. https://www.wiego.org/waste-pickers.
[70] Thornett, Robert. 2015. "In Brazil, a City's Waste Pickers Find Hope in a Pioneering Program." Yale Environment 360. https://e360.yale.edu/features/in_brazil_a_citys_waste_pickers_find_hope_in_a_pioneering_program.
[71] Jafari, N. H., T. D. Stark, and S. Merry. 2013. "The July 10 2000 Payatas Landfill Slope Failure." *International Journal of Geoengineering Case Histories* 2 (3): 208-228. http://casehistories.geoengineer.org/.

FIGURE 10. PAYATAS LANDFILL COLLAPSE – BEFORE AND AFTER[72]

3.7.5 SITE CLOSURE

When the landfill is complete, a closure plan should be developed and implemented that considers the long-term containment of the site, including capping materials and vegetation, proposals for after-use of the site (if appropriate), leachate and gas control, environmental monitoring and inspections, and engineering aspects such as settlement and slope stability.

Existing informal dumpsites or semi-formal landfills may be capped or the contents moved to a sanitary landfill to reduce their impacts. In some cases, it may be necessary to clean up (remediate) existing dumpsites and landfills that contain hazardous waste and pollutants that affect human health and the environment. Many methods of site remediation are available, including removal, containment, stabilization, and chemical, biological, and thermal treatments. Remediation of landfills and dumpsites is usually very costly and requires careful planning and management to avoid spreading the contamination during implementation.

3.8 HAZARDOUS WASTE TREATMENT AND DISPOSAL

In developing countries, technical and financial resources limitations, minimal political and governmental commitment, and lack of training and awareness can adversely affect hazardous waste management practices. In these countries, there may be little legislation, technical guidance, or training programs available for entities that engage in hazardous waste generation (i.e., producers), transport, and disposal or treatment. Deficient management of hazardous waste can expose handlers and their communities to substantial health and safety risks or place local environmental receptors at risk of contamination. In the least developed countries, actual quantities of hazardous waste available for treatment and disposal are unknown because the waste streams are not properly documented and are typically commingled with conventional solid waste. This mix of hazardous and non-hazardous waste can end up being disposed of in an unsafe, unsecure, and uncontrolled manner, perhaps through burial, burning, or surface dumping.

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[72] geoengineer.org. 2000. *Paper documents failure at Payatas landfill in the Philippines that killed 330.* https://www.geoengineer.org/news/paper-documents-failure-at-payatas-landfill-in-the-philippines-that-killed-330.

Hazardous waste management requires robust regulation and enforcement to ensure safe, responsible management from "cradle to grave." Waste should be subject to screening to identify potentially hazardous materials and characterization to determine the type and properties of any identified materials present so that the proper handling, storage, transportation, processing, and disposal protocols can be followed. Strict regulations should be in place to establish general operational and management standards and minimum design standards, and provide direction on contingency and emergency planning, recordkeeping, and monitoring.

In many developing countries, weak governance, lack of awareness, and deficient financial, technical, and infrastructural resources can lead to the mismanagement of hazardous waste, including the following:

- Commingling of hazardous waste with MSW
- Lack of a recordkeeping audit trail and liability
- Disposal in an uncontrolled landfill or dumpsite
- Uncontrolled intermediate storage
- Handling and transportation by unlicensed/unregistered haulers and uncertified personnel
- No provision of personal protective equipment (PPE) or training for workers handling hazardous waste

Improper management of hazardous materials may potentially result in spills; leaks; fires; and the contamination of air, soil, and groundwater or drinking water.

Many types of hazardous waste can be recycled safely and effectively, while other waste requires treatment or secure disposal. Recycling hazardous waste reduces the consumption of raw materials and the volume of waste materials that must be treated and disposed of. Examples of hazardous waste materials that may potentially be appropriate for recycling include batteries, mercury-containing equipment, lead paint, and strip lamps.

Hazardous waste can be treated by a variety of technologies, such as chemical, biological, thermal, and physical processes. However, not all treatment methods are effective for all types of hazardous waste, and the most appropriate technology should be determined based on the targeted materials' characteristics and chemical composition. Chemical treatment methods are intended to cause a chemical reaction that breaks down the hazardous constituents into non-toxic materials or alters the chemical properties of the waste. For plastics, for example, chemical treatment and recycling methods include gasification, pyrolysis, and depolymerization. While such technologies may be proven, the extent to which technologies can address the plastics waste crisis in any meaningful way is uncertain given factors such as economic viability and heterogeneous waste streams. Biological treatment typically involves mixing the targeted waste with soil, spreading it across a suitable tract of land, and amending the mixture with microbes and nutrients that metabolize the waste (i.e., consume it as a food source). Thermal treatment, such as incineration, involves heating the waste to very high temperatures, resulting in the thermal destruction of its hazardous constituents and a reduction in waste volume. Although high-temperature incineration is an effective treatment technology, emission control systems are required to mitigate air quality impacts.

Hazardous waste also can be disposed of in a lined landfill, which offers secure long-term containment. These facilities should be robustly designed and constructed, and include double impermeable liner systems, double leachate collection and extraction systems, leak detection systems, and a network of groundwater monitoring points. There are other land disposal options for the storage of hazardous waste, such as surface impoundments and waste piles. These lined and berm-surrounded land disposal options offer secure, albeit temporary, storage of hazardous waste until it can be treated or disposed of in a landfill.

4. PLANNING AND IMPLEMENTING WASTE MANAGEMENT SYSTEMS

To plan and implement waste management systems effectively and efficiently, it is important that solid waste strategies are developed by authorities at various geographic scales. Waste management strategies should include a vision and specific objectives to meet the waste management needs of the territory and solutions and plans to achieve those objectives. Realistic targets and indicators for monitoring progress also should be specified. A strategy should be consistent with the principles of the waste management hierarchy and resource recovery and conservation objectives. It should include integrated and sustainable waste management practices and be aligned to other national plans and policies, including those related to the environment, economy, energy, and land. A waste strategy should achieve the following:

- Clearly set out objectives and services standards, along with specific and measurable targets and associated indicators;
- Identify a preferred solution for collection, treatment, and disposal;
- Provide a framework for procurement, development, and operation of waste infrastructure and facilities; and
- Communicate these plans to government, key stakeholders, partners, and the broader community.

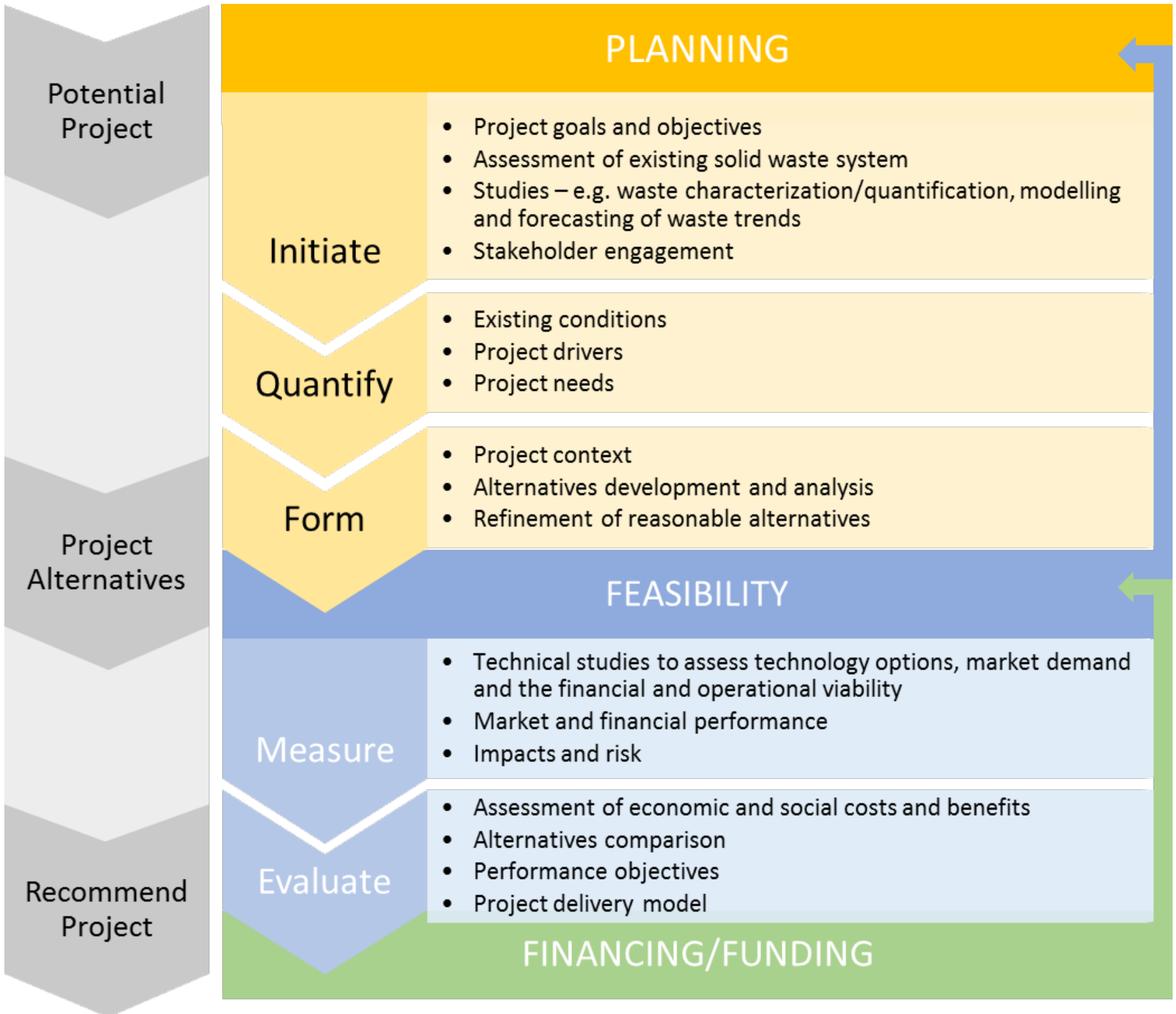
Not all regions will have a strategy in place and further/additional technical reviews of potential waste solutions will be required in the subsequent planning and feasibility stages.

4.1 PLANNING AND FEASIBILITY

Project planning and feasibility should be carried out in line with the relevant contracting and procurement legislation of the host country. Increasingly, new waste infrastructure is being delivered under the public-private partnership (PPP or P3) procurement model (see Section 4.2.3 *Public-Private Partnerships*).

Feasibility studies are required to demonstrate the practicality of the proposed project or activity to stakeholders, including investors, lenders, contractors, regulators, and the public. Feasibility studies vary in scope and size depending on the project or activity but often include the key elements shown in Figure 11.

FIGURE 11. PROJECT PLANNING AND FEASIBILITY PROCESS



Through these aspects, stakeholders will evaluate the feasibility of the project based on a preferred technical and commercial configuration.

4.2 PROJECT PREPARATION

The preparation of the project will take the findings of the feasibility study and build them into a structured information memorandum that considers each stage of the procurement process. This memorandum will identify the project program/schedule and ensure that there is an in-place agreement on the overall finances of the project prior to its commencement. The development of an information memorandum can be preceded by a "market sounding" study to test market interest in the project and ensure that there are sufficient investors, partners, and suppliers. Market studies and enquiries are followed by issuing a Notice, which may include the date of a bidders' day for interested contractors to hear more about the project.

4.2.1 ENGINEERING DESIGN

In design-build contracts, a contractor is responsible for the design, procurement of materials, financing, and construction of waste management facilities and infrastructure in accordance with specifications and performance requirements. The engineering design process typically includes the stages shown in Box 5.

BOX 5. TYPICAL ENGINEERING DESIGN STEPS FOR DESIGN-BUILD PROJECTS

1. Preparation and design brief
2. Concept design (30% design stage)
3. Developed design (60% design stage)
4. Technical design (100% design stage)
5. Construction
6. Handover to owner/operator
7. Operational use

Waste PPP projects (see Section 4.2.3 *Public-Private Partnerships*) are often procured through a design, build, finance, and operate contract. The contractual documents produced by the waste authorities usually cover the first two stages.

- **Preparation Brief:** This document develops the project objectives and outcomes, project budget, and development of an initial project brief including undertaking the feasibility study described in Section 4.1 *Planning and Feasibility*.

- **Concept Design:** This document includes the preparation of the outline proposals for structural design, outline specifications, and preliminary cost information, together with an outline layout of the plant.

The remaining stages are undertaken by the contractor in the response to the tender and the subsequent design phase on contract close.

4.2.2 PUBLIC SERVICES DELIVERY

Waste management infrastructure is an essential part of the services and public waste management authorities have the right to publicize or disclose information regarding projects. Projects usually affect multiple stakeholders and conflicts may arise where interests diverge. To manage conflicts and develop solutions and outcomes that are acceptable to all stakeholders, workshops can be undertaken to explain, discuss, and draw together ideas.

4.2.3 PUBLIC-PRIVATE PARTNERSHIPS

The PPP Knowledge Lab defines a PPP as “a long-term contract between a private party and a government entity, for providing a public asset or service, in which the private party bears significant risk and management responsibility, and remuneration is linked to performance”. The PPP development model is increasingly being used to deliver public infrastructure projects and services and is widely used for the delivery of waste management facilities and collection services. In developing countries, the development of large-scale and technologically sophisticated waste facilities often requires private sector participation as the capacity of public authorities to deliver such projects alone is limited. USAID recognizes the importance of the private sector in delivering development projects. Since it launched its public-private alliance program, Global Development Alliance (GDA), in 2001, USAID has delivered thousands of development assistance projects under the PPP model (Brookings Report, 2016).[73]

A key feature of a PPP is that the assets or services provided are specified in terms of outputs, that is, defining what is required rather than specifying how exactly it should be done. Through PPPs, the private sector can provide valuable technological and management expertise or partnerships for the development of infrastructure and facilities. Partners are expected to invest financially, leveraging donor funding at least 1:1 with USAID contributions, increasing resourcing, and sharing risk.

However, using the PPP model to deliver and operate public infrastructure or services is not appropriate in all cases. In some situations, the benefits of a PPP do not sufficiently offset political, procurement, delivery, or revenue risks. Projects or programs are often funded by tolls, fees, or other direct user charges, which can be politically sensitive and expensive for consumers. Stakeholders (donors or governments) also face risks should private partners fail to properly execute contracts or deliver adequate services. As such, a detailed procurement process should be followed, including detailed risk management, robust contract and technical specifications, and analysis of value for the money.[74]

Many types of PPP models exist and the selection of the correct configuration is essential to achieving successful outcomes. Types of PPP contracts can be defined by how project phases or functions (i.e., design [engineering], construction, financing, and O&M) are bundled together and allocated. Usually a dedicated special-purpose vehicle (SPV) is set up as the contracting entity, which takes on defined assets and liabilities. For example, many waste management facilities are delivered under Design, Build, Operate (and Maintain) (DBO) contracts, whereby all of these activities are contracted to an entity for a specific period of time (perhaps 15 to 20 years). Under such contracts, entities are entitled to collect fees and/or subsidies for operation during that period, with payment usually linked to performance. At the end of the period, "ownership" or the right to operate the facility transfers back to the government, who may extend or re-tender the contract, or bring the operation in-house.

A review of suitable PPP models should be based on international best practices and be specific to the local project context. The review should include the evaluation against current national and regional laws, policies, and institutional arrangements to identify any constraints

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[73] Ingram, George M., Anne E. Johnson, and Helen Moser. 2016. *USAID's Public-Private Partnerships: A Data Picture and Review of Business Engagement.* Global Economy and Development at Brookings. https://www.brookings.edu/wp-content/uploads/2016/07/WP94PPPReport2016Web.pdf.

[74] To achieve "value for money," waste management solutions must be both financially affordable and able to deliver maximum efficiency for the resources available.

within the project, including any capacity to manage and monitor implementation, including advice on the following:

- Public sector procurement
- Resourcing, training, and capacity-building needs for the public sector
- Operational arrangements between the public sector and advisers during procurement
- Contract management arrangements

The PPP review will develop the legal structure and transaction design, identifying the type of PPP contract to be used, together with the investment plan and the type of public sector support required. By taking into account the legal PPP framework, relevant environmental legislation, and policies, technical solutions can be developed that are:

- **Flexible:** Able to treat a range of waste quantities and types, and to contractually allow changes without requiring contract renegotiation.
- **Deliverable:** Using proven technologies and processing to meet the output specification requirements. Contractually, the contractor must be able to provide a clear and realistic project program and method statements providing assurance that the project can be delivered on time and on budget.
- **Having value for the money:** Key methods for doing this are by having a clear output specification and minimizing the amount of input specification, while ensuring that the key requirements of the waste strategy are met.
- **Meeting environmental performance requirements:** Waste should be moved up the waste hierarchy (see Section 3.2 *Waste Reduction and the Waste Hierarchy*), minimizing the environmental impact of waste management.

4.3 SOLICITATION OF CONTRACTORS AND CONTRACT MANAGEMENT

Proponents can solicit offers or quotations for services from contractors using sealed bid procedures (often referred to as “invitations for bid” or “invitations to tender”) or using negotiated procedures (“requests for proposals” or “requests for quotations”). For large contracts, sealed bidding procedures are often preferred. The process must be transparent to reduce opportunities for corruption and ensure that the contractor offering the best value is appointed to undertake the work and services. Transparency can be achieved by issuing tender evaluation criteria at the start of procurement to make it clear what the criteria for selection will be. A two-envelope system, where the commercial offer is only opened after bidders have passed the technical evaluation, is often adopted for public procurement projects.

Bidders who do not pass the technical evaluation threshold will not proceed to the opening of the commercial offers.

Contract management, or contract administration, refers to the processes and procedures that public waste authorities and other project proponents implement to manage the negotiation, execution, performance, modification, and termination of contracts. Contract management arrangements should incorporate procedures that complement payment mechanisms, ensure that there is evidence submitted to support payments, and that payments are in accordance with the terms of the contract.

4.4 OPERATIONS AND MAINTENANCE

A services delivery plan should be developed as part of O&M services. This plan states how the contractor(s) will deliver the services against the contractual requirements that have been laid down under the contract, and should include the following:

- A service operational plan (SOP) that is required for each waste management facility, which provides for how the plants will be operated and maintained.
- The SOP will include the operational capacity of the facility to ensure that the planned tonnage is met and the capacity is not exceeded.
- An environmental impact control plan to ensure that the waste facilities are being monitored to avoid impacts caused by noise, odor, litter, emissions, traffic, and pests.
- A waste acceptance plan to ensure that waste complies with the protocols and does not include waste material outside of the permitted waste acceptance criteria.
- A contingency plan to ensure that the waste site can be maintained correctly and that any waste diversion or storage arrangements are sufficient to ensure that the service continues in accordance with the contract.
- A routine inspection and maintenance plan to ensure that all preventative maintenance and equipment services are undertaken in accordance with the schedule to ensure that the plants can operate effectively and without damage to the equipment.

4.5 WASTE COLLECTION, TREATMENT, DISPOSAL FEES, AND OTHER REVENUE STREAMS

Waste management is first and foremost an essential community service aimed at protecting human health and the environment. The cost of providing a modern system can be reduced but not replaced by a variety of means. One approach is for system operators to charge a fee for collection, treatment, and/or disposal services. This fee is often charged at the waste management site and helps to cover the capital cost and O&M costs associated with waste management facilities. Other revenue stream examples include the sale of compost generated by the organic fraction of the waste stream, recyclables recovered from the waste stream, and electricity generated from energy recovery plants.

4.6 ESTIMATING PROJECT COSTS AND STAFFING REQUIREMENTS

Once a preferred technical model has been selected in the technical feasibility study, a cost model can be developed for the project or activity, including (as relevant) the design, construction, and O&M costs. Capital costs/expenditures are initial outlays required for the procurement and development of solid waste assets (e.g., infrastructure and equipment) or any other upfront fees and deposits. Capital outlays may be required for vehicles, waste containers, equipment, and machinery at transfer sites, treatment locations, and supporting infrastructure. Disposal and treatment costs will be driven by the selection and design of the treatment technology chosen in the feasibility study.

Operational expenditures are based on the staffing and maintenance requirements to operate the waste management facilities and potentially equipment replacement costs. Operational costs are a key consideration for authorities and investors because the operational costs over the lifetime of facilities or services usually far exceed the initial capital costs. Authorities should build operational costs into financial models for each stage of the waste management process, including waste collection, disposal, treatment, and landfill after-care costs, as well as related non-project costs such as waste prevention and education programs, and recycling and waste diversion initiatives to determine long-term budgets.

Financial models estimate the costs over the contract or strategy period and include many assumptions that cannot be known with certainty at the outset, such as macro-economic factors (e.g., inflation, revenues). Financial models should therefore include sensitivity analysis to develop risk management strategies and contingencies.

4.7 INSTITUTIONAL CAPACITY, POLICY, AND REGULATORY CONSIDERATIONS

4.7.1 STRENGTHENING OF INSTITUTIONS AND CAPACITY-BUILDING

When undertaking waste management projects, it is important to understand the institutional capacity and capabilities of public authorities and partners. In some cases, public authorities may lack the experience or resources required for delivery of the project or program in question. Therefore, development proposals that include capacity-building and training for public authorities, private waste management companies, NGOs, or civil society organizations may be valuable for the success and sustainability of development projects and waste services provision more generally. Technical assistance and capacity-building also may be required to ensure effective O&M of waste facilities and infrastructure. The ability to transfer knowledge and skills by carrying out training sessions will assist the recipients of donor assistance to take ownership of projects or programs and facilitate the development of new projects and programs by the application of newly developed capacity and skills.

4.7.2 POLICY AND REGULATORY CONSIDERATIONS

The formulation of policies and strategies and their translation into legislation and regulations are the backbone of effective solid waste governance. Waste management policy formation is driven by goals such as improving public health and sanitation, environmental protection, and the recovery of resource value from discarded materials. Waste management goals should be identified and prioritized in consultation with local stakeholders. Once legislation has been enacted, a regulatory program must be developed, implemented, and enforced by the relevant executive authorities. Regulations are ancillary or subordinate to laws; however, both laws and regulations are enforceable.

Laws and regulations can limit or prohibit actions such as informal dumping, open burning, and hazardous waste disposal; provide specifications for technologies; and set out functional requirements (e.g., environmental pollution limits). Other non-regulatory instruments and policy measures also can be used for implementing policies and strategies and improving compliance, such as social mobilization (e.g., education and awareness, participation) and economic instruments (i.e., incentives and disincentives).

Legislation should include purpose and scope; definitions; requirements, procedures, and standards; enforcement; and administration. It is important to clearly establish the relevant authorities and responsibilities of different government institutions and provide resources for their implementation and enforcement. Political support, institutional capacity, and financing are essential to successfully implement and enforce new waste legislation and regulations.

When developing solid waste projects or implementing waste programs, the host country's policies, legislation, and regulatory environment must be fully understood and complied with. There are likely to be a wide range of applicable laws, regulations, and policies related to waste, land ownership, spatial planning, public health, environmental permitting, and many others.

5. PLANNING FOR CLIMATE CHANGE

Climate change is a cross-cutting issue that can undermine development progress and increase risk and insecurity in developing countries, and thus should be a key part of activity planning. There also are opportunities to reduce or avoid potential GHG emissions from USAID-funded activities that could contribute to climate change.

The effects of global climate change are already being felt and are likely to increase in the near and long terms. Observed and future projected climate change hazards include sea level rise; seasonal shifts and variability in temperature and precipitation; and increased frequency, intensity, and duration of extreme events (e.g., droughts, floods, high winds, tropical storms). In the long-term, sea-level rise could lead to permanent loss of low-lying and coastal land areas or an increased need for coastal engineering and management to prevent inundation.

When seeking to address climate change challenges, it is useful to take a broad perspective in considering options for reducing emissions and building resilience. These actions can be supplemented with and strengthened by complementary efforts, including measures to mobilize financing for climate-related investments; efforts to strengthen enabling conditions, governance, and shifts to market signals that support climate action and sustainability; and engagement with Indigenous Peoples, local communities, and women, youth, and marginalized groups to foster buy-in and direct engagement in the construction, operation, and maintenance of waste management projects.

Consistent with proven approaches for sustainable, effective development assistance, activities focused on managing climate risks and mitigating GHG emissions or increasing carbon sequestration should, where applicable, also seek to reflect the principles of locally led development, equity, and inclusion; private sector engagement; nature-based solutions; innovation; and the use of evidence.

5.1 BUILDING RESILIENCE AND ADAPTING TO CLIMATE CHANGE

By making projects more resilient against and reducing their vulnerability to the effects of climate change, USAID can increase the sustainability of its investments and improve the likelihood of their long-term success. To plan for a changing climate, USAID and its implementing partners should identify and assess potential climate change risks relevant to their projects, programs, and operations, and develop ways to manage such risks through avoidance or adaptation. USAID provides guidance for climate risk management in Automated Directives System (ADS) Reference 201mal, Climate Risk Management for USAID Projects and Activities.

5.1.1 CLIMATE RISK MANAGEMENT

Climate Risk Management (CRM) is the process of assessing, addressing, and adaptively managing climate risks at all stages in the program cycle. With few exceptions, USAID Project and Activity Design Teams are required to identify and assess relevant climate risks, implement measures to mitigate significant risks, and monitor and evaluate the effectiveness of adopted measures in accordance with ADS Reference 201mal. The CRM process involves identifying climate risks, risk ratings, how risks are addressed, opportunities, and Project Appraisal Documents any additional analysis needed. These elements and results of the CRM should be documented in Project Appraisal Documents (PADs) and Environmental Compliance Analyses (e.g., the Initial Environmental Examination [IEE]). It also is important to monitor and evaluate the application of climate change mitigation during implementation and to apply learning throughout the Program Cycle.[75]

5.1.2 ASSESSING CLIMATE CHANGE RISKS

Assessing climate change risks associated with a project or activity involves (1) assessing potential climate change trends and related climate stressors, (2) evaluating the project or activity's level of exposure to impacts from that stressor and its vulnerability (i.e., ability to cope with impacts) to determine the potential severity of impacts, and (3) evaluating the likelihood that impacts will occur. Project designers also should consider the potential effects from the project or activity itself on the vulnerability of communities and physical assets to climate change impacts and adaptability.

Project design teams should assess the likely extent of variability and extreme climate-related events, drawing from available historical records, current trends, and future projections. The timeframe of projects should reflect the type of investment being made. Planned actions associated with the project or activity should then be evaluated against historical and projected trends to identify potential climate change risks. The procedural aspects of identifying climate change impacts associated with a project or activity are set out in ADS 201mal.

Tools are increasingly available to help decision-makers and project designers pragmatically assess potential climate risks in the face of uncertainty by first screening for climate vulnerabilities through the use of a decision tree. Additional or deeper analysis is performed only as needed, allowing decision-makers to allocate scarce project resources in proportion to project needs.[76]

Climate change risks and impacts will be distinctive to the specific location, timing, and characteristics of the project or activity. Examples of potential risks that could be associated with solid waste management sites and operations are listed in Table 3 and are discussed in the paragraphs below.

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[75] USAID. 2022b. "Climate Risk Management for USAID Projects and Activities: A Mandatory Reference for ADS Chapter 201." https://www.usaid.gov/sites/default/files/2022-12/201mal.pdf.

[76] Ray, Patrick A., and Casey M. Brown. 2015. *Confronting Climate Uncertainty in Water Resources Planning and Project Design.* Washington D.C.: World Bank Group. https://documents1.worldbank.org/curated/en/516801467986326382/pdf/99180-PUB-Box393189B-PUBLIC-PUBDATE-8-19-15-DOI-10-1596-978-1-4648-0477-9-EPI-210477.pdf.

TABLE 3. CLIMATE RISKS IN THE SOLID WASTE MANAGEMENT SECTOR[77,78]

CLIMATE STRESSORS	CLIMATE RISKS
Increasing average air temperatures and incidence and/or severity of heat waves Increasing incidence and/or severity of drought	• Fires at landfills, waste storage areas, and dumpsites • Altered chemical composition of contaminants below the surface and changes in evaporation rates affecting land disposal • Increased rate of plastic waste breakdown, contributing to increased microplastic pollution and accumulation in soils • Proliferation of disease vectors (e.g., insects, vermin) at waste storage areas and disposal sites • Overheating of collection vehicles and sorting equipment • Reduced storage times for organic waste • Odor around storage areas and facilities • Mobilization of dust and volatile organics, leading to the deterioration of air quality • In cold climates, thawing permafrost or soils disrupting drainage and surface water flow around landfill sites
Increasing incidence and/or intensity of storms (high rainfall and high wind events)	• Saturated soils and the decreased stability of slopes at open and landfill linings at waste management sites • Flooding of waste sites leading to groundwater, soil, and surface water contamination, including by potential hazardous chemicals, toxins, and microplastics, and the mobilization of hazardous materials • Disruptions in the removal and transportation of solid waste • Damage to waste containment facilities or structures, potentially contributing to adverse health outcomes • Increased requirement to manage debris following storms or flooding
Increasing incidence and/or intensity of storm surges	• Inundation of waste sites releasing contaminants, potentially including hazardous chemicals, toxins, and microplastics, to waterways, land, and occupied areas • Potential for pools of standing, contaminated water that promote waterborne and vector-borne diseases • Impacts on coastal docking and transfer facilities • Floating waste and debris washing up due to storm surges • Intermittent inundation of collection, processing, and disposal infrastructure in coastal areas • Damage to waste containment facilities or structures, potentially contributing to adverse health outcomes
Sea level rise	• Flooding of waste management sites and facilities in coastal areas, potentially resulting in adverse health outcomes and biodiversity impacts • Contamination of groundwater, aquifers, waterways, and water supplies due to the impact of rising water tables on the hydrology around landfills in coastal areas • Impacts on coastal docking and transfer facilities

[77] Zimmerman, Rae, and Craig Faris. 2010. "New York City Panel on Climate Change 2010 Report Chapter 4: Infrastructure Impacts and Adaptation Challenges." Annals of the New York Academy of Sciences 1196 (1): 63-86. https://nyaspubs.onlinelibrary.wiley.com/doi/full/10.1111/j.1749-6632.2009.05318.x.

[78] C40 Cities. n.d. Waste Management. https://www.c40.org/what-we-do/scaling-up-climate-action/waste-management/.

CLIMATE STRESSORS	CLIMATE RISKS
	● Deterioration of impermeable lining ● Intermittent and increasingly permanent inundation of collection, processing, and disposal infrastructure in coastal areas

Once risks and potential impacts have been identified and described, project designers should determine their overall significance, which involves assessing the severity of the impacts and the likelihood that they will occur.

The key determinants of the severity of climate impacts are exposure (the degree to which a system is exposed to significant climate variations) and vulnerability. Waste management facilities, particularly landfills and dumpsites, can be vulnerable to flooding or rising groundwater, potentially spreading contaminants from untreated waste into soils, groundwater, and surface waters, or undermining their structural integrity. Increasing temperatures and drought can lead to a higher frequency of fires at waste sites, as well as an increasing incidence of odor, vermin and vectors, and dust, which may require higher collection frequencies and improved waste management controls. Increased climate risks in the solid waste sector increase the exposure to contaminants by waste industry workers and the general public, resulting in adverse health outcomes. Additionally, as climate change threatens the structural integrity of waste infrastructure, this may disrupt livelihoods and income for those reliant on the waste processing sector.

In many developing countries, solid waste management systems can be inadequate, leading to the accumulation of waste in areas that affect water runoff or flood control, such as drains, sewers, channels, and waterways.[79] These conditions can lead to increased vulnerability to flooding from intense precipitation, storm surges, and even moderate rainfall. Such impacts can be pronounced in urban areas, particularly in informal settlements, which often lack formal infrastructure or are on marginal lands (e.g., hillsides, marshland, floodplains). Flooding can increase exposure to contaminated water and to water- and vector-borne diseases, landslides, and damage to property and livelihoods.

Vulnerability to climate change impacts can be compounded in some developing countries due to a limited ability to provide planned and coordinated debris clean-up and management following storms and flooding. Much of the debris left behind after storms and flooding represents a danger to human health and safety and can be a barrier to rescue and relief operations and post-disaster recovery. Larger disasters can result in significant damage and debris, adding greatly to the challenges associated with waste collection and management during recovery efforts, often with lasting effects.

The magnitude, timing, and geographic variability of climate change impacts cannot be predicted with certainty. However, it is widely accepted that without significant reductions in global GHG emissions, climate change will continue to worsen in the coming years and extreme climate events also are likely to increase in frequency and severity. From a risk management

[79] US EPA. 2020. *Best Practices for Solid Waste Management: A Guide for Decision-Makers in Developing Countries.* US EPA Office of Resource Conservation and Recovery. https://www.epa.gov/sites/default/files/2020-10/documents/master_swmg_10-20-20_0.pdf.

perspective, depending on the project, it is appropriate to take a precautionary approach that seeks to reduce risk in the face of such uncertainty. Users, businesses, and governments in developing countries may not be able to absorb the full cost of the damages or risk the loss of services, so planning for risk management as early as possible can be important.

5.1.3 ADDRESSING CLIMATE CHANGE RISKS

USAID design teams that are considering the inclusion of solid waste activities in new projects should be aware of the potential impacts from climate change and ensure that procurement documents and contracts or agreements include requirements for conducting appropriate architectural and engineering design and risk management procedures that incorporate climate risk considerations.

The overall objective is to create projects or activities that are resilient to the effects of climate change. Climate resilience is the capacity of a system to absorb the stresses imposed by climate change, respond to them, and evolve into more sustainable and robust systems. Embedding climate resilience in the design of waste management activities will contribute to minimizing future losses and damage (and the associated costs) associated with extreme climate events and help them to rebound swiftly.

The siting and design of waste facilities in coastal areas should account for potential changes in daily sea-level, sea-level rise, and storm surges and appropriate locations should be selected based on these considerations. The same principle applies to solid waste projects near floodplains, rivers, and wetlands. Siting decisions should be informed by accurate data on geology, groundwater, surface water, flooding hazards, and proximity to vulnerable populations. Adapting design, operation, and maintenance of solid waste management sites to changing climate conditions and risks involves ensuring that structures and systems can withstand climate stressors such as increasing temperatures and increasing frequency and intensity of extreme climate-related events (e.g., floods, wildfires, high-wind storms) to protect occupants and maintain the uninterrupted provision of services.

Reducing the amount of solid waste transported to and deposited in landfills is one of the easiest ways to reduce their climate vulnerability. Promoting circular economy policies and principles and establishing or strengthening waste sorting and recycling facilities can create both formal and informal local employment while reducing the amount of waste that ends up in landfills.

Flood-related risks to the waste sector can be mitigated through the improvement of solid waste management practices, such as carrying out the regular collection of waste from streets, drains, and waterways. This can be taken as a low-cost measure in advance of an anticipated storm. In MSW collection systems, the accumulation of waste and informal disposal should be minimized, and adequate collection and storage and containment systems should be in place to reduce the spread of contamination and litter from flooding.[80] However, many governments and municipal

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[80] World Bank. 2018. *What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050.* https://openknowledge.worldbank.org/entities/publication/d3f9d45e-115f-559b-b14f-28552410e90a.

authorities in developing countries face a variety of challenges in implementing effective solid waste management systems, including struggling to finance minimal solid waste operations.

Improved waste management practices can themselves serve as measures to improve climate resilience. For example, preventing waste blockages in a drainage system can significantly improve stormwater and wastewater management, particularly under increasing high rainfall events. Improving waste management can reduce the impacts of the increasing severity and/or frequencies of heat waves, storms, drought, and sea level rise, increasing the community's resilience to climate change.

The ability of waste management sites to provide continuous services during extreme climate events also is a key factor in establishing resilient projects and activities. Adaptation includes integrating, where economically feasible, back-up systems to provide services (e.g., power, water, communications) in the event of sudden or intermittent failures due to weather events. Debris management following these events also is important to protect human health, comply with regulations, conserve disposal capacity, reduce injuries, and prevent or minimize environmental impacts.

Climate risk management and adaptation measures also could inadvertently result in increased vulnerability to climate impacts for certain individuals or communities, particularly those who are already marginalized. This is sometimes called *maladaptation*. For example, a community that is displaced to accommodate the construction of a new waste management structure that aims to improve climate resilience could potentially suffer economically and lose cultural or knowledge-based connections with the land, ultimately leaving that community less resilient to climate stressors.

Equity should be a critical element of climate-resilient activities because activities that lack resilience or address resilience without considering equity concerns can create or reinforce vulnerabilities for people. In addition to the example noted above, waste management facilities that are improperly strengthened against flooding may weaken or fail during a flood event, exposing workers and the surrounding community to safety risks. This could exacerbate existing inequalities or create new risks of inequality. Project planners should seek to both improve climate resilience and work with local communities and Indigenous Peoples to ensure that local knowledge and voices, including around potential climate risks and adaptation measures, are incorporated into project design and implementation.

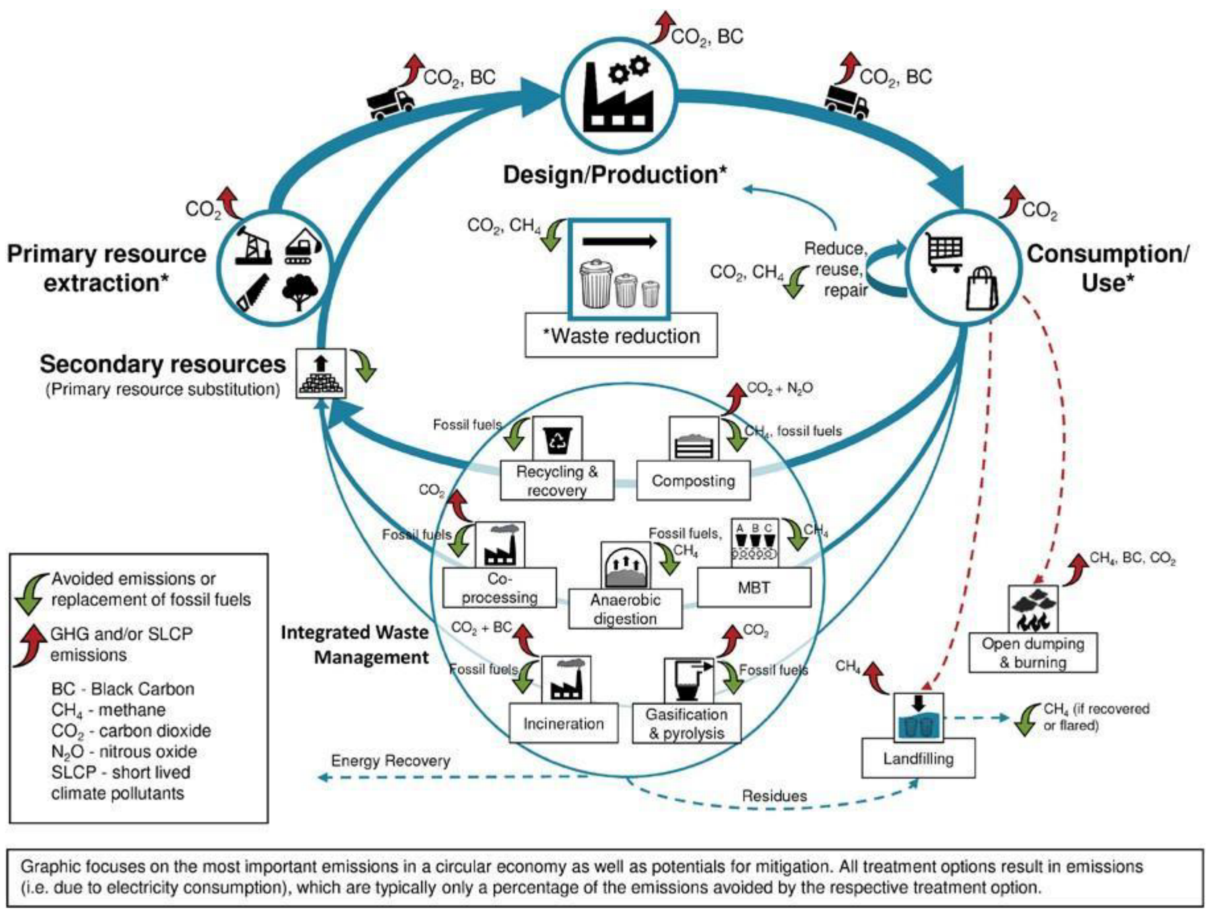
See Table 8 *Mitigating Climate Risks to Solid Waste Management*, Table 3 *Climate risks in the Solid Waste Management Sector* and Table 9 *Mitigating GHG Emissions in Solid Waste Management* for information on mitigating the climate risks discussed above.

5.2 REDUCING GREENHOUSE GAS EMISSIONS IN SOLID WASTE MANAGEMENT

USAID seeks to reduce GHG emissions in its activities and demonstrate that it is possible for countries to grow their economies sustainably and in ways that reduce or avoid emissions, consistent with a country's national emission reduction goals and targets. The waste management sector is a source of GHG emissions, most significantly through the release of CH_4 as organic waste breaks down in landfills and dumpsites but also through the transportation4 of waste, emissions from incineration and open burning, and inefficient use of resources (see Figure 12). The treatment and disposal of solid waste produces CH_4, biogenic CO_2, non-methane volatile organic compounds, and small amounts of nitrous oxide (N_2O, a gas with much higher global warming potential than CO_2 or CH_4), nitrogen oxides (NO_X), and CO.[81]

Best management practice examples to reduce GHG and other waste management emissions, detailed in EPA's 2023 Solid Waste Management and Climate Change Decision-Makers Guide, include: Waste segregation, collection fees, collection route optimization, circular economy policies, open burning bans, appropriately sized treatment facilities, diverting recyclables and organic waste from disposal operations, and landfill gas recovery.[82]

FIGURE 12. RELATIONSHIP BETWEEN MATERIAL LIFE CYCLE AND CLIMATE CHANGE[83]



[81] IPCC. 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 5: Waste - Chapter 3: Solid Waste Disposal. National Greenhouse Gas Inventories Programme, IPCC, Japan: IGES. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_3_Ch3_SWDS.pdf.

[82] US EPA. 2020. *Best Practices for Solid Waste Management: A Guide for Decision-Makers in Developing Countries.* US EPA Office of Resource Conservation and Recovery. https://www.epa.gov/sites/default/files/2020-10/documents/master_swmg_10-20-20_0.pdf.

[83] GIZ. 2017. "Sectoral implementation of nationally determined contributions (NDCs): Circular Economy and Solid Waste Management." https://www.giz.de/de/downloads/giz2017-en-ndc-waste-management.pdf.

The total amount of MSW being generated will nearly double worldwide by 2050 due, in large part, to the combined effects of population growth, urbanization, and changing consumption patterns, thus increasing the pressure on cities and communities to manage this growing economic, environmental, and social challenge.[84] Furthermore, it is estimated that more than 50% of collected waste is not managed properly but is burned or dumped at landfills without sorting or sustainable landfill management practices.[85] Reducing GHG emissions through well-managed waste systems and energy and resource recovery can contribute to GHG emissions mitigation and also could have significant health, environmental, and economic co-benefits.

The two main approaches to reducing direct CH_4 emissions from landfills are (1) capturing the CH_4 generated in landfills and either flaring or, preferably, using it to produce energy (electricity and heat); and (2) reducing the quantity of landfilled waste through source reduction, recycling, composting, and anaerobic digestion of organic waste. To reduce indirect emissions from solid waste management, project designers and managers should evaluate the modes of transportation used to collect and dispose of waste, the energy sources used throughout the waste management process, and other impacts along the value chain.

Examples of waste management activities, their associated GHG emissions, and measures to reduce GHG emissions in solid waste management are outlined in Table 9 *Mitigating GHG Emissions in Solid Waste Management*.

Consideration should be given to reducing GHG emissions when planning, designing, and implementing solid waste management projects and activities. However, decisions with regard to adopting specific measures should be based on sound financial principles, subject to cost-benefit analysis and evaluated on a case-by-case basis.

[84] World Bank. 2018. *What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050*. https://openknowledge.worldbank.org/entities/publication/d3f9d45e-115f-559b-b14f-28552410e90a and UNFCCC. 2015. *Mitigating SLCPs from the Municipal Solid Waste Sector.* https://unfccc.int/news/mitigating-slcps-from-the-municipal-solid-waste-sector.
[85] Gautam, M., and M. Agrawal. 2021. "Greenhouse Gas Emissions from Municipal Solid Waste Management: A Review of Global Scenario." In *Carbon Footprint Case Studies. Environmental Footprints and Eco-design of Products and Processes,* by S. S. Muthu. Springer. https://doi.org/10.1007/978-981-15-9577-6_5.

6. ENVIRONMENTAL IMPACTS

The environmental impacts associated with solid waste can be divided into those associated with i) construction and decommissioning of waste management facilities; and ii) operation of waste management facilities. Impacts associated with the development (i.e., construction) and decommissioning of waste management facilities are similar to those associated with other types of industrial or public facilities. Detailed descriptions and examples of impacts associated with construction are provided in the USAID Construction SEG.[86] Examples of general environmental impacts associated with the execution of solid waste management activities and the operation of waste disposal facilities are described in Table 4, presented by category of impact. Impacts associated with specific projects and activities will be dependent upon their specific features and circumstances. The impacts provided here are examples for informational purposes only and do not represent an exhaustive list.

[86] For more information, see the Construction SEG on USAID's Sector Environmental Guidelines & Resources webpage accessible at https://www.usaid.gov/environmental-procedures/sectoral-environmental-social-best-practices/sector-environmental-guidelines-resources.

TABLE 4. POTENTIAL OPERATIONAL ENVIRONMENTAL IMPACTS AND EFFECTS

CATEGORY OF IMPACT	DESCRIPTION OF POTENTIAL IMPACTS AND EFFECTS
Air quality	Pollution from waste management facilities and activities can adversely affect air quality. Typical releases and emissions include the following: ● **Landfills and dumpsites:** Landfill gas (CH_4, CO_2, and a range of other potential contaminants, including hydrogen sulfide, ammonia, non-methane organic carbons [NMOCs], at low concentrations); dust; volatilization of organics. ● **Incinerators and energy-from-waste:** Emissions of NO_X, sulfur oxides (SO_X), CO_2, CO, unburned hydrocarbons (HC), dioxins, furans, and particulates. NO_x contributes to the formation of smog and acid rain and affects tropospheric ozone. ● **MRFs, transfer stations, and composting facilities:** Generate dust and volatile organic compounds (VOCs) from daily operations. Enclosed facilities can contain these releases; however, open sites are far more common in the developing world. ● **Transportation:** Most waste vehicles use internal combustion engines and represent a mobile source of air pollution (including NO_X, SO_X, HC, CO, CO_2 and particulates). The significance of the impacts is dependent upon many factors, such as the source, intensity, duration, proximity to sensitive receivers, and climatic conditions, but can affect human health (see below) and ecology.
Noise and vibration	● Waste management operations can generate significant amounts of noise from (1) fixed equipment or process operations, (2) mobile equipment or process operations, and (3) waste transport. ● Heavy mobile equipment (e.g., compactors, tipper trucks) can generate ground vibration, which can affect nearby people and structures. ● Solid waste facilities may operate 24 hours per day but are typically located in industrial areas, which are less sensitive to noise. ● Facilities generate traffic, causing chronic low-level noise affecting communities located along roadways. Waste collections also generate significant noise in urban areas, usually early in the morning. ● Noise impacts can affect human (see Table 6 and Table 7) and ecological health and well-being.

CATEGORY OF IMPACT	DESCRIPTION OF POTENTIAL IMPACTS AND EFFECTS
Pollution of surface waters and groundwater	Waste management activities can have a range of impacts on the quality of fresh and marine surface waterbodies and groundwater. ● Waste management facilities, such as landfills and transfer stations, generate leachate and contaminated stormwater, which can pollute soils, groundwater, and surface waters if discharged to ground, stormwater drains, or sewerage systems. ● Pollutants (e.g., biological oxygen demand (BOD), chemical oxygen demand (COD), ammonia, inorganic salts) in higher concentrations make leachate a potential source of contamination for surface waters (and groundwaters [see below]). ● Stormwater runoff contaminated with pollutants, including hydrocarbons, heavy metals, litter, and organics, can enter water or groundwater via drainage or sewerage systems through infiltration or direct overflow, leading to adverse effects on water quality. ● Direct stormwater runoff may contain elevated levels of suspended sediments, which can increase the turbidity of the receiving waters and nutrients. ● Nutrient pollution from organics/leachate leads to excessive plant/algae growth (eutrophication), blocking light and absorbing oxygen in the water, which can kill aquatic animals. ● The application of liquid byproducts from anaerobic digestion onto land can lead to nutrient pollution in waterbodies via runoff or groundwater connectivity. ● Uncontrolled landfills or dumpsites containing toxic hazardous waste risk the contamination of surface water and groundwater. The risk depends on the quantity, concentration, leachability, and characteristics of source material(s), pathways, and receptors. ● Groundwater pollution is difficult and expensive to remediate. In some cases (e.g., contamination of an aquifer) such impacts may be long term/irreversible. ● Plastic waste can harm physical habitats and aquatic life, transport chemical pollutants, and interfere with human uses of river, marine, and coastal environments (see Section 2.9 *Plastic Waste*). ● Discharges to water from waste sites containing trace levels of heavy metals and other persistent compounds can build up in river and marine sediments over time. If disturbed, such sediments can become a source of pollution, causing the deterioration of water quality.

CATEGORY OF IMPACT	DESCRIPTION OF POTENTIAL IMPACTS AND EFFECTS
Soil/Sediment and land contamination	Waste management is closely related to contaminated land management because existing and former waste sites may be a source of contamination and engineered waste sites manage waste from the remediation of contaminated land. There may be many existing or former waste sites within a developing country that are contaminated by hazardous materials, including industrial sites and dumpsites or semi-controlled landfills containing hazardous waste. Such sites can pose a significant long-term risk to human health and can disrupt ecosystem services and productive use of land. If waste is also leachable, contaminants can be mobilized via water and groundwater pathways (see the *Pollution of Surface Waters and Groundwater* section above). ● Contaminants in soils may be dispersed via windblown dust and particulates when the ground is exposed or by volatilization to the atmosphere and thus pose a risk to people via direct contact or ingestion of contaminated food, particularly where such sites are not secured. ● Attempts to remediate or contain contaminated sites may lead to the mobilization of contaminants if not properly planned and implemented (e.g., the breaking up of asbestos concrete creating respirable dust). The legacy of hazardous waste contamination can last many years, particularly in the case of heavy metals, persistent organic pollutants (POPs), and other non-biodegradable compounds.
Ecology and biodiversity	Pollution from waste management sites and activities can adversely affect wildlife, habitats, and ecosystems on land, and in rivers, coastal areas, and the ocean. Understanding these impacts requires an assessment of the species present, their abundance, the ecological context, relevant processes and interactions, and the nature of adverse effects. Examples of adverse effects on wildlife include the following: ● Contamination of marine and fresh water leading to toxic effects on aquatic species (e.g., nutrient-rich discharges causing eutrophication or harmful algal blooms, changes in water chemistry or pH leading to habitat degradation and fish kills). ● Waste management activities and sites can also disturb local ecosystems by attracting scavenging animals such as vermin and birds that may outcompete, directly prey upon, or eat the eggs of native animal species ● Chronic and frequent noise interferes with animals' abilities to detect sounds, and intermittent and unpredictable noise may be perceived as a threat. This can lead to adverse behavioral and physiological responses, affecting fitness, foraging, breeding, or mortality. ● Accumulated waste and litter can damage sensitive habitats, which may be home to threatened and endangered species.

CATEGORY OF IMPACT	DESCRIPTION OF POTENTIAL IMPACTS AND EFFECTS
	• Plastic litter is consumed by organisms that mistake it for food at many trophic levels (from plankton to whales). Plastics can harm birds and aquatic animals by blocking their digestive system or toxicity. In particular, marine plastic pollution has increased tenfold since 1980.[87] Waste sites, particularly those containing hazardous waste, can cause deterioration in ecosystem services (such as freshwater provision, ecological uses) and the productive use of land (e.g., construction, agriculture).

[87] UNEP. 2022. A roadmap towards a circular plastics economy. https://www.unep.org/news-and-stories/speech/roadmap-towards-circular-plastics-economy.

7. SOCIAL IMPACTS

The potential exists for adverse and unintended negative social impacts as a result of solid waste projects and activities. USAID is committed to integrating stakeholders' voices, concerns, perspectives, and values as a form of acquiring feedback and input on a proposed project to identify potential social impacts early on and make sound decisions during the design and planning phase. As indicated in the adjacent textbox, per ADS 201, USAID requires an initial screen of potential social impacts.

USAID's visions, policies, and strategies call for a participatory process that safeguards against doing harm to its beneficiaries. This process includes ensuring meaningful stakeholder engagement from government, communities, and individuals to assure that USAID's international development efforts benefit all members of society, particularly marginalized and underrepresented groups and/or people in vulnerable situations.

Stakeholder engagement is critical for ensuring that USAID maintains accountability to program participants by ensuring the active participation of local communities, developing mitigation measures that include participants' voices, as well as ensuring that affected individuals and communities can communicate their concerns through USAID's Accountability Mechanism.[90] Given the importance of stakeholder engagement for fostering a successful project, the project may benefit from sustaining this engagement throughout the entire project life.

SOCIAL IMPACT RISK INITIAL SCREENING (SIRS) TOOL

Per the June 2024 update to ADS Chapter 201 Program Cycle Operational Policy, USAID design teams must conduct an initial screening of the social impact of their Activities and Programs using the Social Impact Risk Initial Screening and Diagnostic Tools (ADS 201mbf).[88] The Social Impact Risk Initial Screening (SIRS)[89] Tool is intended to help USAID design teams plan for, mitigate, and monitor potential adverse social impacts from USAID Activities and Programs. The Tool consists of 10 questions designed to kickstart mandatory analytical thinking about a variety of different potential adverse social impacts and help identify when additional social safeguarding is needed. Additional social safeguarding may include redesigning Activity/Program components or concepts, identifying social impact mitigation measures, or conducting additional analyses, such as a Social Impact Assessment. When filling out the Tool, design teams should only check "no" when they are highly certain that there is no potential for an adverse impact. The complexity of the process for completing the Tool will vary based on the severity of social impacts posed by the Activity/Program.

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[88] USAID. 2024. A Mandatory Reference for ADS Chapter 201. https://www.usaid.gov/about-us/agency-policy/series-200/references-chapter/201mbf.

[89] USAID. 2024. "Social Impact Risk Initial Screening and Diagnostic Tools. A Mandatory Reference for ADS Chapter 201." https://www.usaid.gov/sites/default/files/2024-05/201mbf_051424.pdf.

[90] The USAID Social, Economic, and Environmental Accountability Mechanism (SEE-AM) is expected to be formally launched in summer 2024. The SEE-AM offers communities and project participants to report adverse social, economic, or environmental impacts caused by USAID-funded activities. Complaints and questions can be submitted to disclosures@usaid.gov.

Just as environmental compliance measures under 22 Code of Federal Regulations (CFR) 216[91] seeks to avoid, minimize, and mitigate impacts, including with solid waste projects and activities, social impacts should be assessed to determine whether there has been a change from baseline conditions for individuals and communities resulting from a USAID project. Furthermore, there may be pre-existing adverse conditions in a local community prior to a USAID-funded activity, which should be taken into consideration to maximize benefit sharing so that proposed USAID-funded activities minimize unintended social consequences, such as impacts on a person's livelihood, economic activities, traditional vocations, land or property rights, access to natural resources, culture and customs, and health and well-being.

7.1 KEY SOCIAL IMPACTS

This section is organized according to the principles presented in USAID's Voluntary Social Impacts Principles Framework.[92] The Voluntary Social Impact Principles Framework encompasses nine principles for considering and assessing potential social risks and social impacts across USAID programs, projects, and activities. Table 5 summarizes the nine principles. For additional information on the nine Principles see the USAID Voluntary Social Impact Principles Framework. The subsequent sections present an illustrative list of potential social impacts pertaining to solid waste projects and activities that Missions and/or Implementing Partners (IPs) should consider.

TABLE 5: USAID SOCIAL IMPACT PRINCIPLES

PRINCIPLE		DESCRIPTION
1	Indigenous Peoples	Indigenous Peoples are a distinct cultural, linguistic, and social group with historical continuity, collective attachment to surrounding natural resources, and/or commitment to maintaining ancestral systems. Specific actions are required of USAID programs involving Indigenous Peoples.
2	Cultural Heritage	Cultural heritage is part of every culture and is found all over the world. It includes archaeological sites, historic buildings, artifacts, and natural environments inherited from past generations as well as intangible knowledge and practices. Working in areas with cultural heritage or on cultural heritage projects can have consequences beyond just destruction of an important resource and can also offer potential means of positively engaging with communities.

[91] USAID. Reg. 216 (22 CFR 216). https://www.usaid.gov/environmental-procedures/laws-regulations-policies/22-cfr-216.
[92] USAID. 2024. "Voluntary Social Impact Principles Framework."https://www.usaid.gov/environmental-procedures/environmental-compliance-esdm-program-cycle/social-impact-assessment.

3	Land Tenure, Displacement, and Resettlement	Land tenure is associated with acquiring and managing rights to land. Land use change may lead to compulsory displacement and resettlement (CDR), and/or the loss of access and/or use of land and natural resources, which should be avoided and minimized to reduce social impacts on affected landholders, tenants, community members, and pastoralists, among other groups. Failure to account for, and respect, the land and resource rights of local community members can cause costly delays, work stoppages, protests, and, in some cases, violence. USAID may face legal actions and suffer financial, brand, or reputational harm.
4	Health, Well-being, and Safety	Health, Well-being, and Safety is safeguarding against potential physical, psycho-social, and health impacts among project staff, program participants, and communities where AID actions are implemented. Individual USAID actions must account for potential occupational health and safety risks, as well as potential uneven socio-economic gains across affected communities/program participants, to avoid unintended consequences.
5	Working with Security Personnel	Cognizance of the unique challenges involved in engaging security personnel, working with security personnel prioritizes a rights-based approach to ensure respect for, and safety of, individuals and local communities. Without transparent and accountable oversight of rule of law, the risks of potential human rights violations increase.
6	Conflict Dynamics	Attentiveness to the operational context in relation to past and present conflicts as well as sensitivity around the role that a USAID action has in shaping the conflict landscape. Poor understanding of conflict dynamics increases the possibility of contributing to or exacerbating conflict.
7	Inclusive Development	Inclusive development is an equitable development approach built on the understanding that every individual and community, of all diverse identities and experiences, is instrumental in the transformation of their own societies, which means providing them with the opportunity to be included, express their voices, and exercise their rights in activities and public decisions that impact their lives. Inclusion is key to aid effectiveness. Nondiscrimination is the basic foundation of USAID's inclusive development approach.
8	Environmental Justice	Environmental Justice (EJ) is the fair treatment and meaningful engagement throughout the project life cycle of marginalized and underrepresented groups and/or people in vulnerable situations, with respect to environmental and/or health impacts and implementation and enforcement of environmental laws. It includes the protection of marginalized and underrepresented groups that may face enhanced vulnerability due to environmental harms caused by any action or activity. Marginalized and underrepresented groups and/or people in vulnerable situations may include (but are not limited to): Indigenous Peoples, LGBTQI+ persons, persons with disabilities, children and other youth, older persons, women, low-income populations, and all

		disadvantaged and marginalized communities across race, color, gender, or national origin.
9	Labor	The Labor principle focuses on advancing worker empowerment, rights, and labor standards through programming, policies, and partnerships to advance sustainable development outcomes. USAID recognizes the high risk of labor abuses that may result from programming, and, thus, USAID works to establish and strengthen labor protections (including social protections) that align with internationally recognized worker rights. This principle includes the promotion of safe and healthy work environments; respecting the principles of freedom of association and collective bargaining; the elimination of forced labor and the worst forms of child labor; and the protection from discrimination at work.

7.1.1 CULTURAL HERITAGE

Cultural heritage is part of every culture and is found around the world. Working in areas with cultural heritage resources can have consequences beyond just the destruction of an important cultural site. It is important to assess cultural heritage when planning for solid waste projects and activities because there may be unintended impacts. Cultural heritage refers to monuments (e.g., architecture, sculptures, elements, or structures of an archaeological nature), groups of buildings, and sites (e.g., archaeological sites, burial sites, areas of human-made and natural features) that are of outstanding universal value from a historical, artistic, scientific, aesthetic, ethnological, or anthropological point of view. Examples of this tangible type of cultural heritage also include moveable objects (including artifacts, paintings, coins, manuscripts, and sculpture), underwater resources or sites (including shipwrecks, ruins, and submerged landscapes), and paleontological remains. In addition to tangible resources, cultural heritage includes intangible resources, which may be aspects of culture, knowledge, history, customs, beliefs, and traditions that may be invisible or not apparent and are often unseen by people who are not of that culture. The United Nations Educational, Scientific and Cultural Organization (UNESCO) states that intangible heritage can include oral traditions and expressions, folklore, beliefs, language, knowledge, performing arts, social practices, rituals, festive events, and traditional craftsmanship.

In order to ascertain whether a project or activity may have unintended impacts on cultural heritage, USAID has released a resource on the potential positive and negative impacts for cultural heritage resources as the result of USAID programming. In addition, several resources are available from the U.S. National Park Service, the International Council on Monuments and Sites, UNESCO, and the International Finance Corporation (IFC) (see footnote). Furthermore, prior to project implementation, it is important to carry out a Social Impact Assessment while including broad and in-depth stakeholder consultations to become aware of the existence of the cultural resources in or nearby the proposed project site.

7.1.2 LAND TENURE, DISPLACEMENT, AND RESETTLEMENT

Land-based projects will likely cause land use change and inherent components of land use change are imminent changes or impacts on land tenure. The impacts will depend on the size of the project—whether it is a small-scale or a large-scale solid waste project.

While small-scale projects and activities will likely not be necessitating large stretches of land to undertake a project, it is important to be cognizant of the social implications that may come about due to land use change. In particular, land use change may have repercussions for land use access, access to land resources, and implications on land tenure and resource claims and rights, due to the siting or placement of projects. Consequently, land use change and the associated repercussions should be assessed early on during the design phase when a project is being proposed.

Land tenure is associated with acquiring and managing rights to land. Loss of access to land and/or resources, changes to the use of land and resources, and/or CDR is to be avoided or minimized to reduce the risk of impoverishment of the affected landholders, tenants, local community, and pastoralists. Failure to account for the land and resource rights of local people can cause costly delays, work stoppages, protests, and, in some cases, violent conflict.

Land tenure is the relationship that individuals and groups of people hold with respect to land and related resources. Land tenure rules define the ways in which property rights to land are allocated, transferred, used, or managed in a particular society. Land tenure issues can be complicated in areas that may not have a formal system of land ownership or of documentation of land ownership. Traditional rights of use (e.g., for hunting and/or gathering) may be allocated at the local level without a legal registration system. These alternate forms of land tenure and land use must be considered when assessing impacts, designing mitigation measures, and determining compensation. These projects should be assessed for the risk of the impingement of use rights.

Land tenure issues may lead to CDR. In the context of solid waste projects and activities, there may be a potential social impact of economic displacement, rather than physical displacement or involuntary resettlement due to the smaller footprint of the project or activity; however, economic displacement may affect local community members. Economic displacement is an impact that should be avoided, minimized, or mitigated.

Economic displacement may occur when a business moves from a valuable location, a worker must travel a greater distance to get to his or her place of employment, or an individual or business loses access to natural resources that provide an economic or survival benefit. Displacement can also have social implications by disrupting or dispersing communities, fracturing social networks, or reducing access to important cultural heritage resources and sites. Resettlement to alternative sites can have negative social impacts on both the resettled population and the established community at the new site, with one or both groups subject to discrimination, prejudice, social conflicts, and/or violence.

There may also be physical displacement. When there is the potential for partial or total physical displacement, economic displacement, or resettlement, the social impacts must be assessed and addressed in an Environmental and Social Impact Assessment (ESIA). USAID's Environmental Compliance Procedures (22 CFR 216) identify resettlement as a class of action with a “significant effect” on the environment and therefore requires, as appropriate, either an EA or Environmental Impact Statement (EIS).

USAID has implemented guidelines that cover CDR93 that may result from USAID programs. Given the importance of stakeholder engagement, an important first step is to review the Agency’s social assessment-related resources, including the Environmental Compliance Factsheet: Stakeholder Engagement in the Environmental and Social Impact Assessment Process.[94] Specific guidelines that USAID[95] and its partners should follow to avoid, minimize, and mitigate CDR risks include the following:

- Understand the legal and institutional contexts.
- Identify all legitimate landholders and relevant risks.
- Develop a Resettlement Action Plan and a Livelihood Action Plan (LAP) if physical displacement is unavoidable.
- Promote informed and meaningful engagement.
- Improve livelihoods and living standards.
- Provide additional protections for marginalized and underrepresented groups and/or people in vulnerable situations, especially women and Indigenous Peoples.

The USAID CDR guidelines[96] are consistent with leading international standards on land and resource tenure, including IFC Performance Standard 5, Land Acquisition and Involuntary Resettlement,[97] and Environmental and Social Standard 5 in the World Bank Environmental and Social Framework.[98]

Resettlement must consider not only the impacts on displaced people but also the impacts on the communities to which the displaced people are resettled. Failure to address the issues of all stakeholders can lead to many challenges, including adverse impacts on project-affected groups and individuals, delays in project implementation, possible cancellation of the project, protests, conflict, and/or violence.

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93 USAID. 2016. "Guidelines on Compulsory Displacement and Resettlement in USAID Programming." https://www.land-links.org/wp-content/uploads/2016/09/USAID_Land_Tenure_Guidelines_CDR.pdf.
94 USAID. 2016. "Environmental Compliance Factsheet: Stakeholder Engagement in the Environmental and Social Impact Assessment (ESIA) Process." https://www.usaid.gov/sites/default/files/2022-05/Stakeholder_Engagement_052016.pdf.
95 USAID. 2024. "Voluntary Social Impact Principles Framework." https://www.usaid.gov/environmental-procedures/environmental-compliance-esdm-program-cycle/social-impact-assessment.
96 USAID. n.d. "Securing Land Tenure and Property Rights for Stability and Prosperity." https://www.usaid.gov/land-tenure.; USAID. 2016. "Why Land Rights Matter." https://2017-2020.usaid.gov/sites/default/files/documents/1865/USAID_Land_Tenure_Infographic_October-2016b.pdf; and
USAID. 2016. "Guidelines on Compulsory Displacement and Resettlement in USAID Programming." https://www.land-links.org/wp-content/uploads/2016/09/USAID_Land_Tenure_Guidelines_CDR.pdf.
97 IFC. 2012. "Performance Standard 5: Land Acquisition and Involuntary Resettlement." https://www.ifc.org/en/insights-reports/2012/ifc-performance-standard-5.
98 International Bank for Reconstruction and Development/The World Bank. 2017. "The World Bank Environmental and Social Framework." Washington, D.C. https://thedocs.worldbank.org/en/doc/837721522762050108-0290022018/original/ESFFramework.pdf.

7.1.3 HEALTH, WELL-BEING, AND SAFETY

Specific choices around project design and implementation invariably have the potential to influence health, well-being, and safety. Assessing and managing the potential social impacts related to health, well-being, and safety of solid waste projects and activities requires a careful and sustained effort.

For example, the decomposition of solid waste can leach into the ground-polluting waterways. Furthermore, road construction, which may be part of the project, could lead to unintended impacts on the local community because the trucks that transport waste to the facility may cause noise, air pollution, dust, and a foul smell. Furthermore, truck traffic may result in negative changes to local road traffic patterns, causing an increase in pedestrian-related accidents or spillage of potentially hazardous waste, and therefore should be planned for ahead of time. Public safety risks also may arise, depending on the waste management project being proposed, which should be taken into consideration.

Municipal waste management activities are carried out for the benefit of human health. However, in themselves, they can be associated with a wide range of public health and occupational health and safety impacts. Box 6 provides examples of these impacts.

BOX 6: EXAMPLES OF PUBLIC HEALTH AND OCCUPATIONAL HEALTH AND SAFETY IMPACTS

- Hazardous gas emissions from landfills and dumps can lead to human health impacts through toxicity, fires, and explosions. People can be exposed to landfill gas in the air in the proximity of the site, or gas can migrate through the ground where it can accumulate in confined spaces (e.g., basements, tunnels, pipes).
- Landfill gas contains CH4, which is a highly combustible gas, that presents a risk of fire, explosion, or low-level toxicity. Landfill gas also can contain small amounts of hydrogen sulfide, nitrogen dioxide, ammonia, and VOCs, which can be harmful to human health.
- Whether waste emissions pose a health hazard depends on the chemical concentrations to which people are being exposed and the duration of the exposure. Many exposures involve chemicals at low or trace levels, as well as mixtures of chemicals.
- Particulates and toxic fumes from fires may be released in smoke. The toxicity of the fumes and smoke depends on the source material. Tires, batteries, and hazardous chemicals, as well as consumer products, such as plastics, pesticides, paints, solvents, or cleaners, can lead to toxic releases when burned.
- The production of dioxins and furans (potential carcinogens) are also a documented risk factor from burning waste, including at municipal incinerators. People working at, or living adjacent to, landfills and dumpsites with fires can be directly exposed to toxic fumes.
- Most fires at landfills are small surface fires; however, under certain conditions, they can escalate into a major incident with impacts over a large area. Fires at waste dumps and landfills also can burn underground in the absence of oxygen and without flames. Such fires may not be

apparent at the surface, are extremely difficult to combat, and can burn for days or even weeks. Subsurface fires also can cause the collapse of slopes.

- Landfills and other waste management facilities that contain hazardous materials can represent a hazard to workers, pickers, and nearby populations. Pathways could include physical contact by unprotected workers, inhalation of fugitive dust and fumes, and ingestion of contaminated water or food.
- Informal work at waste sites can be dangerous and proper health and safety precautions are often absent. Under such conditions, workers may be at risk of injuries, diseases, and psychological trauma. Major occupational hazards for workers include being struck by vehicles and plant equipment, burns, being buried under collapsing waste piles, infections, and chronic respiratory diseases.
- Odor from decomposing waste (e.g., sulfides, ammonia) and the presence of volatile chemicals can cause a nuisance for nearby communities. Odor often prompts complaints and people also may have concerns about health effects. Temporary storage and transportation of waste also can lead to odor impacts, especially in hot climates.
- Regular exposure to elevated noise levels can cause annoyance and lead to physical and psychological health consequences, including hypertension, heart disease, and sleep disturbance. Unprotected workers in waste facilities with elevated noise can face hearing impairment. Noise is a common complaint from populations near waste facilities in residential areas and on collection and transportation routes.
- Contamination (of surface water and groundwater) by leachate and other pollutants from waste sites can enter potable water supplies. The risks associated with contamination of water sources is elevated if a landfill or dumpsite contains hazardous waste. If ingested, pathogens and toxins can cause significant health problems. The likelihood of this occurring is increased in the developing world, as many people rely on informal or untreated water sources.
- Landfills, dumpsites, and open transfer stations in the proximity of airports are a safety hazard. Birds that are attracted to these sites can threaten aircraft.
- Incidences of landfills and dumpsites collapsing are well documented. Such incidents have led to injury and fatalities among workers, as well as among the people occupying homes in adjacent (usually informal) settlements. Following collapse, there is the added risk of the material catching fire. Earthquakes also can cause landfill/dumpsite collapse.
- The risk of flooding can be exaggerated due to the presence of waste accumulated in drainage systems. Flooding also can mobilize waste from dumpsites and facilities, leading to materials that are harmful to human health or the environment dispersing over a wide area.
- The presence of waste and debris following flooding and storms also can hamper rescue and recovery activities.

International best practices, namely IFC Performance Standard 4: Community Health, Safety, and Security[99], provide additional guidance on potential social impacts on health and well-being.

7.1.4 CONFLICT DYNAMICS

USAID's projects are often implemented in fragile or conflict-affected environments. USAID's work encompasses investments in conflict prevention and mitigation, stabilization, and peace building, parallel to investments in other sectors. Understanding conflict dynamics and how a solid waste project and activity affects or is being affected by these dynamics is an essential component of being conflict aware and conflict sensitive[100].

For example, the proposed siting of a new solid waste management project may spur conflict between two different groups in the local community and cause local tensions because the members of the local community do not want a new waste management facility placed near their homes or place of business as this siting may affect property values or be a deterrent for patrons to visit local businesses. The establishment of new waste management and/or treatment facilities may be targeted by "not in my backyard" campaigners who are concerned about the effect of these facilities on their communities and on the environment.

There may be historical grievances that come to light due to proposing a project or activity associated with this sector to benefit one group of people over another, or due to siting and placement of the project, which may exclude one group over another, thus exacerbating local tensions. Therefore, conflict dynamics at the site level should be understood during the design phase by means of engaging stakeholders in a participatory approach and assessing conflict

[99] IFC. 2012. Performance Standard 4: Community health, Safety, and Security. https://www.ifc.org/en/insights-reports/2012/ifc-performance-standard-4.
[100] USAID. 2024. "Voluntary Social Impact Principles Framework." https://www.usaid.gov/environmental-procedures/environmental-compliance-esdm-program-cycle/social-impact-assessment.

dynamics. Additional resources and guidance on conflict dynamics may be found in the footnotes.[101]

7.1.5 ENVIRONMENTAL JUSTICE

Environmental justice (EJ) is the fair treatment and meaningful stakeholder engagement throughout the project life cycle of all project-affected persons, particularly marginalized and underrepresented groups and/or people in vulnerable situations with respect to environmental and/or health impacts, and implementation and enforcement of environmental laws. It includes the protection of marginalized and underrepresented groups and/or people in vulnerable situations that may face enhanced vulnerability due to environmental harms caused by any action or activity. It also includes equitable access to environmental benefits and/or ecosystem services that a project may enhance. Marginalized and underrepresented groups and/or people in vulnerable situations may include (but are not limited to): Indigenous Peoples, LGBTQI+ persons, persons with disabilities, children and other youth, older persons, women, low-income populations, and all disadvantaged and marginalized communities across race, color, gender, or national origin.[103]

Meaningful stakeholder engagement entails:

- People from diverse social groups are provided with an opportunity to participate in decisions about activities that may affect their environment, livelihoods, well-being, and/or health;
- The public's contribution can influence the agency's decision;
- Community views, perspectives, and concerns will be considered in the decision-making process; and
- Decision makers will seek out and facilitate the stakeholder engagement process with potentially affected people[102]

The main objective is to provide a framework for assessing adverse environmental and social impacts of USAID programs on marginalized and underrepresented groups and/or people in vulnerable situations and to provide guidance to USAID staff and Ips on identifying and stakeholder engagement with marginalized and underrepresented groups and/or people in vulnerable situations. Further guidance on EJ is available in the USAID Voluntary Social Impact Principles Framework (see footnote below).[104]

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[101] USAID. n.d. *Technical Publications on Conflict Management and Mitigation.* https://www.usaid.gov/conflict-violence-prevention/technical-publications; USAID. 2024. "Voluntary Social Impact Principles Framework." https://www.usaid.gov/environmental-procedures/environmental-compliance-esdm-program-cycle/social-impact-assessment.

[102] USAID. 2024. "Voluntary Social Impact Principles Framework." https://www.usaid.gov/environmental-procedures/environmental-compliance-esdm-program-cycle/social-impact-assessment.

[103] Ibid.

[104] Ibid.

7.1.6 LABOR

Solid waste projects may involve workers. Each project implementer should be aware of the International Labor Organization's (ILO) conventions[105] that the host country has signed. Adherence to ILO's core labor standards is essential. The ILO core labor standards address freedom of association, collective bargaining, abolition of forced labor and the worst forms of child labor, minimum age, equal remuneration, discrimination, and the protection of children and young persons. Even for countries that do not adopt one or more standards, they are fundamental to the protection of the workforce. USAID's Agency-Wide Counter-Trafficking in Persons Code of Conduct has the goal of prohibiting USAID contractors, subcontractors, grantees, and sub-grantees from engaging in trafficking in persons, procuring commercial sex acts, or using forced labor. Please refer to the guidance in the footnote.[106]

7.2 OTHER SOCIAL CONSIDERATIONS

7.2.1 THE ROLE OF STAKEHOLDER ENGAGEMENT

Stakeholder engagement provides a systematic approach to Missions and Implementing Partners to acquire stakeholders' input, information, feedback, local and traditional knowledge,

[105] As per IFC Performance Standard 2, this Performances Standard recognizes that "the pursuit of economic growth through employment creation and income generation should be accompanied by protection of the fundamental rights of workers and must respect several International Labor Organization (ILO) Conventions, including ILO Convention 87 on Freedom of Association and Protection of the Right to Organize; ILO Convention 98 on the Right to Organize and Collective Bargaining; ILO Convention 29 on Forced Labor; ILO Convention 105 on the Abolition of Forced Labor; ILO Convention 138 on Minimum Age (of Employment); ILO Convention 182 on the Worst Forms of Child Labor; ILO Convention 100 on Equal Remuneration; ILO Convention 111 on Discrimination (Employment and Occupation); UN Convention on the Rights of the Child, Article 32.1; and the UN Convention on the Protection of the Rights of all Migrant Workers and Members of their Families" (IFC. 2012b. "Performance Standard 3: Resource Efficiency and Pollution Prevention." https://www.ifc.org/content/dam/ifc/doc/2010/2012-ifc-performance-standard-3-en.pdf.)

[106] Alliance 8.7. n.d. Ending Forced Labour, Modern Slavery, Human Trafficking and Child Labour. https://www.alliance87.org/.; Department of Labor. n.d. "Comply Chain: Business Tools for Labor Compliance in Global Supply Chains." https://www.dol.gov/general/apps/ilab-comply-chain.; ILO. 2011. "Convention 189: Domestic Workers Convention." https://normlex.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:12100:0::NO::P12100_ILO_CODE:C189.; Rainforest Action Network. 2017. "Workers' Rights and Environment Justice."https://www.ran.org/issue/workers-rights-and-environmentaljustice/#:~:text=Workers%20are%20exploited%2C%20exposed%20to,care%2C%20food%2C%20and%20education.; Responsible Sourcing Tool. n.d. "Is Forced Labor Hidden in Your Global Supply Chain." https://www.responsiblesourcingtool.org/.; The White House. 2023. "Memorandum on Advancing Worker Empowerment, Rights, and High Labor Standards Globally." https://www.whitehouse.gov/briefing-room/presidential-actions/2023/11/16/memorandum-on-advancing-worker-empowerment-rights-and-high-labor-standards-globally/.; United Nations. 2023. "Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all." https://sdgs.un.org/goals/goal8.; USAID. 2023. "ADS Chapter 225: Program Principles for Trade and Investment Activities and the "Impact on U.S. Jobs" and "Workers' Rights"." https://www.usaid.gov/about-us/agency-policy/series-200/225.

local perspectives, and concerns early on, during the design and planning phase, well before the assessment of the social impacts phase, as well as should be sustained throughout the entire project life cycle[107]. Stakeholders may be groups or individuals from the private or public sector, as well as individuals who may be considered an affected party along with those who may have interests in a project or the ability to influence its outcome, either positively or negatively. Members of civil society organizations may also be considered such as youth groups, church groups, or women's clubs. Special attention should be paid to marginalized and underrepresented groups and/or people in vulnerable situations because they may be inequitably affected by a project.

Stakeholder mapping, engagement, and consultation are key steps in the planning process of solid waste projects and activities and will also be crucial in identifying opportunities for the inclusion of marginalized and underrepresented groups and/or people in vulnerable situations. [108] Stakeholder engagement should be a broad, inclusive, and continuous process. The benefit of beginning the stakeholder engagement process early on and sustaining it throughout the entire project life cycle is that it may allow for the co-creation[109] of positive benefits, for example identifying mitigation measures regarding the social impacts based on traditional knowledge from local community members, through adaptive management. Information on best practices for stakeholder engagement is available in the USAID document entitled Environmental Compliance Factsheet: Stakeholder Engagement in the Environmental and Social Impact Assessment (ESIA) Process.[110]

7.2.2 LOCAL COMMUNITY

When planning and designing solid waste projects and activities, the local community in which the project will be embedded should be assessed. This assessment may be addressed prior to assessing potential social impacts by means of undertaking a desktop review of the characteristics of the community, such as demographics; socioeconomic composition; and political, institutional, and legal frameworks, as well as through field visits and stakeholder engagement. Although the particulars of identifying social impacts for solid waste projects and activities depends on the site location, and local context, undertaking stakeholder engagement early on is necessary to improve the understanding of how the proposed project may affect the local community. If stakeholders in a local community voice concerns regarding potential negative social impacts due to a proposed project, the social impacts may be assessed, and

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[107] USAID. 2022. "Community Engagement Guide." https://www.climatelinks.org/sites/default/files/asset/document/2022-04/5a.%201_Community%20Engagement%20Reference%20Guide_30Mar22_508.pdf.

[108] USAID. 2016. "Environmental Compliance Factsheet: Stakeholder Engagement in the Environmental and Social Impact Assessment (ESIA) Process." https://www.usaid.gov/sites/default/files/2022-05/Stakeholder_Engagement_052016.pdf.

[109] USAID defines co-creation as a process that "brings people together to collectively design solutions to specific development challenges. Time limited and participatory, partners, potential implementers, and end-users define a problem collaboratively, identify new and existing solutions, build consensus around action, and refine plans to move forward with program and projects." For additional information see https://www.usaid.gov/co-creation-usaid.

[110] USAID. 2016. "Environmental Compliance Factsheet: Stakeholder Engagement in the Environmental and Social Impact Assessment (ESIA) Process." https://www.usaid.gov/sites/default/files/2022-05/Stakeholder_Engagement_052016.pdf.

mitigation and monitoring measures designed. Management measures should be commensurate with the degree of the identified adverse social impacts. In cases where social impacts from project activities are deemed to adversely affect the lands, rights, and livelihoods of individuals and communities, implementation of the project should be reconsidered (i.e., potentially ended). If/when the project is under implementation, the local community is adversely impacted, implementation of the project may need to be curtailed until adequate management measures have been designed and implemented to mitigate the identified impacts.

Box 7 presents several types of potential impacts to the community for consideration, including potential economic impacts.

BOX 7: EXAMPLES OF COMMUNITY IMPACTS

- Waste management activities and sites can lead to visual and amenity impacts when located in residential areas. Unsightly waste sites, litter, dust, noise, and odor can affect the quality of life in nearby communities, as well as affecting land/property values and businesses.
- Workers' welfare and rights may not be prioritized by some employers and governments, with many working under poor conditions for very low income. Informal waste activities are often carried out by vulnerable populations, including children and the elderly, who may face increased risks of health problems or being victims of crime or exploitation.
- In some cases, activities in the waste management sector can be associated with incidences of corruption. Corrupt contracting practices, graft, and illegal trading and dumping of hazardous and other waste are examples of opportunities for corrupt officials and criminals.
- Traffic impacts are a major consideration when implementing waste management activities. Traffic accidents involving waste vehicles can result in spillage of hazardous materials (e.g., clinical and industrial waste, contaminated soils).
- While the import of recyclable materials is an important generator of foreign currency, employment, and materials for industry, the environmental and social costs may offset the economic gains.
- The presence of dumpsites and litter can reduce the value of land and property. The buildup of plastic debris on beaches can affect coastal areas ' attractiveness to tourists.
- Projects and activities aimed at improving waste management may increase capital and operational expenditures for public authorities, businesses, and taxpayers, and can divert funds from other programs.

7.2.3 GENDER EQUALITY

Many social impacts are gender differentiated and can affect men and women in different ways. USAID seeks to support gender equality with the following goals: (1) improve the lives of people by advancing gender equality; (2) empower women and girls to participate fully in, and equally benefit from, the development of their societies on the same basis as men; and (3) secure equal economic, social, cultural, civil, and political rights regardless of gender. USAID policy requires that a Gender Analysis “be integrated in strategic planning, project design and approval, procurement processes, and measurement and evaluation” as part of ADS 205: Integrating Gender Equality and Women's Empowerment in USAID’s Program Cycle, which seeks to integrate gender and equality into the program cycle.[111]

Special attention must be paid to how solid waste projects and activities may affect women and girls. Gender Analysis[112] “is a systematic analytical process used to identify, understand, and describe gender differences and the relevance of gender roles and power dynamics in a specific context.” Such analysis[113] typically involves examining the differential impact of development policies and programs on women and men and may include the collection of sex-disaggregated or gender-sensitive data. Gender Analysis examines the “different roles, rights, and opportunities of men and women and relations between them. It also identifies disparities, examines why such disparities exist, determines whether they are a potential impediment to achieving results, and looks at how they can be addressed.”[114] Furthermore, there may be gender divisions in the decision-making process that may influence how the placement of the project may be proposed.

Disparate gender impacts on solid waste projects and activities may involve imbalances in stakeholder input, decision making, employment opportunities, and monetary compensation for project impacts. A Gender Analysis helps to identify gender disparities in the community early on. Because USAID projects require stakeholder engagement and consultation as part of the process of identifying, avoiding, and mitigating adverse social impacts, it is increasingly important to be aware of gender-based barriers to public participation. In these cases, stakeholder engagement and consultations may need to occur in a gender sensitive manner, for instance by having separate venues for men and women. To acquire input and feedback from women, a combination of methods may be undertaken (such as interviews and focus groups). For, instance semi-structured interviews or women-only focus groups may be conducted with women in a safe space such as an individuals’ home or place of worship. Providing a space in which to obtain women’s perspectives may shed light on a potential gender division in decision making and consultation, and in turn could impact siting and benefit sharing.

Examples of social impacts and the associated mitigation measures are provided in Table 7 in Section 8 *Impact Mitigation, Enhancement, and Monitoring*.

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[111] USAID. 2023. "ADS Chapter 205: Integrating Gender Equality and Women's Empowerment in USAID’s Program Cycle." https://www.usaid.gov/about-us/agency-policy/series-200/205#:~:text=USAID%20has%20adopted%20several%20comprehensive,fully%20exercise%20their%20rights%2C%20determine.

[112] USAID. 2023. "2023 Gender Equality and Women's Empowerment Policy." https://www.usaid.gov/document/2023-gender-equality-and-womens-empowerment-policy.

[113] USAID. 2011. "Tips for Conducting a Gender Analysis at the Activity or Project Level." https://pdf.usaid.gov/pdf_docs/PDACX964.pdf.

[114] USAID. 2023. "2023 Gender Equality and Women's Empowerment Policy." https://www.usaid.gov/document/2023-gender-equality-and-womens-empowerment-policy.; USAID. n.d.(f). *USAID Websites with Gender-Related Issues.* Accessed 2024. https://www.usaid.gov/what-we-do/gender-equality-and-womens-empowerment/usaid-websites-related-gender-resources.

8. IMPACT MITIGATION, ENHANCEMENT, AND MONITORING

8.1 MITIGATION AND IMPLEMENTATION HIERARCHY

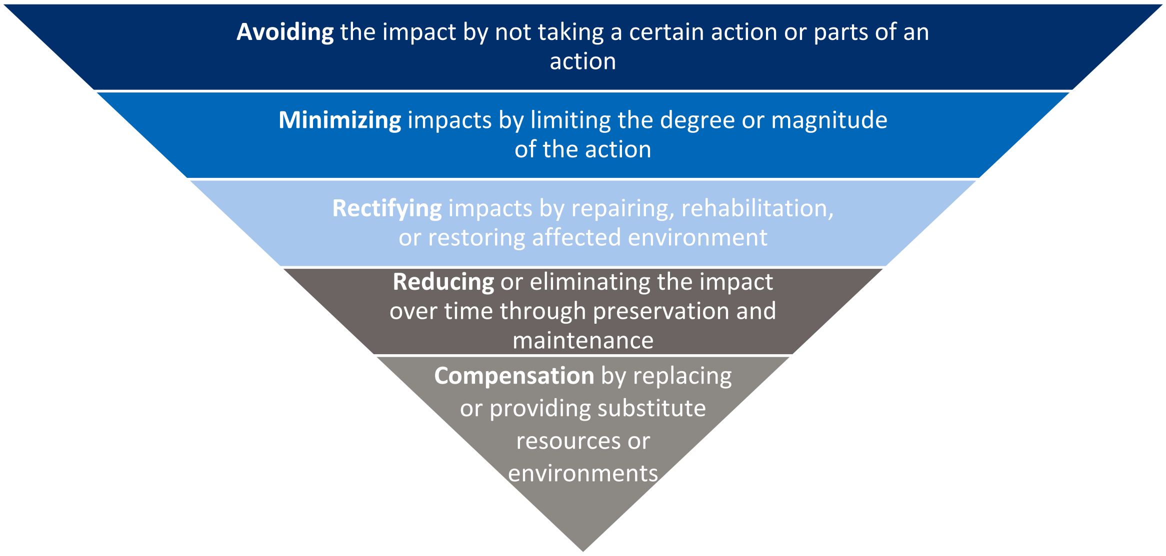
Where impacts are identified, it is necessary to work though possible mitigation and enhancement measures to manage impacts. Mitigation is the identification and application of measures to avoid, minimize, or remedy impacts. These may be defined as part of a formal EIA process and can be implemented at all stages of the project cycle. However, the earlier that impacts are considered, the more likely they can be avoided. “Mitigation” is defined[115] as any activity that includes the following:

- Avoiding the impact altogether by not taking a certain action or parts of an action.
- Minimizing impacts by limiting the degree or magnitude of the action and its implementation.
- Rectifying the impact by repairing, rehabilitating, or restoring the affected environment.
- Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.
- Compensating for the impact by replacing or providing substitute resources or environments.

Those responsible for designing or implementing projects or activities should prioritize mitigation measures in line with the “mitigation hierarchy,” as illustrated in Figure 13.

FIGURE 13. MITIGATION HIERARCHY

[115] Defined under 40 CFR 1508.20, related to the US National Environmental Protection Act (Council on Environmental Quality. 2020. Code of Federal Regulations: Title 40, Part 1508 (40 CFR Part 1508). Council on Environmental Quality, Executive Office of the President, National Archives. https://www.ecfr.gov/current/title-40/chapter-V/subchapter-A/part-1508.)


Avoiding the impact by not taking a certain action or parts of an action
Minimizing impacts by limiting the degree or magnitude of the action
Rectifying impacts by repairing, rehabilitation, or restoring affected environment
Reducing or eliminating the impact over time through preservation and maintenance
Compensation by replacing or providing substitute resources or environments

8.2 GOOD MANAGEMENT PRACTICES IN PLANNING AND DESIGN

USAID-funded projects and related interventions or activities should be designed to maintain or improve environmental, health, or sociopolitical systems, as well as minimize negative impacts. Projects should be designed to meet good international industry practices and should follow the steps outlined in Reg. 216.[116]

Environmental Mitigation and Monitoring Plans (EMMPs) are now required for most USAID-funded projects.

8.3 OPERATIONAL STAGE MITIGATION AND MONITORING

It is essential that project managers engage environmental and social specialists to assist in identifying opportunities to avoid and minimize impacts. In countries where project infrastructure for supporting good environmental and social management is lacking, it is important that Mission leaders take a proactive role in determining local solutions that achieve the best practices set out in the SEGs and nationally or internationally accepted standards.

The mitigation tables below serve as a reference on possible operational impacts and associated measures that can be planned for and implemented throughout the life cycle of a project or activity, the objectives of these measures, and the indicators that may be used to monitor impacts. They are general references and the specific characteristics of each project context should be considered before applying them.

These mitigation and monitoring tables are organized by environmental or social component (e.g., air quality, social). For implementation, a column identifying the person or entity responsible for implementation within an organization should be included in the EMMP.

For environmental and social mitigation measures related to the construction stage, refer to the Construction SEG, available at USAID's Sector Environmental Guidelines & Resources webpage, accessible at https://www.usaid.gov/environmental-procedures/sectoral-environmental-social-best-practices/sector-environmental-guidelines-resources.

[116] USAID. n.d.(c). *Reg. 216 (22 CFR 216).* Accessed 2024. https://www.usaid.gov/environmental-procedures/laws-regulations-policies/22-cfr-216.

TABLE 6. REFERENCE GUIDE FOR OPERATIONAL MITIGATION MEASURES AND MONITORING

CATEGORY	MITIGATION / ENHANCEMENT EXAMPLES	MONITORING EXAMPLES
Air quality	Emissions from landfills are typically controlled by installing a gas collection system and combusting the collected gas (e.g., flares or gas engines). Gas collection systems are not 100% efficient in collecting landfill gas, so emissions of CH4 and non-methane organic carbon still occur. Emissions from the open burning of waste should be managed through the prevention of fires. The stockpiling of large volumes of flammable materials (e.g., recyclables, wood, paper and plastic bales, tires) should be avoided or carefully managed, and open burning should be especially prevented where hazardous materials are present or nearby. Landfill gas collection systems are effective at reducing the risk of fires at landfill sites. However, the overdrawing of landfill gas also is a fire risk. Effective fire control measures are required where there is a risk of fire, including the development of fire prevention and response plans, communication with emergency responders (where available), training of operations staff, and the provision of firefighting equipment. Equipment may include fire suppression systems (water hoses and retardants) or stockpiles of sand/dirt to cover fires. Subsurface fires at landfills are more difficult to manage and may require specialized firefighting equipment. Pollution prevention systems (PPS) should be installed where exhausts (e.g., chimneys from incinerators and gas engines, generators or ventilation) may cause releases to air that exceed statutory limits or cause ambient air quality standards to be exceeded. Examples of PPS technologies are filters, catalysts, scrubbers, condensers, and pressure swing adsorption. Operational control measures, such as reducing outputs or shutting off equipment when limits are reached, also may be employed. Reduce dust generation at exposed areas, working areas, and stockpiles at waste sites (e.g., landfills, transfer stations):	• Emissions of CH4 and NMOCs at site boundary or sensitive receptors • Thermal monitoring to identify subsurface fires at landfills • Continuous monitoring of emissions from incinerators (using Continuous Emission Monitoring System [CEMS])[118] • Dust monitoring (e.g., total particulate matter [TPM], particulate matter < 10 microns in diameter [PM10], and respirable suspended particulates [PM2.5]) • Direct monitoring of odor at boundary/sensitive receptors or the recording of complaints

[118] US EPA Air Emission Measurement Center (EMC) provides additional information on Continuous Emission Monitoring Systems, located at https://www.epa.gov/emc/emc-continuous-emission-monitoring-systems.

CATEGORY	MITIGATION / ENHANCEMENT EXAMPLES	MONITORING EXAMPLES
	• Cover exposed areas of ground and stockpiles to prevent windborne dust. Areas can be covered temporarily with tarp, mulch, or gravel, and the earth compacted, grassed/vegetated, or paved. Vehicles carrying waste also should be covered. Stockpiles, landfill working face, and haul roads can be dampened with fixed water sprayers, hoses, or water bowser trucks. Spraying should be carried out such that areas are not overwatered or underwatered and it is applied evenly. Spraying may be effective during the loading or tipping of dusty materials and during excavation or leveling works. Natural or artificial wind breaks can be used to prevent the erosion of stockpiles and exposed areas or around dust-generating activities. • Dust-generating activities should be limited during high wind conditions. • Designate and implement speed restrictions for vehicles on unpaved roads or areas. Reducing speed from 45 to 35 miles per hour can reduce dust emissions up to 22%.[117] Complaints about odor can be reduced or prevented by enclosing waste facilities and vehicles. Facilities can be operated at negative pressure using extractive fans and exhaust systems. The air in the exhaust systems can be treated by various methods, including biofilters, scrubbers, and ultraviolet light. Scented additives are sometimes used to mask odor; however, preventative measures should be prioritized.	

[117] Washington State Department of Ecology. 2003. "Alternatives to Hazardous Materials: Techniques for Dust Prevention and Suppression." https://www.yakimacounty.us/DocumentCenter/View/2521/Appendix-A-Dust-Suppression-Ecology-PDF?bidId.

CATEGORY	MITIGATION / ENHANCEMENT EXAMPLES	MONITORING EXAMPLES
Noise and vibration	Noise mitigation techniques that may be used during the operation of plant and equipment at waste facilities include: Locate noisy equipment and activities away from sensitive receivers and avoid the clustering of noisy plant /processes in one area. • Screen noise using permanent or temporary barriers, or existing structures/natural features. • Carry out noisy activities (e.g., unloading, compaction) within enclosed areas. • Select a quiet plant and processes wherever feasible. • Maintain plant and equipment in good working condition. • Turn off machinery when not in use. • Train staff to raise their awareness of noise impacts and management. Noise mitigation techniques used for mobile plant/vehicles at waste facilities and during transportation may include the following: • Implement speed restrictions to keep vehicle speeds as low as practical in facilities and during waste transportation. • Minimize vehicle movements (e.g., practice backloading). • Reduce vehicle movements and noise at night and early in the morning. • Route deliveries away from urban areas, where practicable. • Use quiet and well-maintained vehicles. • Appropriate surfacing of access roads and operational areas also can reduce noise. • Train drivers on operational noise control measures (e.g., vehicle speeds, controlled acceleration, use of horn, correct access/egress to sites, limiting the idling/revving of engines). Where noise is generated 24 hours a day, the activity should be inaudible at the nearest residential sensitive receptor at night.	• Noise level checks on equipment and background • Offsite traffic noise: Noise emission checks on vehicles • Vibration monitoring

CATEGORY	MITIGATION / ENHANCEMENT EXAMPLES	MONITORING EXAMPLES
Pollution of surface waters and groundwater	Water and groundwater pollution impacts caused by runoff from waste sites can be controlled, managed, or mitigated by implementing the following measures: • Prevent run-on (from upland areas) from flowing onto the site and contacting waste and ensure that the site is adequately protected from flooding. Control runoff so that it is diverted from active waste management areas and does not create pools or saturated soil conditions. • Erosion and sedimentation control measures, such as minimizing activities during heavy rain, and reducing, compacting, covering, or vegetating areas of exposed soil. Provide and regularly maintain stormwater drainage system, including sediment control (e.g., silt traps). Treatment may be required in contaminated and sensitive locations. • Install containment (e.g., bunding, drip trays) in high-risk areas (e.g., operational areas, fixed equipment, storage areas). • Locate and manage waste stockpiles to reduce runoff impacts. • Regularly clean waste sites and provide cleaning and wheel wash facilities for vehicles at site access/egress; suspended solids should be removed from used washing water prior to disposal. • Prevent, control, and clean up litter to prevent it from entering nearby waters. • Emergency plans should be developed to deal with accidental spillage and leakage. Leaks and spills should be contained and cleaned up immediately. Train staff to clean up leaks and spills and provide clean-up equipment. • Maintain equipment to prevent leaks. The maintenance of vehicles and equipment should take place on a covered hard-standing. • Use green infrastructure, such as bioswales, green roofs, and water harvesting. • Use fire suppression equipment that is designed to minimize the impacts on ground and water from runoff. • Avoid discharging wastewater into waters where it exceeds discharge standards or causes receiving waters to exceed (or further exceed) ambient water quality standards or objectives. Where permissible, sites can be connected to the sanitary sewer system, or for small quantities, effluents may be transported by tankers to municipal sewage treatment plants (although this	• Monitoring of (post-treatment) discharges (including stormwater and effluent) for contaminants of concern • Monitoring of receiving or hydrologically connected waters via sampling and testing or real-time monitoring (e.g., buoy measuring conductivity, turbidity) • Visual monitoring of litter • Groundwater monitoring (e.g., installation of piezometers/monitoring wells, in situ monitoring equipment with data loggers, field monitoring and sampling, laboratory testing)

CATEGORY	MITIGATION / ENHANCEMENT EXAMPLES	MONITORING EXAMPLES
	is expensive and causes additional logistical impacts). If necessary, on-site treatment systems can be used to bring effluents to the appropriate quality for discharge (to waters or sewers). Primary treatment usually includes the removal of sediments by filtration or settlement (often using flocculants and decanters) and grease traps. Secondary (or tertiary) treatments, such as biological treatment or reverse osmosis, may be required for some effluents (e.g., AD liquors, landfill leachate). Complex on-site effluent treatment systems can be expensive and difficult to supply and maintain. Alternatives include the use of evaporation ponds and the recycling of leachates within landfill cells or processes (e.g., anaerobic digestion or composting). • Leachate contamination of waters and groundwater from landfills can be prevented or minimized through containment (e.g., impermeable lining systems and capping), capture (i.e., leachate collection systems), and treatment (e.g., effluent treatment technologies or evaporation ponds). Hazardous materials should not be placed in unlined landfills and should be managed appropriately when stored on site. • Carry out regular inspections and install leakage detection systems on underground storage tanks, aboveground storage, and pipelines that represent a potential source of groundwater pollution. • Where groundwater contamination is present, impacts can be reduced though well extraction in the affected area and appropriate treatment prior to discharge or reinjection. Hydraulic barriers can be installed to divert groundwater flows around sources or contamination. • Disposal to waters may be a management option for inert waste under some circumstances. However, this activity should be highly regulated and controlled, and must not take place in ecologically sensitive areas. Silt curtains can be used to limit turbidity from the disturbance of sediments to the immediate area. Booms can be used to capture floating litter. • Sanitary latrines should be provided to prevent impacts from human waste, including for informal workers. These should be connected to the municipal sewage network or regularly emptied by a licensed contractor for appropriate disposal. • Where impacts on waters have occurred, it may be necessary to remediate the affected waters or provide compensation or enhancements on-site or in other areas.	

CATEGORY	MITIGATION / ENHANCEMENT EXAMPLES	MONITORING EXAMPLES
Soil/ Sediment quality and land contamination	The contamination of soil and sediments can be prevented, controlled, or mitigated by implementing the pollution prevention and control measures (described in the *Pollution of Surface Waters and Groundwater* section above). At landfills and dumpsites, incoming waste materials should be screened so that hazardous materials can be identified and appropriately managed. Hazardous waste should not be disposed of in an unlined or uncontrolled landfill or dumpsite. Illegal dumping of waste and hazardous waste should be prevented through appropriate policies and policing to avoid the contamination of sites. Adopt a cradle-to-grave waste management system that includes good handling practices in storage, collection, transportation, recycling, and disposal. Hazardous waste may require testing for toxicity, leachability, and other properties prior to disposal in an appropriate facility (e.g., high-temperature incineration or double-lined landfill). Where contaminated land, soil, or sediment exists and this represents a risk to human health and/or the environment, it may be necessary to implement control or remediation measures. Such measures may include containment of the contamination (e.g., capping, lining, or hydrological barrier), removal of the source of contamination or contaminated materials (e.g., hazardous waste in a dumpsite), the stabilization of materials (e.g., cement mixing), or in situ remediation (e.g., biological, chemical, or thermal treatment). Where soils are contaminated, it is likely that groundwater also is contaminated. Remediation may therefore include pumped extraction and treatment of groundwater. When removing or remediating materials, it is important that precautions are taken to avoid further disturbance and dispersal of contaminants. Contaminated sediments are usually removed or stabilized in situ. Removal may be done by capital or environmental dredging techniques or by installing a cofferdam and excavating the materials “in the dry.” If it is not practical to remediate contamination at existing (operational or closed) waste sites, affected areas should be controlled such that human health risks are minimized (e.g., close and secure areas of the site, provide PPE, move affected communities).	• Automatic leak detection systems for pipes and underground tanks • Leachability testing of potentially contaminated soil/sediments to determine the disposal risk • Visual surveys for the presence of invasive species • It may be necessary to carry out monitoring/surveys seasonally, depending on the affected species/habitats.

CATEGORY	MITIGATION / ENHANCEMENT EXAMPLES	MONITORING EXAMPLES
	Waste management staff should be given environmental training that includes ecological awareness. Mitigation plans should be in place for staff should they encounter threatened or endangered wildlife (e.g., nesting, in burrows, trapped on the site) to avoid harm to animals. Temporary suspension of activities may be necessary should threatened or endangered wildlife be encountered. Activities at waste sites may need to be modified at certain times of year when threatened or endangered wildlife are present (e.g., breeding, staging, migration, hibernation seasons). Staff also may be trained to identify and manage potential invasive plant species. In sensitive areas for wildlife, and where it represents a risk, hunting and fishing bans could be considered. Vehicles should also yield right-of-way to wildlife. Where water is abstracted from rivers for use at waste management sites, ensure that intake pipes are screened to prevent taking in fish.	

The social impacts discussed in Table 7 are for illustrative purposes only and do not provide an exhaustive list because the social impacts identified for solid waste projects and activities will depend on the site location and the specifics of a proposed project, as well as the local context, among other factors. The mitigation and monitoring measures also are described below and are not an exhaustive list.

TABLE 7. POTENTIAL SOCIAL IMPACTS FOR SOLID WASTE ACTIVITIES

SOCIAL IMPACT	MITIGATION MEASURES	MONITORING CONSIDERATIONS
Land Tenure Changes in land tenure may adversely affect the local community. For example, the development of supporting infrastructure, such as roads for the collection and transportation of solid waste, can result in the loss of land	• Draft a stakeholder engagement plan (SEP) • Consider alternatives in the design phase, which include stakeholders' perspectives, concerns, and views • Engage with stakeholders on a continual basis to assess the placement or siting of the roads necessary for the collection or transportation of waste in a manner that will have the least impact on the local community. • Conduct research to identify locally appropriate technology, improve decision-making regarding supporting infrastructure sch as roads and the collection and transportation solid. • Set up a grievance redress mechanism for project-affected people.	• Periodically review the SEP. • Periodically review the reports land tenure changes and the stakeholders affected. • Keep a log of all potential land tenure changes and the stakeholders who it may be affecting. • Refer to the guidance on monitoring in the Community-Based Natural Resource Management SEG.

SOCIAL IMPACT	MITIGATION MEASURES	MONITORING CONSIDERATIONS
tenure to members of the local community.		• Review the GRM and resolve complaints and grievances in a timely manner.
Environmental Justice Marginalized and underrepresented groups and/or people in vulnerable situations may experience disproportionately high levels of exposure to air, water, and/or land pollution from hazardous gas emissions from landfills and open dumping and burning of waste. This may lead to increased health risks. Furthermore, the siting or placement of the project may also negatively impact marginalized and underrepresented groups and/or people in vulnerable situations.	• Draft a Stakeholder Engagement Plan (SEP) that may include a combination of approaches, such as focus groups and semi-structured interviews with key informants. • Evaluate demographic and geographic data to ensure that projects are sited or placed such that social and ethnic minority groups are not exposed to pollution or toxic waste. • Conduct stakeholder engagement throughout the project life cycle in a socially inclusive sensitive manner to ensure that protections are upheld for marginalized and underrepresented groups and/or people in vulnerable situations • Set up a Grievance Redress Mechanism (GRM)	• Review the SEP periodically. • Review demographic and geographic data for significant changes in community composition. • Keep a log of all stakeholder engagement endeavors and integrate findings into the SEP. • Appoint a community member representative to monitor and track public health data. • Review the GRM on a periodic basis and address complaints and grievances in a timely manner.

SOCIAL IMPACT	MITIGATION MEASURES	MONITORING CONSIDERATIONS
Gender Equality If women in a local community depend on the natural resources from a geographical area, and a proposed project strips them of their right to access those resources, women could find themselves in a situation in which they may have to travel farther away to have access to the natural resources that they depend on for sustenance. Traveling to unfamiliar or remote areas may increase the risk of gender-based violence (GBV). If there is an influx of new laborers for the construction phase and/or ongoing site maintenance of the waste management facility, this may an increase the risk of GBV.	• Establish a Stakeholder Engagement Plan (SEP). • Undertake a Gender Analysis and follow the guidance per the Gender Equality and Women's Empowerment Policy.119 • Undertake ongoing stakeholder engagement in a manner that captures women's perspectives, concerns, and views of the proposed project. This may be achieved by organizing a women-only focus group to better understand the patterns of usage of natural resources, travel time, and locations of importance to women regarding natural resources in order to minimize potential related impacts and risks. • Co-create a community map that actively seeks participation from women to help identify geographical areas of high importance regarding natural resources they use for sustenance. • Establish women-led "community protection groups" to ensure that individuals feel safe traveling to unfamiliar or remote areas that they depend on. • Establish a grievance redress mechanism (GRM). • Establish a strong internal communications plan with new laborers that includes a strict code of conduct. • Train and hold awareness-building workshops with new laborers on GBV.	• Review the SEP periodically and continue to integrate feedback from women and girls on an ongoing basis. • Keep records of the women-led community protection groups. • Keep a log on the trips taken with the women led community protection groups to ensure that women have access to natural resources in a manner that does not pose a risk of GBV. • Review the GRM and address any grievances and complaints in a timely manner. • Keep a log of the number of participants attending the awareness-building workshops on GBV. • Keep a log on how often the code of conduct is communicated regarding new laborers and the number of participants. • Keep a log of all workshops and trainings that have been conducted with new laborers regarding building awareness on the issue of GBV.

[119] USAID. 2023b. "2023 Gender Equality and Women's Empowerment Policy." https://www.usaid.gov/document/2023-gender-equality-and-womens-empowerment-policy.

SOCIAL IMPACT	MITIGATION MEASURES	MONITORING CONSIDERATIONS
Conflict Dynamics A project may unintentionally exacerbate the dynamics of a local community regarding which groups of people are benefited by the project, or which groups are excluded from project benefits (such as direct and/or indirect jobs), which could lead to social conflict. A project may unintentionally cause social conflict in the local community regarding the loss of livelihoods, regarding for example, the role of informal workers in waste management systems. Corrupt contracting practices, and illegal trading and dumping of hazardous and other solid waste may cause the breakdown of social cohesion and increase the risk of social violence.	• Undertake a Conflict Dynamics Analysis. • Draft a Stakeholder Engagement Plan (SEP) during the planning and design phase to acquire feedback and input from stakeholders and sustain stakeholder engagement throughout the entire project life cycle. • Consult with community leaders, government officials, members of civil society, women's groups, church groups, NGOs, and Community-based organizations (CBOs) (among other stakeholders) to understand existing local social conflicts and tensions. • Ensure social inclusion, especially of marginalized and underrepresented groups and/or people in vulnerable situations such as informal waste workers. • Undertake stakeholder engagement with groups that are involved in the informal sector to evaluate the potential impacts on their livelihoods and to better understand adequate mitigation measures (including compensation). • Ensure that contracting practices are formalized to avoid corruption.	• Review the SEP on a periodic basis. • Review the results of the Conflict Dynamics Analysis. • Conduct continued stakeholder engagement with marginalized and underrepresented groups and/or people in vulnerable situations in local power structures, such as informal waste workers, and keep a log on the number of people who have received compensation. • Keep a record of contracting practices and ask for receipts.

SOCIAL IMPACT	MITIGATION MEASURES	MONITORING CONSIDERATIONS
Health, Well-Being, and Safety Decomposing organic waste may result in the increase of disease vectors such as insects, rats, and other vermin, and the products of decomposition can leach into the ground and watercourses, making them polluted and no longer safe; open burning of waste can lead to air pollution; and improper handling of hazardous materials can lead to both acute and long-lasting risks to public health. Traffic accidents involving waste vehicles can result in the spillage of hazardous materials (e.g., clinical and industrial waste, contaminated soils) or increased risk to pedestrians.	Mitigation measures to protect workers and the public from physical hazards during the operation of waste sites involves safety reviews of planned activities and the implementation of best management practice safety measures. Measures include: • Providing and requiring all workers to wear personal protective equipment (PPE). • Establishing worker health and safety protocols according to international best practices. • Drafting a SEP that also includes internal stakeholders, such as workers, during the planning and design phase of the project to acquire feedback and input. • Educating workers and community members on waste management best practices at home and in the community, along with the potential health impact of improper waste management. • Conducting awareness-building and educational workshops that communicate the risks from open dumping and the burning of waste and the potential health impacts. • Appointing safety representatives or form health and safety committees. • Providing comprehensive training for all workers using heavy machinery and ensure adequate security for equipment when not in use to prevent theft. • Installing safety signs or crosswalks for pedestrians near roads. Fire prevention and control is a major consideration at waste sites. The explosion of flammable gas also is a critical risk. Measures to avoid, control, or mitigate fire and gas risks include the following: • The use of fire and life safety systems and equipment, including provisions for escaping a fire. • Fire detection, alarm, and suppression/extinguishing systems • Safe storage of waste/materials, including the capacity and timing of storage, bunkering/containment and safe spacing, and the location of hazardous and highly flammable materials	• Review the SEP periodically. • Document and report cases of hazardous waste exposure, and spillage, regarding workers and community members. • Keep a log on the dissemination of the educational materials from training that is provided to workers and local community members. • Keep a log of participant's attendance at all training sessions • Review the field notes from appointed safety representatives and health and safety committee members and use the new-found data and information to update the mitigation measures regarding health, well-being, and safety risks and impacts. • Regular health and safety inspections, audits, and incident records; record training; issuance of PPE (and enforcement of PPE use); any non- compliance with health safety and environment policies by workers; and carrying out management review at least annually • Fire and life safety monitoring and, where necessary, gas detection systems • Monitoring of slope stability carried out using surveys and

SOCIAL IMPACT	MITIGATION MEASURES	MONITORING CONSIDERATIONS
	• Removal of sources of ignition, including naked flames • Prevention of arson/vandalism, removal of informal waste pickers, and no open burning for waste operations • Fire suppression/extinguishing/fighting systems, connection to the main water supply • Regular maintenance and cleaning program, good housekeeping practices • Provision of “hot works” and “hot loads” areas • Ensuring that adjacent community property is protected (e.g., fire breaks, non-flammable materials, relocation of at-risk communities [only if there is no alternative], following due process) • Training and awareness of staff, fire prevention and control planning, and close communication with local fire department/civil defense Good management practices should be employed to minimize the risks to human health from contact, ingestion, and inhalation of hazardous materials present at waste sites, including the following: • Screening of materials entering landfills and segregation or rejection of the hazardous materials identified • Appropriate storage of hazardous materials, including dedicated storage area (e.g., hard-standing, bunding/drip trays, ventilation, access control, signage), provision of material data sheets, and compliance with safety regulations and standards • Provision of cleaning and containment materials and equipment, training of staff in their use, and the preparation of emergency plans • Licensing, registration, and regulation of hazardous waste collectors/service providers Plant and machinery at waste sites should be in good condition, regularly maintained, and operated in accordance with manufacturers’ instructions. Vehicle collisions are a major source of accidents at waste sites and during waste collection and transportation. Risks to workers, road	continuous monitoring equipment • Monitor driving standards/violations via GPS tracking of vehicles (where feasible) and/or complaints

SOCIAL IMPACT	MITIGATION MEASURES	MONITORING CONSIDERATIONS
	users, and pedestrians should be minimized by using appropriate safety measures and best practices, including the following: • Enhanced driver training, policies, and awareness (e.g., speed, use of mobile phones, seatbelt use, safe reversing, zero tolerance of drugs/alcohol) • Provision of safety equipment on vehicles, including emergency shut-off, audible reversing alert, LED and strobe lights, reflective tape, logos and decals, GPS, and back-up cameras • Regular inspection and maintenance of vehicles • PPE is essential safety equipment. PPE includes clothing and equipment, such as safety boots, hard hats, safety glasses, ear defenders, gloves, respirators, high-visibility clothing, kneepads, overalls, and, if required, hazardous materials (HAZMAT) suits. The selection of appropriate PPE for workers and visitors at a waste site must be based on a risk assessment of the site and activities. Limiting access for waste pickers will minimize the health and safety risks associated with these activities (e.g., being struck by vehicles at landfill working face). However, this is associated with many unwanted social and political implications. Formalizing waste reclaiming/picking activities at waste sites will allow workers to be equipped with appropriate PPE and trained and provided with safe, sanitary, and secure working conditions. The stability of landfills and stockpiles should be ensured to minimize the risks associated with collapse. Measures include reducing gradients, reinforcing slopes (e.g., gabions, concrete cap, vegetation, soil nails), erosion control and drainage methods, and relocating at-risk workers or communities (e.g., waste pickers, informal settlements at the toe of slopes). Long-term impacts on the public from exposure to contaminated media (i.e., soil, water, plants, and animals) would be mitigated through the use of access controls (e.g., fences, warning signs, personnel to limit public access to contaminated areas) and engineered barriers designed to reduce the migration of contaminants to the accessible	

SOCIAL IMPACT	MITIGATION MEASURES	MONITORING CONSIDERATIONS
	environment. In places where fencing would not be practical (e.g., along a public stream), signs could be used to warn against the ingestion of contaminated water, plants, and animals.	
Labor Improper safety protection or training for workers can lead to exposure to toxic chemicals or workplace accidents (e.g., working with heavy machinery). Occupational health and unfair labor practices are heightened when national occupational labor standards are poorly developed or enforced. Workers' welfare and rights may not be prioritized by some employers and governments, with many working in poor conditions for very low income. Enterprises may not provide equal employment	• Establish a Stakeholder Engagement Plan (SEP) during the planning and design phase to acquire feedback and sustain stakeholder engagement throughout the project life cycle. • Follow guidance as per ILO 155.[120] • Address occupational safety in the pre-implementation ESIA process (e.g., USAID IEEs and EAs). The process should specifically address labor safety and health risks presented by waste management activities. • Conduct safety trainings for workers. • Identify any host country laws and regulations and/or international laws or regulations regarding labor safety. • Solicit worker input from both men and women to fully understand their capabilities. • Discuss which tasks workers are comfortable performing and which tasks they are uncomfortable performing. • Offer all roles to potential workers in a socially inclusive manner that includes women.	• Review and update the SEP periodically. • Institute procedures for documenting and reporting exposures, accidents, and incidents. • Keep records of the training sessions on labor safety and require periodic retraining. • Conduct monthly reviews to monitor gender equality in the workplace. • Set up an anonymous process for submitting concerns regarding conditions or practices without fear of reprisal. • Keep records of both men and women entering the workforce.

[120] ILO. 1981. "Protocol 155 - Protocol of 2022 to the Occupational Safety and Health Convention." https://normlex.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:12100:0::NO::P12100_INSTRUMENT_ID:312338.

SOCIAL IMPACT	MITIGATION MEASURES	MONITORING CONSIDERATIONS
opportunities for women and underrepresented groups.		
Social and community	In residential areas, waste management sites should be operated and activities carried out with minimal impacts on the amenities of nearby communities. Visual amenity impacts can be mitigated by screening (e.g., tree planting, solid fencing/walls), sensitive design of buildings, community art, architectural features). Measures to mitigate odor, dust, and noise can be implemented as outlined above (see *Air Quality* and *Noise and Vibration* sections of Table 6). Potential disease vectors (e.g., rodents, insects, birds) and other pests can be prevented by covering waste (e.g., applying daily cover in landfills, covering stored tires); frequent waste collection; minimal storage of organic waste; enclosing facilities; eliminating standing water; adequate water supplies and sanitation; improving the cleanliness of the site, containers, and equipment (e.g., washing out drains, scrubbing tanks, cleaning stored recyclables); and safely using pesticides, traps, and other measures. Traffic impacts associated with solid waste management sites and activities should be minimized though the implementation of measures set out in a traffic management plan. In some cases, plans should be developed based on a detailed Traffic Impact Assessment (TIA), which may include the modeling of impacts on roads and junctions. Mitigation measures may include the following:	• See sections on pollution, noise, odor, and air quality monitoring in Table 6.. • Traffic monitoring via direct observation surveys, global positioning system (GPS) tracking, and complaints monitoring. • Worker welfare monitoring carried out via qualitative interviews, anonymous reporting, grievance mechanism, and independent audits.

SOCIAL IMPACT	MITIGATION MEASURES	MONITORING CONSIDERATIONS
	• Reducing the amount of traffic by reducing generation at the source, consolidation of collection services, reducing the frequency of collection (i.e., for dry recyclables), efficient routing, backhauling, and the selection of vehicle type (e.g., compactor refuse collection vehicle (RCV), containerized transport). • The timing of vehicle movements outside of peak traffic hours. • Improving site access/egress, roads, and junctions, and providing truck lanes and off-street parking for vehicles. • Providing waste transfer or materials recovery facilities. Worker welfare impacts can be mitigated through the adoption and implementation of specific policies and practices that aim to improve labor conditions. Policies may include minimum standards for worker accommodation, safe transportation, rights (e.g., the right to form unions), human resource standards (e.g., sick pay and vacation entitlements), reasonable working hours, minimum wages, free health and safety training and PPE, and the provision of adequate well-being facilities (e.g., ablutions, canteen, first aid). Labor agents should be regulated to prevent the payment of fees leading to bonded labor conditions or the withholding of documents or wages. It should be noted that the right to form unions is legally restricted in some jurisdictions. Minimum standards should be in line with local labor laws. The informal sector can be a significant resource for implementing socially sustainable waste projects, and the rights and livelihoods of existing workers should be protected. The right approach for providing inclusivity for the informal sector will be contextual but could include formalizing waste picking at landfills by creating cooperatives with proper sorting facilities and improved working conditions. Such measures can improve material recovery rates for minimal investment and deliver considerable improvements in the quality of life for workers. Policies and procedures should be in place to prevent corruption (e.g., using open competitive tendering and prequalification when letting	

SOCIAL IMPACT	MITIGATION MEASURES	MONITORING CONSIDERATIONS
	operational contracts). GPS tracking of vehicles and robust waste manifest and record collection systems also can help prevent illegal waste dumping.	
Disasters and emergencies	Waste sites and programs should prepare detailed emergency response and contingency planning to effectively respond to emergency incidents and events, such as flooding, typhoon/hurricanes, earthquakes, fires, landslides, disease outbreak, and security issues. Flood prevention and control measures at waste sites include the following: • Development of a flood prevention strategy • Structural measures (defense structures) • Flood forecasting and warning measures and emergency preparedness and response planning • Clearing litter and debris from storm drains • Good housekeeping and proper storage of materials Following an emergency event, such as a flood or typhoon/hurricane, public authorities and waste facilities may be required to quickly and effectively manage the resulting debris from infrastructure and the public realm. Such debris can prevent rescue operations, lead to disease outbreaks by encouraging vectors, divert resources, and slow down an area's recovery. Emergency plans for debris management	• Regional and local earthquake and flooding early warning systems (where present) and monitoring of weather reports as part of emergency planning and management at facilities.

SOCIAL IMPACT	MITIGATION MEASURES	MONITORING CONSIDERATIONS
	should include provisions for labor, equipment, facility capacity, and operations.	

TABLE 8. MITIGATING CLIMATE RISKS TO SOLID WASTE MANAGEMENT

CLIMATE STRESSORS	RISK MITIGATION MEASURES	MONITORING EXAMPLES
Increasing average air temperatures, incidence, and severity of heat waves	• For site selection, consider the likelihood of climate risk impacts on the specific location in question, with consideration of historical, current, and projected climate conditions. • Promote integrated watershed management and rainfall capture/water efficiency practices to build resilience to decreased water availability and drought. • Incorporate heat stress in the Health and Safety Guidelines. • Provide project workers with a work schedule that allows for breaks and water consumption at regular intervals. • Decentralize waste transfer and processing stations to reduce transport distances and allow for smaller collection vehicles. • Provide for the protection and aeration of sorting facilities in which waste salvagers and pickers sort waste. • Ensure emergency plan documents are available and posted	• Indicate the consideration of high temperature risks in site selection, material selection, and design/construction. • Document local capacity strengthening in emergency preparedness and response. • Identify and document available early warning systems and their use. • Emergency plan documents are available and posted. • Document the process for providing breaks for workers in implementation plans to avoid heat stress.
Increasing incidence and severity of drought	• For site selection, consider the likelihood of climate risk impacts on the specific location in question, with consideration of historical, current, and projected climate conditions. • Promote integrated watershed management and rainfall capture/water efficiency practices to build resilience to decreased water availability and/or drought. • Divert organic waste from the landfill through segregated organics collection, if possible, to prevent landfill fire outbursts. • Build fire safety structures and measures for landfills, including periodic cover with dry material.	• Indicate the consideration of increasing incidence and severity of drought in site selection, material selection, and design and construction. • Document local capacity strengthening in emergency preparedness and response. • Document the availability of planned alternative routes to minimize disruptions from extreme events. • Identify and document available early warning systems and their use. • Document the use of integrated watershed management, rainfall capture, and water efficiency.

CLIMATE STRESSORS	RISK MITIGATION MEASURES	MONITORING EXAMPLES
	• Ensure emergency plan documents are available and posted.	
Sea level rise	• For site selection, consider the likelihood of climate risk impacts on the specific location in question, with consideration of historical, current, and projected climate conditions. • Design to robust engineering and construction standards that can withstand sea level rise (e.g., ensuring the stability of solid waste collection, transport, and storage equipment and facilities). • Update the design standards to elevate and strengthen solid waste storage sites to accommodate future sea level rise and high winds. • Identify alternative routes for waste delivery and processing. • Use early warning systems for storm events to allow for proactive preparation for storm surge.	• Indicate the consideration of sea level rise risk in siting selection, material selection, and design and construction in coastal areas. • Document local capacity strengthening in emergency preparedness and response. • Document the availability of planned alternative routes to minimize disruptions from extreme events. • Identify and document available early warning systems and their use. • Emergency plan documents are available and posted.
Increasing incidence and intensity of storms (high rainfall and high wind events)	• For site selection, consider the likelihood of climate risk impacts on the specific location in question, with consideration of historical, current, and projected climate conditions. • Properly site landfills away from floodplains, wetlands, or areas with high water tables. • Design and maintain water catchment systems that can keep pace with projected rainfall patterns. • Design to robust engineering and construction standards that can withstand increasingly variable weather and extreme events (e.g., ensuring the stability of solid waste collection, transport, and storage equipment and facilities). • Use early warning systems for storm and extreme weather events to allow for proactive preparation. • Schedule more frequent waste collection in response to weather forecasts to avoid impacts on waste from flooding and high wind.	• Indicate the consideration of storm risk in siting selection, material selection, and design and construction in coastal areas. • Document local capacity strengthening in emergency preparedness and response. • Document the availability of planned alternative routes to minimize disruptions from extreme events. • Identify and document available early warning systems and their use. • Emergency plan documents are available and posted.

CLIMATE STRESSORS	RISK MITIGATION MEASURES	MONITORING EXAMPLES
	• Cover collection trucks to prevent waste from blowing away in high wind. • Plan landfill leachate collection system with enough capacity for heavy rainfall events. • Provide for the protection of sorting facilities in which waste salvagers and pickers sort waste.	
Increasing incidence and intensity of storm surges	• For site selection, consider the likelihood of climate risk impacts on the specific location in question, with consideration of historical, current, and projected climate conditions. • Ensure robust engineering design and construction standards that can withstand increasingly variable weather and extreme events (e.g., ensure the stability of solid waste collection, transport, and storage equipment and facilities).	• Indicate the consideration of sea level rise risk in siting selection, material selection, and design and construction in coastal areas. • Document local capacity strengthening in emergency preparedness and response. • Document the availability of planned alternative routes to minimize disruptions from extreme events. • Identify and document available early warning systems and their use. • Emergency plan documents are available and posted.

TABLE 9. MITIGATING GHG EMISSIONS IN SOLID WASTE MANAGEMENT

GHG EMISSIONS SOURCES	EMISSIONS MITIGATION OPTIONS	ESTIMATION TOOLS
Waste disposal in dumps and landfills		
The decomposition of organic material in solid waste under anaerobic conditions produces emissions in the form of CH_4[121]. The management of solid waste also produces other GHGs.	• Generate and recover biogas through anaerobic digestion or landfill gas capture, which can be used for electricity or heat generation, as transport fuel, and sold as a fuel. The US EPA Landfill Methane Outreach Program describes collection and treatment of landfill gas, and the US EPA Global Methane Initiative (GMI) website provides additional international considerations. If energy generation at landfills is not viable, flare landfill gases to prevent methane release. • Install landfill biocovers that can reduce CH_4 emissions through microbial oxidization. • Reduce or eliminate the landfilling of organics through mixed-waste separation and changes to waste collection. • Prevent food waste by reducing spoilage, oversupply, and overconsumption. • Encourage household composting to reduce the amount of organic waste in	• USAID's Clean Energy Emissions Reduction (CLEER) Tool can be used to estimate emissions that would be avoided as a result of solar energy projects, including projected avoided emissions to 2050.[122] • USAID's Agriculture, Forestry, and Other Land Use (AFOLU) Carbon Calculator can be used to estimate the emissions (or sequestration) that would result from land use changes.[123]

[121] IPCC. 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 5: Waste - Chapter 3: Solid Waste Disposal. National Greenhouse Gas Inventories Programme, IPCC, Japan: IGES. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_3_Ch3_SWDS.pdf.
[122] See https://www.cleertool.org/
[123] See http://afolucarbon.org/

	landfills and dumpsites and its resulting emissions. • Recover soil improvement materials by composting organic waste. • Adopt circular economy principles for the management of organic waste • Design energy-efficient waste management facilities. • If feasible, consider promoting advanced energy generation technologies in energy-from-waste projects, such as fuel cells. • After landfill closure, promote carbon-negative uses such as tree planting or the installation of solar panels.	
Embedded GHGs in discarded manufactured goods and materials (e.g., plastic, rubber, paper, glass, metals, wood)	• Through reuse-reduce-recycle programs, encourage the reuse of materials, reduce consumption, adopt recycling, and encourage sustainable consumer practices via education and awareness programs. • Recover recyclable materials through separate collections and recovery facilities. • Encourage manufacturers to use materials that are recyclables or that have recycled content. • Reduce emissions from sorting and recycling waste to reduce the amount of waste that goes into landfills. • Restrict plastic bags and single-use plastics.	
Incineration and open burning		
Emissions from incineration and the open burning of waste producing emissions in the form of CO_2, CH_4, and N_2O	• Adopt energy recovery from incineration (with strict pollution control technology). • Restrict open burning practices. •	• The 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5: Incineration

CO_2 emissions from the incineration of carbon in waste of fossil origin (e.g., plastics, textiles, rubber, liquid solvents, waste oil)	• Adopt energy recovery from incineration (with strict pollution control technology). • Restrict open burning practices.	and Open Burning of Waste, can be used to estimate emissions from thermal treatment of waste.[124] • The U.S. EPA's State Inventory and Projection Tool provides an additional resource for considering landfills that collect and burn landfill gas to produce energy (landfill gas to energy plants), although it was developed for U.S. domestic use.[125]
Transportation		
CO_2, CH_4, and N_2O emissions from energy used in the collection, transportation, and disposal of waste	• Use sustainable transport modes, such as barges, rail, and electric vehicles. • Run refuse collection vehicles (RCVs) on green fuels. • Promote efficient collection systems, including the use of transfer stations. • Seek to manage waste at the source location (the proximity principle) and avoid export of large quantities of waste and recyclables.	• The GHG Protocol's GHG Emissions Calculation Tool can be used to estimate possible significant emissions (and emissions reductions) resulting from the use of vehicles and other equipment.[126]

[124] IPCC. 2019. "2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 5: Waste - Chapter 3: Incineration and Open Burning of Waste." Switzerland. https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/0_Overview/19R_V0_00_Cover_Foreword_Preface_Dedication.pdf.
[125] See https://www.epa.gov/statelocalenergy/download-state-inventory-and-projection-tool.
[126] See https://ghgprotocol.org/calculation-tools-and-guidance

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11. GLOSSARY OF TERMS

TERM	DEFINITION
ADAPTIVE MANAGEMENT	An intentional way for USAID to make planning decisions and adjustments during implementation in response to additional information or changes in context.
AREA OF INFLUENCE	The area over which the impacts of a project are likely to be felt, including all of its related or associated (where applicable) facilities, such as transmission line corridors, access roads, accommodation facilities (where required), and any reasonably foreseen unplanned developments induced by a project or cumulative impacts.
BASELINE DATA	Data that describe existing physical, biological, socioeconomic, health, labor, and cultural heritage conditions, or any other variable considered to be relevant before project development.
BIODIVERSITY	Variability among living organisms from all sources, including, inter alia, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are a part. This includes diversity within species, between species, and in ecosystems.
CHANCE FINDS	Archaeological or cultural sites and artifacts, including such items as ceramics, tools, buildings, and burials, previously unrecognized in baseline studies that are discovered during exploration activities.
CLIMATE CHANGE ADAPTATION	Refers to a system or a community's ability to adapt to climate change effects that are already occurring or can be expected to occur soon. The goal of climate change adaptation is to reduce communities' vulnerability to the harmful effects of climate change. To do this, a community must become more resilient, able to rapidly recover after a catastrophe.[127] Climate change adaptation also could refer to finding ways to take advantage of any potential benefits associated with climate change, such as longer growing seasons and increased crop yields in some regions and reduced heating bills in others.
CLIMATE CHANGE MITIGATION	Refers to preventing or reducing the emissions of carbon and other greenhouse gases (GHGs), thereby reducing the negative impacts of climate change in the future. Even if emissions of all GHGs ended today, global warming and climate change will continue to affect future generations.
CLIMATE RESILIENCE	The ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions.

[127] Cambridge Centre for Risk Studies. 2015. "World Cities Risk 2015-2025 Part I: Overview and Results." University of Cambridge Judge Business School, United Kingdom. https://www.jbs.cam.ac.uk/wp-content/uploads/2020/08/crs-lloydsworldcities-pt1-overviewresults.pdf.

TERM	DEFINITION
CLIMATE RISK ASSESSMENT	The systematic process of evaluating the potential climate-related risks that may be involved in a strategy, project, or activity. This includes both screening and analysis.
CONSULTATION	Consultation is a two-way process of dialogue between the project implementer and its stakeholders. Stakeholder consultation is about initiating and sustaining constructive external relationships over time.
CONSTRUCTION	Construction, alteration, or repair of buildings and structures. Includes excavation and demolition activities.
CRITICAL HABITAT	Either modified or natural habitats supporting high biodiversity value, such as habitat required for the survival of threatened or endangered species.
CUMULATIVE IMPACT	An incremental impact of a project action when added to the impacts of past, present, and reasonable near-future impacts. Cumulative impacts are contextual and encompass a broad spectrum of impacts at different spatial and temporal scales.
DIRECT AREA OF IMPACT	Considers the physical footprint of a project, such as the right-of-way, construction sites, work staging area, and the area affected during operational works (e.g., traffic patterns).
DIRECT IMPACT	An impact caused directly by a project action at the same time and in the same place that the action is occurring.
ECOSYSTEM	The interacting system of a biological community and its non-living environmental surroundings.
EMISSION	Pollution discharged into the atmosphere from smokestacks, other vents, and surface areas of commercial or industrial facilities; from residential chimneys; and from motor vehicle, locomotive, or watercraft exhausts.
ENVIRONMENTAL IMPACT ASSESSMENT (EIA)	A forward-looking instrument that proactively advises decision-makers on what might happen if a proposed action is implemented. Impacts are changes that have environmental, political, economic, or social significance to society. Impacts may be positive or negative and may affect the environment, communities, human health and well-being, desired sustainability objectives, or a combination of these.
ENVIRONMENTAL IMPACT STATEMENT (EIS)	A detailed study of the reasonably foreseeable positive and negative environmental impacts of a proposed USAID action and its reasonable alternatives in the United States, the global environment, or areas outside the jurisdiction of any nation. (Chapter 204).
ENVIRONMENTAL AND SOCIAL MANAGEMENT SYSTEM (ESMS)	Part of a project's overall management system that includes the organizational structure, responsibilities, practices, and resources necessary for implementing the project-specific

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	management program developed through the environmental and social assessment of the project.
ENVIRONMENTAL IMPACTS	Impacts on the natural environment, including air, water, ecosystems, flora and fauna, and other naturally occurring phenomena.
GOOD INTERNATIONAL INDUSTRY PRACTICES	The exercise of professional skill, diligence, prudence, and foresight that would reasonably be expected from skilled and experienced professionals engaged in the same type of undertaking under the same or similar circumstances globally or regionally. The outcome should be that the project employs the most appropriate technologies under the project-specific circumstances.
GREENHOUSE GASES	Includes the following six gases or class of gases: CO2, N_2O, CH_4, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).
GRIEVANCE MECHANISM	A procedure developed by the project implementer to receive and facilitate the resolution of affected communities' concerns and grievances about the project's environmental and social performance.
HABITAT	A terrestrial, freshwater, or marine geographical unit or airway that supports assemblages of living organisms and their interactions with the non-living environment.
HAZARDOUS WASTE	The byproducts of society that can pose a substantial or potential hazard to human health or the environment when improperly managed. Substances classified as hazardous waste possess at least one of four characteristics—ignitability, corrosivity, reactivity, or toxicity—or appear on special lists.
INDIGENOUS PEOPLES	Defined by the World Bank Environmental and Social (E&S) Framework as a distinct social and cultural group possessing the following characteristics in varying degrees: (1) self-identification as members of a distinct indigenous social and cultural group and recognition of this identity by others; (2) collective attachment to geographically distinct habitats, ancestral territories, or areas of seasonal use or occupation, as well as to the natural resources in these areas; (3) customary cultural, economic, social, or political institutions that are distinct or separate from those of the mainstream society or culture; and (4) a distinct language or dialect, often different from the official language or languages of the country or region in which they reside.
INDIRECT AREA OF INFLUENCE	Includes an area that may experience project-related changes resulting from activities not under the direct control of the project.

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INDIRECT IMPACT	Impacts from project activities that may occur at different times or at some distance from the project. Also known as secondary or even third-level impacts.
INDUCED IMPACT	Secondary impacts that do not bear a direct relationship to the project itself.
INITIAL ENVIRONMENTAL EXAMINATION (IEE)	The first review of the reasonably foreseeable effects of a proposed action on the environment. Its function is to provide a brief statement of the factual basis for a Threshold Decision as to whether an Environmental Assessment or an Environmental Impact Statement will be required.
LAND ACQUISITION	All methods of obtaining land for project purposes, which may include outright purchase, the expropriation of property, and the acquisition of access rights, such as easements or rights of way.
LIVELIHOOD	The full range of means that individuals, families, and communities utilize to make a living, such as working for wages; participating in agriculture, fishing, foraging, or other natural resource-based livelihoods; petty trade; and bartering.
MAGNITUDE	The assessment of magnitude is undertaken in two steps: First, the potential impacts associated with a project are categorized as beneficial or adverse. Second, the beneficial or adverse impacts are categorized as major, moderate, minor, or negligible based on the consideration of a number of parameters.
MUNICIPAL SOLID WASTE	Waste material that is (1) generated by a household (including a single or multifamily residence) or (2) generated by a commercial, industrial, or institutional entity that is essentially the same as normal household waste; is collected and disposed of with other MSW; and contains hazardous substances not greater than that generated by a typical household.
NATURAL HABITAT	Land and water areas where the biological communities are formed largely by native plant and animal species, and where human activity has not essentially modified the area’s primary ecological functions.
NO NET LOSS	No net loss is a principal that aims to balance the losses of biodiversity in one area with the gains of biodiversity conservation in other areas.
OCCUPATIONAL HEALTH AND SAFETY	The range of endeavors aimed at protecting workers from injury or illness associated with exposure to hazards in the workplace or while working.
PARTICIPATORY APPROACH	A participatory approach recognizes that affected communities should be involved in the determination and identification of ecosystems that may be affected by a project and the

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	management measures that should be implemented to manage the predicted impacts.
PRECAUTIONARY APPROACH	A precautionary approach argues that in the event of scientific uncertainty, the worst reasonable case assumptions should be adopted to predict an impact of an action to ensure that the impact is not underestimated.
PROJECT-AFFECTED PEOPLE OR COMMUNITIES	Individuals, workers, groups, or local communities that are or could be affected by the project, directly or indirectly, including through cumulative impacts.
RENEWABLE ENERGY	Energy sources derived from solar power, hydro, wind, certain types of geothermal resources, and biomass.
SENSITIVITY	The sensitivity of a receptor is determined based on the review of the population (including proximity/numbers/vulnerability), biological features of the site and the surrounding area, soil, agricultural suitability, geology and geomorphology, the proximity of aquifers and watercourses, existing air quality, the presence of any archaeological features, and so forth.
SIGNIFICANCE	The significance of an impact accounts for the interaction between the magnitude and sensitivity criteria.
SOCIAL IMPACTS	Impacts on health and well-being determinants such as lifestyle, personal circumstances, genetics, biophysical environment, social influences, economic conditions, and availability and access to services and facilities.
SOLID WASTE	Material with low liquid content, sometimes hazardous. Includes municipal garbage, industrial and commercial waste, sewage sludge, waste resulting from agricultural and animal husbandry operations, and other connected activities, demolition waste, and mining residues.
STAKEHOLDERS	Stakeholders are persons or groups who are directly or indirectly affected by a project, as well as those who may have interests in a project or the ability to influence its outcome, either positively or negatively.
TRANSBOUNDRY IMPACT	An impact that transcends national boundaries.
VOLATILIZATION	A process through which compounds, particularly organic compounds, change from a liquid or a solid into a vapor.
VULNERABLE, MARGINALIZED, AND UNDERREPRESENTED GROUPS	These are individuals and groups that may be directly and differentially or disproportionately affected by project activities because of their disadvantaged or vulnerable status (based on race, color, sex, language, religion, political or other opinion, national or social origin, property, birth, or other status).