PROGRAM FOR LOCAL AND URBAN SUSTAINABILITY

TASK 3: GREENHOUSE GAS EMISSIONS MEASUREMENT AND REPORTING GUIDE

Guidance to Reduce and Measure GHG Emissions Along the SWM Value Chain
October 2023

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ACRONYMS

Acronym	Definition
AD	Anaerobic digestion
BAU	Business-as-usual
CCBO	Clean Cities, Blue Ocean
CO2e	Carbon dioxide equivalent
DDOC	Decomposable degradable organic carbon
DOC	Degradable organic carbon
DoS	Department of State
EG	Economic growth
GHG	Greenhouse gas
LandGEM	Landfill gas emissions model
LFG	Landfill gas
MEL	Monitoring, evaluation, and learning
MRV	Measurement, reporting, and verification
MT	Metric tons
OP	Ocean plastics
OU	Operating Unit
PLUS	Program for Local and Urban Sustainability
SWEET	Solid Waste Emissions Estimation Tool
SWM	Solid waste management
USAID	U.S. Agency for International Development
USEPA	U.S. Environmental Protection Agency
WaCT	Waste Wise Cities Tool
WtE	Waste-to-energy

I. INTRODUCTION

A. BACKGROUND

The United States Agency for International Development (USAID) Program for Local and Urban Sustainability (PLUS)[1] is a task order under the OASIS Unrestricted Contract (Pool 1), awarded to Deloitte Consulting LLP for the period July 18, 2022–July 17, 2027. The goal of PLUS is to foster healthy, prosperous, and resilient cities for all people and the planet by scaling USAID's inclusive development approach at the urban scale and enabling USAID to invest in "green city" strategies that advance five critical objectives: (1) advancing net-zero systems; (2) increasing urban resilience; (3) reducing pollution and waste; (4) improving local governance and equitable access to services; (5) mainstreaming inclusive green jobs.

In 2022, USAID launched its [Climate Strategy 2022-2030] to confront the climate crisis and prioritize equitable and ambitious climate actions that achieve net-zero greenhouse gas (GHG) emissions.[2] The Agency's solid waste management (SWM) and ocean plastic programs are positioned to play an important role in achieving the Climate Strategy mitigation targets. At present, however, USAID is not routinely or systematically measuring the GHG emissions reductions that result from its SWM and ocean plastics programs and activities. There is currently no standardized and widely-applied methodology for estimating these GHG reductions, reporting results, or utilizing such information for purposes of tracking progress and making improvements over time. As a result, USAID is likely undercounting the full GHG impact of its recent and ongoing SWM and ocean plastics activities, and missing an opportunity to count these reductions towards Climate Strategy targets. The lack of a robust and widely-applied methodology for measuring and reporting waste-sector GHG reductions also means that the Agency is missing opportunities to "learn by doing," and to collect information that can be used to inform key SWM-related planning questions (such as whether Agency funding should be directed towards waste-sector programs and activities that maximize GHG reductions and directly support the Climate Strategy).

To address these gaps, the Agency is taking steps to understand the GHG reduction opportunities associated its SWM and ocean plastics programs, and to provide associated guidance, tools, and information to USAID Headquarters, Mission staff, and local partners. For example, a 2022 report from the PLUS team identifies *Greenhouse Gas Mitigation Opportunities for USAID Solid Waste Sector Activities.* Through desktop research and consultations with select USAID Missions (Kenya/East Africa, Dominican Republic, Indonesia, and Peru) and the Clean Cities Blue Oceans (CCBO) program[3], the report identifies 104 recent and ongoing SWM and ocean plastics activities undertaken by USAID and local partners. It also describes key steps in the SWM value chain (see **Figure 1**, below), identifies sources of GHGs across the value chain, and outlines specific opportunities and actionable recommendations for reducing emissions. This information is intended for use by USAID and local partners to plan for, enhance, and expand their portfolio of SWM activities in a manner that is consistent with Climate Strategy goals.

Figure 1: SWM Value Chain

[1] In 2022, USAID launched the Save Our Seas Initiative to combat ocean plastics pollution globally and the Program for Local and Urban Sustainability (PLUS) to help cities achieve multiple development objectives, including preventing solid waste and reducing pollution.
[2] USAID. (2022). "Climate Strategy 2022-2030."
[3] USAID established the flagship Clean Cities, Blue Oceans (CCBO) program in 2019 to implement the Save Our Seas 2.0 Act.

Source: USAID. (2019). "CBCO Monitoring, Evaluation, and Learning Plan."

The information contained in this *Greenhouse Gas Emissions Measurement and Reporting Guide* builds from the recommendations outlined in the above-mentioned report, and provides USAID, Missions, and local partners with the information necessary to begin measuring and reporting waste-sector GHG reductions.[4]

B. PURPOSE AND OBJECTIVES

This *Greenhouse Gas Emissions Measurement and Reporting Guide* is designed to help USAID staff, Missions, and local partners measure and report GHG emissions reductions from their current and future SWM activities. It identifies available tools and methodologies for measuring GHG emissions, and provides information intended to help implementers, managers, and analysts choose the tool or methodology most appropriate for their circumstances. For each tool and methodology, the guide informs this choice with information about the applicable data inputs and outputs, as well as descriptions of its relative ease of use based upon technical complexity, length of time to complete, and data requirements. Case studies are provided, as is information about the analytic limitations of each tool and methodology.

In addition to helping USAID Missions and local partners select a tool or methodology for *measuring* emissions reductions, this guide provides key details about the subsequent *reporting* of these reductions in a complete, timely, and credible manner.[5] Applied broadly, the guide can inform USAID efforts to establish a robust, systematic, and comprehensive approach to measuring and reporting the sum total of GHG reductions resulting from current and future waste-sector programs and activities.

C. METHODOLOGY

The following steps were undertaken to develop this guide:

- **Identified and inventoried credible, widely used, and cost-free tools and methodologies** for measuring GHG reductions from SWM and ocean plastics activities.[6] Tools are defined as including pre-loaded functions that enable users to generate GHG estimates without having to perform manual calculations. Certain tools also include pre-loaded default data, while others require or provide the option for users to collect and input their own data. Methodologies are defined as consisting of step-by-step guidance on how to collect data and manually calculate GHG reductions.
- **Categorized tools and methodologies by steps in the SWM value chain**, as established in the *Greenhouse Gas Mitigation Opportunities for USAID Solid Waste Sector Activities* report. Certain tools and methodologies are shown in **Appendix 1** to be applicable across multiple SWM categories. For example, the Global Methane Initiative's (GMI) Solid Waste Emissions Estimation Tool (SWEET) can be used to measure GHG emissions from

[4] This primary audiences for this guide include USAID Missions and their local partners responsible for on-the-ground planning and implementation of climate focused SWM activities. The terms "USAID staff" and "USAID" is used to refer broadly to all the Agency entities—including Missions, as well as Washington-based Bureaus and Operating Units—charged with advancing SWM and related GHG objectives.

[5] While this document discusses concepts and resources related to measurement, reporting, and verification (MRV), it is not intended as an MRV primer. While MRV is typically applied at the level of national governments—with the aim of providing robust data to support the development of GHG targets, mitigation policies, and national inventories—this document is more narrowly focuses on helping USAID staff and local partners identify tools and methodologies for measuring GHG reductions at the level of individual activities or sets of activities. More information about MRV is available in Section III.E.

[6] Information about the tools and methodologies presented in this guide was gathered via desktop research, relying on author experience to limit inclusion to those resources that are widely used, deemed credible, and free of charge.

the Collection and Transportation, Processing and Treatment, and Final Disposal steps of the value chain.

- **Categorized tools and methodologies by GHG emission type**, to provide a snapshot of how these resources can be used to calculate emissions of one or more GHGs. **Appendix 2** maps the tools and methodologies by GHG type.
- **Assessed the applicability and relevance** of each tool and methodology to USAID SWM and ocean plastics activities. Additionally, characterized the technical complexity, level of effort, data requirements, inputs, outputs, and other considerations pertaining to each tool and methodology.
- **Identified the gaps and limitations** of inventoried tools and methodologies, including a description of how they can serve as a barrier to effective measurement and reporting of GHG emissions from USAID SWM and ocean plastics activities.

D. HOW TO USE THIS GUIDE

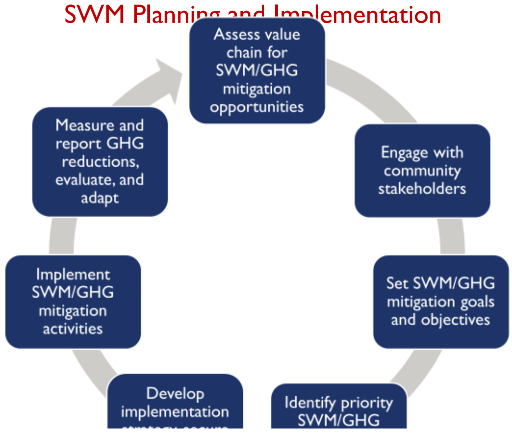
The following bullets describe each section of this guide and indicate how USAID staff and local partners can use this information to measure GHG emissions from their SWM and ocean plastics activities.

- **Getting Started with GHG Measurement and Reporting.** This section begins with a discussion of how USAID Missions and local partners can take steps to plan GHG measurement and reporting, and then offers guidance for establishing related climate indicators for tracking progress. USAID Missions and local partners can use this section to conduct GHG measurement planning and establish climate focused SWM indicators.
- **Tools and Methodologies to Measure GHG Emissions from SWM.** This section provides key details about each of the tools and methodologies for estimating GHG emissions, including their technical complexity, length of time required to complete, data requirements, appropriate applications and use cases, and gaps and limitations. USAID staff and local partners can use this section to select tools and methodologies appropriate for their level of technical expertise, data availability, and timeline for analysis.
- **Appendices 3-6.** These appendices provide additional information on required data inputs, interpreting outputs, appropriate applications and use cases, and case studies. They are intended to supplement the summary tables in the above-referenced section on Tools and Methodologies to Measure GHG Emissions from SWM.

II. GETTING STARTED WITH GHG MEASUREMENT AND REPORTING

Two key steps for measuring and reporting GHG reductions from waste-sector activities include planning and developing a GHG measurement and reporting approach—and then, once an activity is in place and reducing emissions—executing this approach by applying one or more GHG measurement tools and methodologies described below (see **Figure 2**). Taking these steps provides USAID Missions and local partners (including SWM activity managers, funders, local government officials, and others) with timely, credible, and accurate information about the magnitude of GHG reductions resulting from SWM and oceans plastics activities. A separate but related opportunity is

Figure 2: Illustrative Framework for Climate Focused SWM Planning and Implementation



Source: Adapted from USAID. (2018). "Sector Environmental Guideline for Solid Waste."

for USAID Missions and OUs to leverage the resulting data streams to develop and track climate indicators in accordance with key USAID guidelines, including the *Climate Strategy*; the 2023 *Climate Change Standard Indicator Handbook; Selecting Performance Indicators*[7]; the *CCBO Monitoring, Evaluation, and Learning Plan*[8]; and other applicable documents.

A. PLANNING FOR GHG MEASUREMENT AND REPORTING

Developing and executing a GHG measurement and reporting plan provides critical information about whether emissions reductions are being achieved, as intended by USAID staff and local implementing partners. By applying the GHG measurement tools and methodologies identified in Section III below, these stakeholders can arm themselves with the data needed to emissions reductions from their SWM activities, and therefore bolster support and buy-in from private-sector implementers, funders, government agencies, and other key partners. From the perspective of USAID staff, timely and credible GHG reduction data can also shed light on the contribution that the Agency's waste sector programs and investments are making towards achieving the USAID *Climate Strategy* targets. Local partners and government representatives can similarly use data from GHG measurement tools and methodologies to report on the contribution that SWM activities are making towards achieving applicable local and national climate goals.

The remainder of this section describes the key steps necessary for increasing the likelihood that GHG reduction data are accurate, credible, and available in a timely manner. To get started, it is important to **develop a GHG measurement and reporting plan**[9] that guides, informs, and helps coordinate the use of the tools and methodologies described below. This step typically occurs early in the SWM planning process (before SWM activities are implemented), and may include:

- Identifying the applicable SWM activities, the GHGs reduced, and the associated step(s) in the value chain
- Identifying the GHG tools and methodologies that are potentially applicable to the SWM activities of interest
- Settling on an approach for data collection, including the appropriate tool inputs, data resolution, and frequency of collection
- Determining how data will be stored, accessed, and checked for accuracy, including whether a central reporting repository exists (or will be established), who will fund and maintain it, and who has access to it
- Establishing an approach to reporting, including but not limited to reporting frequency, whether reported data will be publicly accessible, and whether data from individual SWM activities will be rolled up and reported to the national government or international bodies
- Certifying that GHG reductions data meet basic criteria for reliability and credibility, such as **completeness** (all significant emissions sources are in the baseline and activity scenarios), **consistency** (the tool or methodology allows for year-to-year comparisons), and **transparency** (data and supporting documentation are readily available).
- Establishing principles for data quality, which may include:

[7] USAID. (2021). "Monitoring Toolkit: Selecting Performance Indicators."
[8] USAID. (2020). "CCBO Monitoring, Evaluation, and Learning Plan."
[9] Such a plan is intended to assist USAID Missions and local partners with the limited objective of enhancing GHG measurement and reporting. It can inform the development of, but does not replace the need for, a "robust and sophisticated Monitoring, Evaluation, and Learning (MEL) system that records outputs and reflects outcomes towards the goal of reducing the flow of plastic waste entering our oceans" (as described in the *CCBO Monitoring, Evaluation, and Learning Plan*).

- **Demonstrating additionality**: Emissions reductions from SWM activities are considered "additional" if they would not have occurred in the absence of the activity.
- **Avoiding "leakage"**: Leakage occurs when an SWM activity results in emissions reductions in one area but emissions increase elsewhere (outside of the physical boundary of the SWM activity).[10]
- **Safeguarding permanence**: Emissions reductions from SWM activities should be continuous and lasting (e.g., that are not readily reversible due to engineering failure, behavioral changes, or other factors).

- Identifying performance indicators and associated data collection requirements, as described below in Section II.B

Once a SWM activity has been implemented and is reducing emissions, USAID and local partners can take the following steps to measure emissions reductions, aggregate and collect GHG reduction data, and report reductions as appropriate:

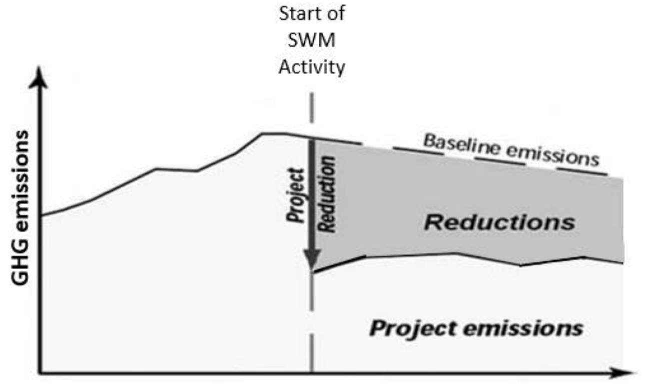
1. **Align on and apply GHG measurement tools and/or methodologies**. A comprehensive list of credible, widely used, and free-of-charge tools and methodologies is available in **Section III** below**.** Sections **III.A-E** include information on the relative ease of use, gaps, and applicability to USAID programming, while **Appendices 3-6** supplement these sections with detailed information on data requirements, case studies, and limitations.

   One consideration for selecting a tool or methodology is that it is typically necessary to balance measurement "rigor" (e.g., data collection, level of accuracy, cost, time) with the expected GHG reductions from the SWM activity under consideration. That is, a neighborhood-scale SWM activity likely does not warrant expenditure of a large fraction of total staff time or budget available for measuring emissions.

2. **Determine baseline GHG emissions**, which are the emissions that would have occurred in the absence of the SWM or ocean plastics activity in place. Baseline GHG emissions are typically calculated directly by a GHG measurement tool; when using a GHG methodology, they are calculated manually.

3. **Measure GHG reductions** from the baseline using the selected tools and/or methodologies (see **Figure 3** for an illustrative example). GHG reductions are defined as the difference between emissions measured with a SWM activity in place and the best estimate of GHG emissions in the absence of the SWM activity. Thus, GHG reductions are measured relative to the counterfactual baseline established in step 3 above.

Figure 3: Illustrative Example of GHG Reductions Relative to an Emissions Baseline



Source: Adapted from The Waste Advantage. (2014). "Carbon Offset Hurdles for Municipal Solid Waste Projects."

4. **Consider other factors related to GHG measurement**, including but not limited to:

[10] For example, if organic material is separated and collected in one community—but ultimately gets transported and dumped in a neighboring community's landfill—the GHG reductions that appear to have occurred in one area in fact occur elsewhere, resulting in no net GHG reduction. Leakage risk can be mitigated by strengthening the design of an activity, as well as by as conservatively measuring emission reductions.

a. Determining the useful life[11] of the SWM activity, project, or intervention

b. Verifying that the SWM activity is installed and operating properly

c. Accounting for variables that may affect observed GHG reductions, but are not accounted for in tools or methodologies

5. **Report emissions GHG reductions** to entities overseeing, funding, or supporting the GHG reduction activity, as well as to other key stakeholders and the public, as appropriate. When reporting emissions, USAID and local partners can take care not to double count GHG reductions, especially in cases where there are multiple funders, implementers, or government bodies involved (e.g., if multiple local governments share a waste management facility, they should not each report the reductions from a single SWM activity)

B. LEVERAGING GHG MEASUREMENT TO ESTABLISH CLIMATE INDICATORS

This section briefly describes USAID's current use of performance indicators for SWM and oceans plastics programs, and discusses how data used to calculate GHG reductions can potentially be used to establish and support climate indicators. As defined by USAID, "Performance indicators measure expected outputs and outcomes of strategies, projects, or activities [and] are the basis for observing progress and measuring actual results compared to expected results."[12] Relevant climate indicators can therefore include the quantity of GHG reduced—as measured by applying the tools and methodologies described in this guide—as well as certain waste-sector activity data used as inputs to the tools and methodologies. USAID Missions and OUs can leverage the GHG measurement planning process described above to initiate or expand their approach to climate indicators, as documented in Annex II of the *Climate Strategy 2022-2023*.

Current Use of Indicators for USAID SWM and Ocean Plastic Activities

The PLUS team's consultations with select Missions and CCBO revealed that the use of climate indicators for SWM and ocean plastics activities is not standard practice. Similarly, climate indicators are not typically included in monitoring, evaluation, and learning (MEL) plans for waste-sector programs. A key reason for this is that the previous version of the USAID *Climate Change Standard Indicator Handbook*[13], released in 2016, does not identify or require the use of such indicators for waste-sector programs or activities.

While USAID Missions and OU do not actively report climate indicators for SWM and oceans plastics, they do currently collect data and report on indicator EG.10.1-2: *Amount of municipal solid waste (in metric tons) diverted from the environment supported by USG assistance*[14]. The use of this indicator is specified in the CCBO *Monitoring, Evaluation, and Learning (MEL) Plan*[15] and the *Ocean Plastics Indicator Handbook: Definition Sheets*[16]. In addition, USAID SWM and ocean plastics programs commonly collect granular data on the material breakdown (e.g., plastics, organics), plastic polymer breakdown (e.g., PET, HDPE) and recovery type (e.g., recycling, landfill). While these are not climate indicators in and of themselves, they can be used as inputs to select tools and methodologies for calculating GHG reductions.

[11] "Useful life" refers to the duration of time an SWM activity is anticipated to remain in place and operable with the potential to reduce GHG emissions.

[12] USAID. (2021). "Monitoring Toolkit: Selecting Performance Indicators.

[13] USAID. (2023). "2023 Climate Change Standard Indicator Handbook: Definition Sheets."

[14] The Ocean Plastic Pollution standard indicators fall under Economic Growth category, Program Area EG.10: Clean Productive Environment, Program Element 10.1. The indicator referred to in the text is titled: *EG.10.1-2: Amount of municipal solid waste (in metric tons) diverted from the environment supported by USG assistance*.

[15] USAID. (2023). "CCBO Monitoring, Evaluation, and Learning (MEL) Plan."

[16] USAID. (2022). "2022 USAID Ocean Plastics Indicator Handbook: Definition Sheets."

Opportunity to Use Climate Indicators for SWM and Ocean Plastics

As documented in the *Greenhouse Gas Mitigation Opportunities for USAID Solid Waste Sector Activities* report, USAID has significant opportunities to reduce waste-sector GHG emissions. Expanding the use of climate indicators to track these efforts is a logical priority and next step that can help Missions and OUs:

- **Account for the full climate impact of SWM activities** towards the Agency's ambitious Climate Strategy goals.
- **Identify and prioritize the set of SWM activities that maximize GHG reductions**, thereby fostering alignment with the *Climate Strategy* and helping channel climate funding towards high-impact SWM activities.

For USAID Missions and OUs committed to maintaining and expanding their climate focused SWM activities, the process of identifying and using climate indicators for waste-sector programs and activities can begin with a review of the Agency's recent update to the *Climate Change Standard Indicator Handbook*. This version of the handbook was released in September 2023, based upon the U.S. Department of State (DoS) Foreign Assistance Standardized Program Structure for Economic Growth. [17] It includes two new "Economic Growth (EG)" areas—EG.12: Clean Energy, and EG.13: Sustainable Landscapes—with climate indicators that can be applied for reporting on SWM and ocean plastics activities.

The two prevailing types of climate indicators are referred to in the handbook as "standard" and "custom." **Table 1** below provides examples of both types of climate indicators for USAID's consideration, and illustrates how much of the data necessary for establishing such indicators may already be available as part of the data collection for EG.10.1-2 and for other waste-sector indicators, as described above. In other cases, the development of climate indicators can leverage the data inputs and outputs associated with applying GHG tools and methodologies presented in this guide.

The determination of which climate indicators to select will also likely depend upon factors unique to the SWM or oceans plastics activities of interest, including but not limited to where the activities fall along the SWM value chain, the specific GHGs reduced, and available program resources (e.g., staff, funding). A related decision for USAID Missions and OUs relates to the number of climate indicators to adopt, which may also depend upon available program resources, as well as the breadth of SWM activities, the overall magnitude of expected GHG reductions[18], level of funding, program end-date, and other factors.

[17] U.S. DoS. (2017). "Updated Foreign Assistance Standardized Structure and Definitions."

[18] USAID can pay particular attention to climate indicators that capture reductions of emissions that are short lived in the atmosphere and have a high global warming potential (GWP), as stated in the *USAID Short-Lived Climate Pollutants & USAID's Climate Strategy: Achieving Fast Mitigation and the USAID Climate Strategy 2022-2030*, Strategic Objective 1. Two such pollutants that occur along the SWM value chain are methane and black carbon.

Table 1: Illustrative Climate Indicators for SWM and Ocean Plastics

Type[19]	Indicator Title	Data Needs[20]	Considerations
Custom	GHG emissions, estimated in MT of CO_2-equivalent, avoided from **waste reduction and minimization activities** supported by USG assistance	Use **existing data** already collected per CCBO MEL Plan: • Material type (e.g., organic, plastic) • Plastic by resin type	This "material inclusive" indicator measures GHG emissions reductions from waste reduction and minimization activities, i.e., from reductions in waste generation and management. Using existing data, this indicator can be tailored to plastic and organic waste or pertain to a default composition of municipal solid waste.
Custom	GHG emissions estimated in MT of CO_2-equivalent, reduced, sequestered or avoided through **plastic recovery activities, specifically reuse and/or recycling,** supported by USG assistance	Utilize **existing data** already defined and collected per CCBO MEL Plan: • Material type • Plastic by resin type • Recovery type (e.g., reuse, mechanical recycling)	This "material specific" indicator measures lifecycle GHG reductions from plastic reuse and recycling activities. A plastic specific metric can help USAID estimate the lifecycle GHG emissions avoided[21] through reuse and recycling of plastics. Using existing data on plastic type and recovery type, this indicator calculates GHG emissions avoided from new plastic production through reuse and recycling.
Custom	Projected GHG emissions, measured in CO_2-equivalent, reduced or avoided from adopted **laws, policies, regulations, or technologies related to both plastic reduction and recovery** as supported by USG assistance	Use **existing data** already defined and collected per CCBO MEL Plan: • Material type • Plastic by resin type • Recovery type (e.g., reduction, reuse, mechanical recycling)	This "material specific" indicator measures lifecycle GHG reductions from a wider range of plastic reduction and recovery activities. For comparison, the above indicator is limited to GHG emissions avoided through reuse and recycling.

[19] An "existing" indicator refers to indicators listed in the USAID *Climate Change Standard Indicators Handbook* (2023). A "custom" indicator has been developed to monitor and report on USAID SWM and ocean plastics activities.

[20] To streamline reporting, USAID Missions and OUs can leverage existing definitions, data collection, and methodologies from the CCBO MEL Plan for select indicators pertaining to material and management types.

[21] 90 percent of plastic lifecycle emissions come from upstream processes. Therefore, reuse and recycling may avoid GHG emissions from virgin plastic production. GHG emissions from land disposal of plastics are minimal.

Standard	EG.12-6: GHG Emissions estimated in MT of CO_2 equivalent, reduced, sequestered or avoided by **clean energy activities** supported by USG assistance.	Use **existing data** already defined and collected per CCBO MEL Plan: • Material type (e.g., food waste, green waste) • Recovery type (e.g., anaerobic digestion, landfill gas to energy) Additionally, this metric may use existing data on route optimization from CCBO (not a formal metric per CCBO MEL Plan)	This "material specific" indicator measures GHG emissions reductions from organic waste, which occur during final disposal. This indicator can also address GHG reductions from transportation improvements. The applicable definition of "clean energy" from the USAID handbook refers to management options of anerobic digestion and landfill gas capture and utilization.[22] This indicator can reflect MT of methane captured and converted for use in anaerobic digestion (AD) facilities. The clean energy definition may also be applied to transportation improvements that reduce GHG emissions from waste collection, including route optimization or to improving fleet collection energy sources (electric, biogas).[23]
Standard	EG.12-7: Projected GHG emissions reduced or avoided from adopted laws, policies, regulations, or technologies related to **clean energy activities** supported by USG assistance	Use **existing data** already defined and collected per CCBO MEL Plan: • Material type (e.g., food waste, green waste) • Recovery type (e.g., anaerobic digestion, landfill gas to	This "material specific" indicator measures GHG emissions reductions from organic waste, which is emitted during final disposal. This indicator can also address GHG reductions from transportation improvements. *The clean energy definition and considerations mentioned above apply for this indicator.*

An additional resource that USAID Missions and OUs can consult as they initiate or expand their reporting indicators is USAID's *Monitoring Toolkit* for guidance.[24] This document outlines an approach and provides guidance for:

- Selecting either absolute (e.g., MT of methane captured) or intensity-based (e.g., carbon dioxide/km travelled) indicators
- Selecting indicators tailored to the policy or action in question (i.e., leveraging existing data where possible to reduce additional administrative burdens)
- Including indicators in the measurement and reporting plan (see Section III.A for recommendations for establishing a measurement and reporting plan)

[22] USAID. (2023). "2023 Climate Change Standard Indicator Handbook: Definition Sheets." "*Clean energy under this indicator is generally defined as inclusive of renewable energy technologies, end-use efficiency technologies and nuclear energy technologies, but also includes activities related to energy storage, the reduction of carbon and methane emissions such as carbon capture, utilization and storage (CCUS), end-use electrification, and low-emission transportation, among others*."

[23] The definition does not apply to composting operations, as no energy is produced. However, USAID may include composting in this treatment category by supplementing the clean energy definition. Alternatively, additional metrics for methane reductions from composting can be developed.

[24] USAID. (2021). "Monitoring Toolkit: Selecting Performance Indicators."

Additional EG.12 Clean Energy indicators—such as the number of people trained in clean energy[25] (EG.12-1) and number of institutions with improved capacity to address clean energy issues (EG.12-2)—can be used when solutions such as anaerobic digestion are targeted during SWM activities.[26]

[25] USAID. (2023). "2023 Climate Change Standard Indicator Handbook: Definition Sheets." "*Clean energy under this indicator is generally defined as inclusive of renewable energy technologies, end-use efficiency technologies and nuclear energy technologies, but also includes activities related to energy storage, the reduction of carbon and methane emissions such as carbon capture, utilization and storage (CCUS), end-use electrification, and low-emission transportation, among others*."

[26] For EPA's support on behalf of the Global Methane Initiative, the Agency is required to track and report on EG 12: Clean Energy indicators. Including EG.12-6 and EG.12-7, as listed in Table 1.

III. TOOLS AND METHODOLOGIES FOR MEASURING WASTE SECTOR GHG REDUCTIONS

This section discusses tools and methodologies that USAID staff, Missions, and local partners can use to measure GHG emissions from their current and future SWM and ocean plastics activities. The tools and methodologies presented below are widely viewed as credible, published by leading agencies and organizations, readily accessible, and free of charge. They also have a broad user base among governments and stakeholders similarly working to measure and track GHG reductions from their waste-sector programs and activities.

Each of the tools and methodologies below can be used to measure one or more of the three significant GHGs emitted in the waste sector: methane, carbon dioxide, and black carbon. Several of them can also be used to estimate other GHGs, as well as local air pollutants such as nitrous oxides and hydrofluorocarbons. However, because these pollutants are typically emitted in negligible quantities compared to carbon dioxide, methane, and black carbon,[27] they are not a focus of this guide (refer to the *GHG Mitigation Opportunities and Recommendations for USAID Solid Waste Sector* for more information on SWM emissions and sources).

Tools, as defined here, include pre-loaded functions that enable users to generate GHG estimates without having to perform manual calculations. Some tools may include pre-loaded default data, while others require users to collect and input their own data. Default data are often based upon literature reviews or actual national average data from the country in which the tool was developed. While default data can be applied when country-specific data are not available, users should take care to assess the implications for accuracy and caveat results accordingly. In contrast to tools, methodologies consist of guidance, instructions, and formulas that inform data collection and manual calculation of GHG reductions.

Each tool and methodology presented below is characterized by technical complexity, approximate length of time to complete, and required data inputs, and is categorized by applicability to the steps in the SWM value chain.[28] Additional details on each tool and methodology—including data inputs, outputs, and examples and use cases—are provided in **Appendices 3-6**. The legend below (**Table 2**) applies to all tools and methodologies summary tables in Section III.

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[27] UNEP. (2010). "Waste and Climate Change."

[28] No tools or methodologies exist to measure GHGs from source separation, as source separation does not directly reduce emissions. Rather, it supports and can help drive GHG reductions in subsequent steps of the SWM value chain.

Table 2: Legend for Tools and Methodologies Tables

Legend					
Technical Complexity		**Length of Time to Complete**		**Data Requirements**	
	Basic technical capability (e.g., public; agency staff; policy makers)		Less than one hour to a few hours		Requires minimal data inputs; complete default data are available
	Moderate technical capability (e.g., agency staff, project developers, site managers)		A few hours to multiple days		Requires many inputs, some of which may be challenging to obtain; some default data available
	Advanced technical capability (e.g., agency staff, site managers, engineers, waste sector consultants)		Multiple weeks		Requires extensive data compilation; no default data available

A. WASTE PREVENTION AND MINIMIZATION TOOLS AND METHODOLOGIES

Preventing and minimizing waste—at the consumer level by advancing social and behavior change, or at the producer level by partnering with businesses to reduce packaging—presents the highest GHG mitigation opportunity. It can avoid carbon dioxide from extracting raw materials and manufacturing products, as well as carbon dioxide, black carbon, and methane from waste management processes.

The report, *GHG Mitigation Opportunities and Recommendations for USAID Solid Waste Sector Activities*, provides several recommendations for USAID Missions and local partners interested in reducing GHG emissions through waste prevention and minimization for plastic and food waste. These include organizing social and behavior change campaigns, providing technical guidance and capacity building support to crop farmers and food wholesalers and retailers to reduce food loss and waste, partnering with international and local businesses to reduce packaging waste, and more.

Table 3 summarizes the leading tools and methodologies (presented in no specific order) for tracking GHGs from waste prevention and minimization activities. Refer to **Appendix 3**: Waste Prevention and Minimization Tools and for more information on how to use the tool, required data inputs, outputs, and case studies.

Table 3: Summary of Tools and Methodologies for Waste Prevention and Minimization

Tool or Methodology		Ease of Use
	Waste Reduction Model (WARM): This Excel tool calculates and *compares the GHG emissions from waste prevention and minimization to the GHG emissions of other waste management options*, including recycling, composting, anaerobic digestion, combustion, and landfilling. The tool covers a variety of waste materials, including mixed plastics, food waste, yard waste, and more.	
VERRA	**Methodology for Reducing Food Loss and Waste**: This PDF methodology provides guidance for *quantifying emission reductions from project activities that prevent food loss and waste at different stanges of the food supply chain*, including at farms, food processing facilities, retailers, food services/hospitalities, and households.	

UN-HABITAT	**Waste Wise Cities Tool (WaCT)[29]:** This PDF guide walks city decision-makers through how *to collect micro-level data on waste generation (e.g., kilograms of waste generated each day for a week) for a sample group of household and non-household waste generators* (e.g., businesses, schools, offices, supermarkets, restaurants, hotels, hospitals). It includes detailed steps for defining waste generation sample size and survey areas and includes data collection templates and survey questionnaires. Waste generation data collected from selected waste generators can be fed into the WaCT – Data Collection Tool below to calculate waste generation rates.	
UN-HABITAT	**WaCT – Data Collection Tool:** This Excel tool is *complementary to the above PDF guide. Users can enter the waste generation data they collected into the tool to estimate per capita waste generation rates, which are* required inputs for calculating avoided GHGs from waste prevention and minimization using EPA's WARM.	

Gaps in Tools and Methodologies

There is currently a limited number of publicly available tools and methodologies for measuring GHG reductions from waste prevention and minimization activities, and those that exist have certain limitations. For example, the default data on waste management practices (e.g., prevalence of landfill gas recovery, average landfill gas collection efficiency, transportation distances) in EPA's WARM are based on "national averages" from the United States. To increase accuracy for users in other countries, users can enter site-specific information, if available. If these data are not readily available, non-U.S. users can adopt default data for a rough estimate of GHG reductions, taking care to cite appropriately. Other limitations of WARM are that GHG reductions are specified in MT of carbon dioxide equivalent and not broken out by individual GHGs.[30]

A gap with the UN-Habitat's Waste Wise Cities Tool is that it does not include a section dedicated to quantifying GHGs from waste prevention and minimization. However, it does offer a detailed methodology for collecting data on waste generation from households and non-household sources (e.g., schools, markets, hotels, restaurants), and a complementary tool for estimating waste generation rates. Users can enter this waste generation rate into EPA's WARM tool to derive the GHG impacts of a baseline scenario versus a scenario with a waste prevention and minimization intervention.

Verra's Methodology for Reducing Food Loss and Waste includes detailed instructions for quantifying GHGs from activities that minimize food loss and waste, as well as recommendations for collecting primary input data and substituting missing data with U.S.-based default emission factors (including prevention and minimization). A limitation is that the methodology is highly technical and requires users to manually calculate GHG emissions reductions.

At present, no methodologies exist for quantifying GHGs from activities that reduce packaging waste.

B. COLLECTION AND TRANSPORTATION TOOLS AND METHODOLOGIES

Increasing collection frequency and coverage, especially in underserved communities, is a key opportunity to reduce carbon dioxide, methane, and black carbon from the open dumping of waste

[29] Note that while the WaCT includes "tool" in it's name, it is classified as a methodology in this guide. As discussed in the introduction of Section III, tools have pre-built functions that enable users to generate GHG estimates without having to manually perform calculations. In contrast, methodologies consist of high-level guidance on how to collect data and manually calculate GHG emissions for SWM.
[30] EPA. (n.d.). "Frequent Questions about the Waste Reduction Model (WARM)."

in unsanitary landfills[31] and burning of waste in open air. However, expanding collection using fossil-fueled waste collection trucks may lead to additional carbon dioxide and other air emissions. Therefore, activities to expand collection can be paired with the deployment of low-emissions collection vehicles that further mitigate GHG emissions.

The *GHG Mitigation Opportunities and Recommendations for USAID Solid Waste Sector Activities* report provides details on the aforementioned recommendations for reducing GHG emissions from waste collection and transportation, as well as related opportunities to optimize collection routes and formalize the waste picking sector.

Table 4**Table 4** summarizes the tools and methodologies to measure GHGs from collection and transportation activities. Refer to **Appendix 4**: Collection and Transportation Tools and Methodologies for more information on how to use each tool, required data inputs, outputs, and case studies.

Table 4: Summary of Methodologies and Tools for Collection and Transportation

Tool or Methodology	Ease of Use
GHG Emissions Calculator 2.0: This Excel tool estimates the *avoided carbon dioxide, methane, and black carbon from integrating informal waste workers into formal waste collection activities. This tool includes "global average" default data for vehicle type, fuel efficiency, and capacity.* The tool estimates the avoided GHGs from informal waste collection using manual equipment, such as pushcarts and bikes, to replace fossil-fueled collection vehicles.	
Municipal Solid Waste Decision Support Tool: This desktop application allows users to *calculate the GHG emissions impacts from different transportation modes and distances*. However, it *does not include country-specific default values for vehicle distance traveled and vehicle type and fuel usage—all defaults rely upon U.S. data*. Users have the option to enter different collection scenarios, including collection schedules, fuel usage rates, transportation mode, and travel distance. The tool also includes an "optimization mode," in which users can see the scenario that best meets a user-defined optimization objective (e.g., minimize cost, minimize GHGs, etc.). Its accounting mode allows users to estimate cost and GHG impacts from different collection scenarios.	
Solid Waste Emissions Estimation Tool (SWEET): This Excel tool calculates *carbon dioxide, methane, and black carbon associated with the transportation of waste from collection points to processing and treatment and final disposal sites*. This tool *does not include country-specific default values for vehicle distance traveled and vehicle type and fuel usage; all defaults rely upon U.S. data*. With SWEET, users can compare the GHG impacts of waste collection and transportation and open burning and dumping of waste in landfills of uncollected waste. This is particularly important for assessing the trade-offs between expanding collection with fossil-fueled vehicles and leaving waste uncollected. Users can test the effect of different collection rates by opening two SWEET spreadsheets, modeling all inputs the same way except for the waste collection rates, and comparing the differences in results from two workbooks.	

[31] Landfills or open dumpsites that are not engineered or monitored to prevent air pollution, and water and soil contamination from solid waste.

VERRA	**Methodology for Plastic Waste Collection**: This methodology outlines the steps for quantifying the amount of plastic waste collected from waste collection activities. However, it *does not provide guidance for calculating the GHG impacts of plastic waste collection activities*. User estimates for waste collection rates can instead be used as inputs for GHG calculators such as EPA SWEET, and RTI Municipal Solid Waste Decision Support tool.	
UN-HABITAT	**WaCT:** This guide walks readers through *how to collect data on the amount of collected and uncollected solid waste*. However, this guide *does not provide guidance for calculating the GHG impacts of waste collection and transport*. Users can use the gathered data to estimate waste collection rates, which are required inputs to calculate GHG emissions from waste collection and transportation using GMI's SWEET and RTI's Municipal Solid Waste Decision Support Tool.	
UN-HABITAT	**WaCT – Data Collection Tool**: This Excel tool is *complementary to the above PDF guide. Users can enter the data they gathered on collected and uncollected waste to estimate the percentage of collected and uncollected waste, which are* required inputs for GMI's SWEET and RTI's Municipal Solid Waste Decision Support Tool for purposes of estimating GHGs from improper disposal methods such as open burning and dumping of uncollected waste.	

Gaps in Tools and Methodologies

Several tools are publicly available for quantifying GHG emissions from collection and transportation activities. One limitation for both GMI's SWEET and RTI's Solid Waste Decision Support Tool is the lack of default data for transportation (e.g., vehicle distance traveled, vehicle fuel usage, hours spent idling) for areas outside of the United States. As a result, USAID Missions and local partners must identify and enter their own country-specific data for more accurate GHG estimates. In contrast, WIEGO's GHG Emissions Calculator (2.0) includes "global average" default data on vehicle type, capacity, and fuel efficiency. Unlike EPA's and RTI's tools, WIEGO's is specifically intended for estimating the avoided GHGs from integrating and formalizing the waste picking sector.

Neither VERRA's Methodology for Plastic Waste Collection nor the UN-Habitat's WaCT provide guidance for calculating the GHG impacts of waste collection and transport. However, both can be used to estimate waste collection rates, which are required inputs for the EPA and RTI tools. The main difference between the two methodologies is that VERRA's focuses on plastic waste collection, has some default values for plastic waste generation rates, and requires more advanced technical capabilities and understanding.

C. PROCESSING AND TREATMENT (PRE-LAND DISPOSAL) TOOLS AND METHODOLOGIES

Diverting waste from landfills to processing and treatment facilities (e.g., material recovery, composting, anaerobic digestion, waste-to-energy facilities) is a key opportunity for avoiding emissions of carbon dioxide, methane, and black carbon that result from improper management of plastics and organic waste. Switching to renewable power and improving energy efficiency at processing and treatment facilities can further reduce carbon dioxide emissions that would otherwise result from using fossil-fuel-powered equipment and machinery.

The *GHG Mitigation Opportunities and Recommendations for USAID Solid Waste Sector Activities* report provides several recommendations that USAID Missions and local partners can consider when selecting and deploying technologies to treat organic and plastic waste (such as AD). These include composting, promoting material recovery, switching to waste-to-energy technology, improving energy efficiency and transitioning to clean energy sources at facilities, and building the capacity of facility workers to more effectively operate and maintain landfills and treatment facilities.

Table 5 summarizes the tools and methodologies for tracking GHGs from processing and treatment activities. Refer to **Appendix 5**: Processing and Treatment (Pre-land Disposal) Tools and for more information on how to use each tool, required data inputs, outputs, and case studies.

Table 5: Summary of Methodologies and Tools for Processing and Treatment

Tool or Methodology	Ease of Use
Anaerobic Digestion Screening Tool (AD-ST): This Excel tool calculates *the potential quantity of biogas and digestate that an anaerobic digestion* project can produce annually and *estimates the carbon dioxide and methane reductions from the project.* The results from the tool are intended to help project developers and others decide whether an AD project will be technically and economically feasible.	
Biological Treatment of Solid Waste Guidelines: This PDF methodology provides step by step *guidance for collecting data and calculating methane emissions from the biological treatment of organic waste.*[32] While not a GHG tool or calculator, it remains the gold standard for calculating GHG reductions and is widely used as the methodology for many GHG calculators, including GMI's SWEET, GMI's AD-ST, RTI's Municipal Waste Decision Support Tool, and WEIGO's GHG Emissions Calculator 2.0.	
GHG Emissions Calculator 2.0: This Excel tool estimates the *avoided carbon dioxide, methane, and black carbon from integrating informal recyclers into formal waste recycling systems.* The tool calculates the amounts and types of materials that informal waste works manually sort and the avoided GHGs from using energy-intensive sorting technology. It also estimates the avoided GHGs from substituting virgin raw materials with recyclables cleaned and sorted by informal recyclers.	
Municipal Solid Waste Decision Support Tool: This desktop application allows users to *calculate the GHG emissions impacts from different waste processing and treatment options,* including anaerobic digestion, composting, material recovery, and waste-to-energy facilities. Users have the option to input their own facility design and operation data, including labor cost, electricity consumption and cost, etc. The tool's optimization mode allows users to see the solution that best meets the optimization objective (e.g., minimize cost, minimize GHGs). Its accounting mode allows users to estimate cost and GHG impacts from different processing and treatment options.	

[32] Biological treatment of solid waste, also known as organic waste treatment, refers to the conversion of degradable organic matter into other useful products. Composting and anaerobic digestion are examples of biological treatment processes.

	Methodology for Plastic Waste Recycling: This PDF methodology provides guidance for *estimating plastic waste recycled through chemical or mechanical recycling processes*. While it *does not provide guidance for calculating the GHG impacts of plastic waste recycling activities*, the methodology can be used to calculate diversion rates to recycling, which are required inputs for GHG calculators such as EPA SWEET, Ifeu SWM GHG Calculator, and RTI Municipal Solid Waste Decision Support tool.	
	SWEET: This Excel tool from the Global Methane Initiative (GMI) calculates the *carbon dioxide, methane, and black carbon impacts of different waste processing and treatment options*, including composting, anaerobic digestion, waste-to-energy, and recycling. It allows users to enter up to four alternative scenarios in future years.	
	SWM GHG Calculator – Lifecycle Approach: This Excel tool *calculates the carbon dioxide and methane impacts of different waste processing and treatment options* including composting, anaerobic digestion, recycling, and waste-to-energy. Users can enter and compare the GHG impacts of up to four different scenarios, and have the option to input country-specific waste composition and electricity emission factors.	
	WaCT: This PDF guide walks readers through a set of approaches for *gathering data on waste generated and collected for processing and treatment facilities*. Users can use the gathered data to estimate waste generation and collection rates using the tool below.	
	WaCT – Data Collection Tool: This Excel tool is *complementary to the above PDF guide. Users can enter the data they gathered on waste generation and collected for processing and treatment (diversion) to estimate waste generation and diversion rates, which are* required inputs for estimating GHGs from different processing and treatment options using GHG tools such as EPA SWEET, Ifeu SWM GHG Calculator, and RTI Municipal Solid Waste Decision Support tool.	

Gaps in Tools and Methodologies

Several tools are available to help measure GHG emissions from waste processing and treatment, each with certain limitations. For example, GMI's AD-ST is intended as a "pre-feasibility" screening tool to help users understand the approximate quantity of biogas that can be generated from different organic waste feedstocks, and then to determine whether developing an AD system is feasible. The resulting biogas production estimates are based upon a review of published literature on feedstock characteristics and have been calibrated against real-world biogas production data. However, actual biogas production values may vary greatly, depending on waste characteristics, reactor temperature, system design limitations, and daily operations. Therefore, users typically conduct additional modeling and analysis using site-specific data to inform decisions about whether to develop an AD system.

GMI's SWEET allows users to forecast future conditions and scenarios. One limitation is that SWEET's global regional default values for solid waste composition remain constant over time. To model changes in GHG emissions due to changes in waste composition, users must create and compare two individual SWEET spreadsheets.

Both Ifeu's tool and WIEGO's GHG Calculator 2.0 offer country-specific electricity emission factors; however, users should note that WIEGO's emission factors are taken from the International Energy Agency's (IEA) 2009 database and therefore do not represent the current electricity mix. In contrast, Ifeu's emission factors represent the existing cohort of power plants and prospective future power plants. These factors can be assessed to determine the reliability and applicability of these emission factors for a given country. In the case of RTI's Municipal Solid Waste Decision Support Tool, country-specific data are not embedded. All default data, including energy consumption and emissions for different processing and treatment options, are based upon U.S. values. Users are advised to enter their own site-specific data for more accurate results.

IPCC's Biological Treatment of Solid Waste and UN-Habitat's WaCT PDF guide both provide guidance for quantifying GHG emission from waste processing and treatment activities. IPCC's methodology, however, is specifically focused on quantifying GHGs from organic waste treatment (e.g., composting and AD). In contrast, UN-Habitat's methodology can be used for all processing and treatment options, including material recovery and waste-to-energy. Both methodologies require users to collect their own data and carry out calculations manually. UN-Habitat's methodology and companion data collection tool provides more guidance for data collection and is less technically complex than IPCC's methodology.

No tools or methodologies exist for estimating and comparing the GHG impacts of different recycling technologies (e.g., conveyor belts, weighing and compaction equipment, separation and packaging equipment) at MRFs. RTI's Solid Waste Decision Support Tool can be used to estimate GHG reductions from overall reductions in energy consumption at MRFs as a result of switching to more energy-efficient equipment.

D. FINAL DISPOSAL (LAND DISPOSAL) TOOLS AND METHODOLOGIES

Remediating or closing existing dumpsites, and designing and constructing sanitary landfills—engineered to prevent air pollution, water, and soil contamination—are key opportunities to capture the carbon dioxide and methane emissions from decomposed organic waste. Transitioning to cleaner landfill vehicles and equipment, including those powered by the renewable natural gas derived from the captured landfill gas, can further reduce carbon dioxide.

The *GHG Mitigation Opportunities and Recommendations for USAID Solid Waste Sector Activities* report provides several recommendations for USAID Missions and local partners for reducing and capturing landfill gas from final waste disposal sites through dumpsite remediation or closure, and through sanitary landfill construction. It also provides recommendations and practices for successfully transitioning to cleaner landfill vehicles and equipment.

Table 6 summarizes the tools and methodologies to track GHGs from Final Disposal activities. Refer to**Appendix 6:** Final Disposal (Land Disposal) Tools and for more information on how to use the tool, required data inputs, outputs, and case studies.

Table 6: Summary of Methodologies and Tools for Final Disposal

Tool or Methodology	Ease of Use
GHG Emissions Calculator 2.0: This Excel-based tool estimates the *avoided carbon dioxide, methane, and black carbon resulting from transitioning from open burning and dumping to inclusive collection and recycling.* It calculates the types and quantities of degradable materials that informal waste collectors and recyclers divert, and the GHGs avoided from open burning and disposal at dumpsites.	

Incineration and Open Burning of Waste Guidelines: This PDF methodology provides step by step *guidance for collecting data and calculating carbon dioxide and methane emissions from the open burning of waste*. While it is not a GHG tool or calculator, it remains the gold standard for calculating GHG reductions and is widely used to underpin many highly credible GHG tools, including GMI's SWEET, EPA's Landfill Gas Emissions Model (LandGEM), RTI's Municipal Waste Decision Support Tool, and WEIGO's GHG Emissions Calculator 2.0.

Landfill Gas Emissions Model (LandGEM): This Excel tool *quantifies carbon dioxide and methane emissions, as well as other air pollutants* from the decomposition of solid waste at landfills.

Landfill Gas Destruction and Beneficial Use: This PDF methodology *provides guidance for calculating methane emissions reductions from projects* that convert landfill gas to energy; destroy landfill gas in open or closed flares; enhance landfill gas for injection into natural gas pipelines; process landfill gas for use in fleet vehicles, trucks, and cars; and increase landfill gas collection via automated collection systems.

Landfill Gas Screening Tool: This Excel tool calculates *how much landfill gas a landfill site could collect* and whether this volume is sufficient to support a modest-sized landfill gas energy project (e.g., converting landfill gas to generate electricity or fuel vehicles).

Municipal Solid Waste Decision Support Tool: This desktop application allows users to *calculate the GHG emissions impacts from sending waste to landfills*. The tool's optimization mode allows users to estimate the amount of waste that should be diverted from landfills to achieve the lowest GHG emissions. Its accounting mode allows users to estimate cost and GHG impacts from disposing of waste at landfills.

SWEET: This Excel tool calculates the GHG impacts of landfills and dumpsites. It allows users to enter up to four alternative scenarios in future years. Scenarios may include future dumpsite closures or gas collection, flaring, or utilization.

Solid Waste Disposal Guidelines: This PDF methodology provides step by step *guidance for collecting data and calculating carbon dioxide and methane from solid waste disposal.* While it is not a GHG tool or calculator, it remains the gold standard for calculating GHG reductions and is widely used to underpin many highly credible GHG tools, including GMI's SWEET, EPA's Landfill Gas Emissions Model (LandGEM), RTI's Municipal Waste Decision Support Tool, and WEIGO's GHG Emissions Calculator 2.0.

SWM GHG Calculator – Lifecycle Approach: This Excel tool *calculates the carbon dioxide and methane impacts of different waste disposal options*, including landfilling and burning. Users can compare the GHG impacts of up to four different scenarios.

Waste Model: This Excel tool *calculates methane emissions from solid waste disposal from 1950 to 2030*. This tool has complete default data for different countries and regions. Users may also enter their own input data.

UN-HABITAT	**WaCT**: This PDF guide *walks readers through how to collect on waste sent to landfill disposal sites*. It does not provide guidance for quantifying GHGs emitted at landfills. Users can use the gathered data to estimate the percentage of waste sent to landfills using the tool below.	
UN-HABITAT	**WaCT – Data Collection Tool**: This Excel tool is *complementary to the above PDF guide. Users can use this tool to estimate the percentage of waste sent to landfill, which is a required input* for GHG calculators, such as EPA SWEET, Ifeu SWM GHG Calculator, and RTI Municipal Solid Waste Decision Support tool.	

Gaps in Tools and Methodologies

Many tools and methodologies are publicly available for quantifying GHG emissions from various waste disposal options. One common theme is that while each includes easy-to-use default datasets, they allow users the option of inputting their own site-specific data. For example, GMI's Landfill Gas Screening Tool includes several user-friendly "global average" default assumptions for landfill gas generation, collection, and recovery. These data should be examined carefully to assess whether they are likely to accurately represent actual GHGs emitted, captured, and reduced at disposal sites. Users should note that, without direct measurements of landfill gas generation in the field it is not possible to validate the accuracy of generation estimates that are produced by the Landfill Gas Screening Tool. A related limitation of GMI's SWEET tool is that the waste burning default emission factors are derived from a review of the literature on open burning, and are therefore highly uncertain. This is because actual emissions are dependent upon the real-world type and composition of waste burned, which varies from site to site.

A limitation of the American Carbon Registry methodology—that can be used to quantify GHG reductions from landfill gas destruction and beneficial-use projects—is that it includes only U.S. factors and is therefore intended primarily for domestic applications. Nevertheless, users from other countries can apply the underlying equations if country-specific factors and activity data are available. UN-Habitat's methodology does not provide guidance for estimating GHGs from waste disposed of at landfills; rather it recommends using tools such as SWEET to execute this step.

E. POLICY, REGULATORY, GOVERNANCE SUPPORT TOOLS AND METHODOLOGIES

Building the capacity of national and subnational governments to develop and implement policies and programs that improve SWM is critical to reducing GHGs at every step of the SWM value chain. The *GHG Mitigation Opportunities and Recommendations for USAID Solid Waste Sector Activities* report provides several recommendations intended to help USAID Missions and local partners integrate GHG considerations when developing SWM plans, and when designing and implementing policies that prevent and minimize waste and improve processing and treatment.

Table 7 summarizes the methodologies for measuring GHG reductions from Policy, Regulatory, and Governance Support activities.

Appendix 7: Policy, Regulatory, Governance Support Tools and Methodology for more information on how to use methodologies, required data inputs, outputs, and case studies.

Table 7: Summary of Methodologies and Tools

Tool or Methodology		Ease of Use
Global Methane Initiative	**Policy Maker's Handbook for Measurement, Reporting, and Verification (MRV)**: This PDF guide helps policymakers establish *an MRV system that measures and tracks GHG emissions and emissions reductions from projects* that capture methane emissions in the waste sector (e.g., anaerobic digestion and landfill gas energy projects). It draws upon technical guidance and tools from a range of protocols developed by other organizations, such as the IPCC, AgSTAR program, and California Air Resources Board. MRV data aggregated up from individual facilities can help governments address key components of their GHG measurement plans, including establishing more accurate emissions baselines and projections, setting ambitious reduction goals, and identifying targeted strategies to reduce emissions.	
GREENHOUSE GAS PROTOCOL	**Policy and Action Standards:** This PDF guide is designed to help *countries and local governments design, track, and evaluate policies and programs for reducing GHGs*. This high-level resource is applicable across economic sectors, including the waste sector. Policymakers can use this guide to evaluate the effectiveness of extended producer resposibility (EPR), pay-as-you-throw (PAYT), and other climate focused SWM policies and programs.	
UN-HABITAT	**WaCT**: This PDF guide can be used to *build the capacity of local governments to integrate GHG considerations into SWM plans*. It *provides step-by-step guidance for governments to collect data and calculate GHG emissions from waste prevention and minimization, collection and transportation, processing and treatment, and final disposal*. It includes templates for data collection (e.g., household waste sampling and waste composition sheets), questionnaires for waste generators and facility operators, and other useful resources to support waste-sector GHG measurement and reporting.	

Gaps in Tools and Methodologies

In general, the tools and methodologies described in this guide are intended for use in the context of measuring and evaluating GHG reductions from site-level SWM activities. Few tools and methodologies exist to measure GHG reductions that result from a government policy or regulation to manage solid waste and ocean plastics, such as EPR, PAYT, and others.

One option for measuring reductions from a SWM policy or regulation is to apply the Greenhouse Gas Protocol's Policy and Action Standards. A key limitation, however, is that these standards are intended to help countries and local governments evaluate GHG mitigation policies and programs from *any* economic sector, not specifically the waste sector. Policymakers may therefore apply the general approaches and methods in these standards when evaluating waste-sector policies, being sure to characterize limitations appropriately.

In contrast, GMI's Policy Maker's Handbook for MRV is specifically intended for the solid waste sector. It addresses national-level waste sector policies and programs, as well as MRV for waste sector projects and activities (e.g., AD, landfill gas energy, or composting). Users will need to match their circumstances to the appropriate sections of the handbook.

The UN-Habitat's Waste Wise Cities Tool is intended to build the capacity of local governments to collect primary waste management data and measure GHG emissions from SWM activities. While it is not intended as an MRV guide, it can support the establishment of a robust GHG measurement plan for the solid waste sector (as described in **Section II.B**).

IV. CONCLUSION

Bolstering efforts to measure and report GHG reductions can help USAID staff and local partners document the contribution that SWM and oceans plastics activities are making towards achieving *Climate Strategy* goals, as well as host-country GHG targets. Measuring and reporting reductions It also fosters buy-in and support among private-sector implementers, funders, government agencies, the public, and other key stakeholders. A related opportunity is to develop and track climate indicators. Doing so draws upon many of the same datasets as GHG measurement, and can similarly advance transparency and document progress towards achieving climate goals.

To get started, USAID Missions and local partners can take steps to develop a GHG measurement and reporting plan. This plan, which is executed once a SWM activity is in place and reducing emissions, serves as a blueprint for measuring and reporting GHG reductions. It outlines approaches for: identifying and collecting data, conducting data management, selecting tools and methodologies to measure reductions, reporting GHG reductions, and using data inputs and outputs to develop climate indicators.

USAID Missions and partners can use this guide to select among multiple cost-free tools and methodologies currently available to measure GHG emissions reductions from SWM and ocean plastic activities (refer to **Appendix I** for tools and methodologies against steps in the SWM value chain). One common theme across each of the tools and methodologies is that using country-specific input data (e.g., waste generation, composition, collection rates) produces more accurate results. If country-specific data are not available, USAID Missions and local partners may consider using data from countries with similar income levels. In cases where default data is used in place of locally-sourced inputs, the results many not deliver the desired level of accuracy. USAID Missions and local partners are advised to carefully and transparently document assumptions, associated limitations, and appropriate uses for the resulting data.

Aside from the tool- and methodology-specific limitations described above, there are several gaps and opportunities related to the prevailing suite of GHG measurement resources. One such opportunity is that few tools and methodologies are suitable for measuring GHG emissions from waste prevention and minimization, even though this step in the SWM value chain can result in significant emission reductions. Several existing tools, such as EPA's SWEET and WARM tools, can potentially be adjusted and enhanced to better address this gap. Another opportunity is that many SWM tools are developed for use in the United States—and include only U.S.-based default data—limiting their applicability and accuracy in the context of developing and emerging countries. USAID can consider exploring and potentially partnering with EPA and other leading organizations to respond to capture these opportunities, and to ensure that Missions and local partners have the tools and methodologies they need to measure and report waste-sector in an accurate and timely manner.

APPENDICES

APPENDIX I: SUMMARY OF TOOLS AND METHODOLOGIES BY SWM VALUE CHAIN STEPS

Table 8 maps the tools and methodologies in Section III against the steps in the SWM value chain.[33]

Table 8: Tools and Methodologies by SWM Value Chain Steps

Tool or Methodology	Waste Prevention & Minimization	Collection & Transportation	Processing & Treatment	Final Disposal	Policy, Regulatory, Governance Support
Landfill Gas Destruction and Beneficial Use				☑	
Anaerobic Digestion Screening Tool			☑		
Landfill Gas Emissions Model (LandGEM)				☑	
Landfill Gas Screening Tool				☑	
Solid Waste Emissions Estimation Tool		☑	☑	☑	
GHG Emissions Calculator 2.0		☑	☑	☑	
SWM GHG Calculator			☑		
Biological Treatment of Solid Waste Guidelines			☑		
Incineration and Open Burning of Waste Guidelines				☑	
Solid Waste Disposal Guideline				☑	
Methodology for Plastic Waste Collection		☑			
Methodology for Reducing Food Loss and Waste	☑				
Municipal Solid Waste Decision Support Tool	☑	☑	☑	☑	☑
Methodology for Plastic Waste Recycling			☑		
Waste Reduction Model	☑				
Waste Wise Cities Tool (WaCT)	☑	☑	☑	☑	☑
WaCT – Data Collection Tool	☑	☑	☑	☑	
Policy and Action Standards					☑

[33] The "source separation" step in the SWM value chain is not presented here, as such actions facilitate but do not directly reduce GHG emissions.

APPENDIX 2: SUMMARY OF TOOLS AND METHODOLOGIES BY GHG TYPE

Table 9 maps the tools and methodologies in Section III against the type of GHG emissions they calculate.

Table 9: Tools and Methodologies by GHG Type

Tool or Methodology	Carbon Dioxide	Methane	Black Carbon
Landfill Gas Destruction and Beneficial Use	☑	☑	
Anaerobic Digestion Screening Tool		☑	
Landfill Gas Emissions Model (LandGEM)	☑	☑	
Landfill Gas Screening Tool		☑	
Solid Waste Emissions Estimation Tool	☑	☑	☑
GHG Emissions Calculator 2.0	☑	☑	☑
SWM GHG Calculator	☑	☑	
Biological Treatment of Solid Waste Guidelines	☑	☑	
Incineration and Open Burning of Waste Guidelines	☑	☑	
Solid Waste Disposal Guideline	☑	☑	
Methodology for Plastic Waste Collection*			
Methodology for Reducing Food Loss and Waste	☑	☑	
Municipal Solid Waste Decision Support Tool	☑	☑	
Methodology for Plastic Waste Recycling*			
Waste Reduction Model	☑	☑	
Waste Wise Cities Tool (WaCT)	☑	☑	☑
WaCT – Data Collection Tool*			
Policy and Action Standards*			

* Does not directly calculate or provide guidance for calculating GHG impacts; rather, supports data collection, policy steps, and other actions that indirectly contribute to reducing emissions.

APPENDIX 3: WASTE PREVENTION AND MINIMIZATION TOOLS AND METHODOLOGIES

The legend below applies to the tables in Appendices 3-6.

Legend		
Technical Complexity	**Length of Time to Complete**	**Data Requirements**
Basic technical capability and above (e.g., public; agency staff; policy makers)	Less than one hour to a few hours	Requires minimal data inputs; complete default data is available
Moderate technical capability and above (e.g., agency staff, project developers, site managers)	A few hours to multiple days	Requires many inputs, some of which may be challenging to obtain; some default data available
Advanced technical capability (e.g., agency staff, site managers, engineers, waste sector consultants)	Multiple weeks	Requires extensive data compilation; no default data available

	Waste Reduction Model (WARM): This Excel tool calculates and *compares the GHG emissions from waste prevention and minimization to the GHG emissions of other waste management options*, including recycling, composting, anaerobic digestion, combustion, and landfilling.
Type of Tool	Excel tool and open LCA software
Ease of Use	

Data Inputs	• Baseline scenario: Amount of waste (by material type) recycled, landfilled, combusted, composted, and/or anaerobically digested (MT) • Alternative scenario: Amount of waste (by material type) source reduced, recycled, landfilled, combusted, composted, and/or anaerobically digested (MT) • Jurisdiction for which the analysis is conducted • Assumption whether the material that is source reduced would have been manufactured from the current mix of virgin and recycled inputs or 100% virgin inputs • Landfill gas collection efficiency **(includes U.S default data)** • Moisture conditions and bulk decay rate of MSW **(includes U.S default data)** • Type of anaerobic digestion used **(includes U.S default data)** • Digestate management **(includes U.S default data)** • Transportation distances of materials to the management facility **(includes U.S default data)**
Outputs	• GHG emissions (MTCO2e) per ton of material from baseline waste management scenario (without source reduction) and alternative waste management scenario (with source reduction) • Energy use (million BTU) per ton of material from baseline waste management scenario (without source reduction) and alternative waste management scenario (with source reduction) • Employment (labor hours and wages) per ton of material from baseline waste management scenario (without source reduction) and alternative waste management scenario (with source reduction)
Limitations	• Default data are based in the United States. Results would be more precise if country-specific data are used • GHG emissions are in MTCO2e and not broken down by GHGs

Examples of Applicable SWM Recommendations[34]	● Utilize social and behavioral change research, which helps local governments and policymakers identify impactful and sustainable behavioral changes to reduce waste ● Organize household food waste campaigns that raise awareness about the benefits of reducing food waste and the practical ways people can do so at home ● Support the integration of food waste reduction into school curriculum ● Provide technical guidance and capacity building support to crop farmers and food wholesalers and retailers to reduce food loss and waste ● Promote food donation, especially at hotels, grocery stores, supermarkets and restaurants with surplus prepared food, produce, meat, bakery, and dairy items that remain safe to consume ● Partner with international and local businesses to reduce packaging waste, including strategies like bulk vending and refillable containers for certain products (e.g., nuts, grains, milk) ● Leverage extended producer responsibility policies, including taxes on plastic manufacturers and recycled content standards to set requirements for the quantity of recycled plastic used in new products ● Organize behavior change and educational campaigns to raise awareness about the negative ecological, social, and economics impacts of single-use plastics, as well as the benefits of reducing plastic waste by switching to alternatives such as reusable metal straws instead of plastic straws, reusable grocery bags, etc. ● Invest in locally appropriate and innovative technology and infrastructure

[34] The "Examples of Applicable SWM Recommendations" provided here and in Appendix tables below are taken from the companion report, *Greenhouse Gas Mitigation Opportunities for USAID Solid Waste Sector Activities.*

Key Resources	• **User Manual:** Waste Reduction Model (WARM) Tool User's Guide • **Case Study:** Analysis of Solid Waste Management Scenarios Using the WARM Model: Case Study (Brazil) • **Case Study:** Modeling Food Donation Benefits in EPA's Waste Reduction Model
VERRA	**Methodology for Reducing Food Loss and Waste**: This PDF methodology provides guidance for *quantifying emission reductions from project activities that prevent food loss and waste at different stanges of the food supply chain*, including at farms, food processing facilities, retailers, food services/hospitalities, and households.
Type of Tool	PDF methodology
Ease of Use	
Data Inputs	• Food type and characteristics • Emission factor of food loss and waste destination (e.g., landfill, AD facility, composting facility) • Food transport methods and transport distances from the food loss and waste source to food loss and waste destination • Time period considered when calculating food diverted from a food loss and waste destination
Outputs	• Net GHG emission reductions from diverting food from a food loss and waste destination (e.g., landfill, AD facility, composting facility)
Limitations	• Highly technical resource and requires users to manually calculate GHG emissions reductions

<table>
<tr><td>Examples of Applicable SWM Recommendations</td><td>Utilize social and behavioral change research, which helps local governments and policymakers identify impactful and sustainable behavioral changes to reduce waste
Organize household food waste campaigns that raise awareness about the benefits of reducing food waste and the practical ways people can do so at home
Support the integration of food waste reduction into school curriculum
Provide technical guidance and capacity building support to crop farmers and food wholesalers and retailers to reduce food loss and waste
Promote food donation, especially at hotels, grocery stores, supermarkets and restaurants with surplus prepared food, produce, meat, bakery, and dairy items that remain safe to consume</td></tr>
<tr><td>Key Resources</td><td>Tutorial: Overview Webinar on Methodology for Reducing Food Loss and Waste</td></tr>
<tr><td colspan="2">Waste Wise Cities Tool (WaCT)[35]: This PDF guide walks readers through how to collect waste generation data for household and non-household waste generators (e.g., businesses, schools, offices, supermarkets, restaurants, hotels, hospitals). It includes data collection templates and survey questionnaires.</td></tr>
<tr><td>Type of Tool</td><td>PDF Methodology</td></tr>
<tr><td>Ease of Use</td><td></td></tr>
<tr><td>Data Inputs</td><td>No input required. This document only provides guidance for data collection.</td></tr>
<tr><td>Outputs</td><td>Outputs can be calculated using the complementary WaCT – Data Collection Tool discussed below</td></tr>
<tr><td>Limitations</td><td>Does not have a specific section for quantifying GHGs from Waste Prevention and Minimization. However, it does have a detailed methodology for collecting data on waste generation from households and non-household sources (e.g., schools, markets, hotels, restaurants), and a complementary Data Collection Tool for estimating waste generation rates.</td></tr>
</table>

[35] While the name includes the word "tool," it is classified here as a methodology. As discussed in the Section III, methodologies consist of high-level guidance on approaches for collecting data and manually calculate GHG reductions.

Examples of Applicable SWM Recommendations	● Utilize social and behavioral change research, which helps local governments and policymakers identify impactful and sustainable behavioral changes to reduce waste ● Organize household food waste campaigns that raise awareness about the benefits of reducing food waste and the practical ways people can do so at home ● Support the integration of food waste reduction into school curriculum ● Provide technical guidance and capacity building support to crop farmers and food wholesalers and retailers to reduce food loss and waste ● Promote food donation, especially at hotels, grocery stores, supermarkets and restaurants with surplus prepared food, produce, meat, bakery, and dairy items that remain safe to consume ● Partner with international and local businesses to reduce packaging waste, including strategies like bulk vending and refillable containers for certain products (e.g., nuts, grains, milk) ● Leverage extended producer responsibility policies, including taxes on plastic manufacturers and recycled content standards to set requirements for the quantity of recycled plastic used in new products ● Organize behavior change and educational campaigns to raise awareness about the negative ecological, social, and economics impacts of single-use plastics, as well as the benefits of reducing plastic waste by switching to alternatives such as reusable metal straws instead of plastic straws, reusable grocery bags, etc. ● Invest in locally appropriate and innovative technology and infrastructure
Key Resources	● **Case Study:** Waste Wise Cities Tools in Mangalore, India ● **Case Study:** Waste Wise Cities Tools in Thiruvananthapuram, India
UN-HABITAT	**WaCT – Data Collection Tool:** This Excel tool is *complementary to the above PDF guide. Users can enter the waste generation data they collected into the tool to estimate waste generation rates, which are* required inputs for calculating avoided GHGs from waste prevention and minimization using EPA's WARM.
Type of Tool	PDF Methodology
Ease of Use	
Data Inputs	● MSW generated by household and non-household waste generators collected using the methodology in the WaCT PDF guide

Outputs	• Total municipal solid waste (MSW) generated (t/day) • MSW generation rate (kg/day/capita) • Household MSW (kg/day/capita) • Household food waste (kg/day/capita)
Limitations	Requires significant data gathering, which involves: • Determining sample size and selecting survey areas and households • Preparing consent letters explaining the purpose of the survey and how the information will be used • Preparing the survey team, equipment, and transport
Examples of Applicable SWM Recommendations	• Utilize social and behavioral change research, which helps local governments and policymakers identify impactful and sustainable behavioral changes to reduce waste • Organize household food waste campaigns that raise awareness about the benefits of reducing food waste and the practical ways people can do so at home • Support the integration of food waste reduction into school curriculum • Provide technical guidance and capacity building support to crop farmers and food wholesalers and retailers to reduce food loss and waste • Promote food donation, especially at hotels, grocery stores, supermarkets and restaurants with surplus prepared food, produce, meat, bakery, and dairy items that remain safe to consume • Partner with international and local businesses to reduce packaging waste, including strategies like bulk vending and refillable containers for certain products (e.g., nuts, grains, milk) • Leverage extended producer responsibility policies, including taxes on plastic manufacturers and recycled content standards to set requirements for the quantity of recycled plastic used in new products • Organize behavior change and educational campaigns to raise awareness about the negative ecological, social, and economics impacts of single-use plastics, as well as the benefits of reducing plastic waste by switching to alternatives such as reusable metal straws instead of plastic straws, reusable grocery bags, etc. • Invest in locally appropriate and innovative technology and infrastructure
Key Resources	• **User Manual:** Guide to Using the WaCT Data Collection Application • **Tutorial:** How to Use the Data Collection Application

APPENDIX 4: COLLECTION AND TRANSPORTATION TOOLS AND METHODOLOGIES

Global Methane Initiative

EPA Solid Waste Emissions Estimation Tool (SWEET): This Excel tool calculates *carbon dioxide, methane, and black carbon associated with the transportation of waste from collection points to processing and treatment and final disposal sites*. This tool *does not include country-specific default values for vehicle distance traveled and vehicle type and fuel usage—all defaults rely upon U.S. data*. With SWEET, users can compare the GHG impacts of waste collection and transportation and open burning and dumping of waste in landfills of uncollected waste. This is particularly important for assessing the trade-offs between expanding collection with fossil-fueled vehicles and leaving waste uncollected. Users can test the effect of different collection rates by opening two SWEET spreadsheets, modeling all inputs the same way except for the waste collection rates, and comparing the differences in results from two workbooks.

Type of Tool	Excel tool
Ease of Use	
Data Inputs	• Population in and out of formal collection zones • Average annual precipitation (mm/year) • Mean annual temperature (Celsius) • Per capita waste generation rate inside and outside formal collection zones (kg/capita/day) • Historical and projected average annual percentage growth rate in quantity of waste collected • Percentage of waste generated inside and outside formal collection zones • Total waste collected annually inside formal collection zones (MT) • Total waste generated annually inside collection zones (MT) • Average percentage composition of collected waste **(includes global regional default data)** • MT of waste delivered to diversion facility per year • Number of heavy- and light-duty diesel/gasoline/natural gas trucks in operation per year **(includes U.S. default data)** • Kilometers traveled by heavy- and light-duty diesel/gasoline/natural gas trucks in operation per **(includes U.S. default data)** • Emission factors for heavy- and light-duty diesel/gasoline/natural gas trucks **(includes U.S. default data)** • Opening and closing years of disposal site • Annual disposal rate (MT/year)

	• Landfill category • Percentage of uncollected waste burned in the open by residents living inside and outside formal collection zones • Percentage of waste disposed of at landfills or dumpsites that is ultimately burned at the landfill or dumpsite • Number of diesel and gasoline waste handling equipment used
Outputs	• Total emissions (MTCO2e) from 1960 – 2100 • Emissions by waste management process (E.g., waste collection and transport, waste burning, landfills, etc.) (MTCO2e) from 1960 – 2011 • Total methane, sulfur oxides, particulate matter 2.5 and 10, and black carbon (metric tons) from 1960 – 2011 • Total emissions changes from business-as-usual (BAU) scenario from 1960 – 2100 • Total changes in methane, sulfur oxides, particulate matter 2.5 and 10, and black carbon (MT) from BAU scenario from 1960 – 2011
Limitations	• Users **must** enter all inputs regardless of the output desired. For example, users have to enter landfill data input even if they just want to get GHG emissions from collection and transportation • SWEET holds solid waste composition data constant over time. To model changes in GHG emissions from changes in waste composition, users must create and compare two individual SWEET spreadsheets • Does not include country-specific default values for vehicle distance traveled and vehicle type and fuel usage—all defaults rely upon U.S. data. USAID Missions and local partners must enter their own country-specific data for more accurate GHG estimates • Forecasting future conditions and scenario implementation dates represent large source of potential data error
Examples of Applicable SWM Recommendations	• Support the expansion of collection service coverage and frequency to underserved communities to prevent illegal dumping and open burning and reduce associated carbon dioxide and methane emissions • Support the transition to low- or zero-emission collection vehicles to reduce the carbon footprint of waste collection • Optimize collection routes to maximize collection coverage and so that collection vehicles follow the most efficient paths, have full loads, and reduce fuel consumption
Key Resources	• **User Manual:** SWEET User Manual • **Tutorial:** SWEET Advanced Tips

GHG Emissions Calculator 2.0: This Excel tool estimates the *avoided carbon dioxide, methane, and black carbon from integrating informal waste workers into formal waste collection activities*. This *tool has "global average" default data for vehicle type, fuel efficiency, and capacity.* The tool estimates the avoided GHGs from informal waste collection using manual equipment, such as pushcarts and bikes, to replace fossil-fueled collection vehicles.

Type of Tool	Excel tool
Ease of Use	
Data Inputs	• Landfill type • Total MSW landfilled (MT/year) • Percentage waste composition of waste diverted by informal waste collectors • Percentage waste composition at the final disposal site • Collection vehicle type **(includes default values based on literature review)** • Collection capacity (MT) **(includes default values based on literature review)** • Fuel efficiency (liters/100 km) **(includes default values based on literature review)** • Distance from collection point to disposal site (km) • Amount of MSW transported (MT/year) • Number of trips per year • Fuel type
Outputs	• GHG emissions saved through informal waste collection intervention (MT of carbon dioxide equivalent/year)
Limitations	• Specifically intended for estimating the avoided GHGs from integrating informal waste workers into formal waste collection and transportation activities
Examples of Applicable SWM Recommendations	• Support formalization of informal waste collection. Informal workers rely on collecting waste and recovering recyclables as a source of income
Key Resources	• **User Manual:** Reducing Greenhouse Gas Emissions through Inclusive Recycling
VERRA	**Methodology for Plastic Waste Collection**: This methodology outlines the steps for quantifying the amount of plastic waste collected from waste collection activities. However, it *does not provide guidance for calculating the GHG impacts of plastic waste collection activities*. User estimates for waste collection rates can instead be used as inputs for GHG calculators such as EPA SWEET, Ifeu SWM GHG Calculator, and RTI Municipal Solid Waste Decision Support tool.
Type of Tool	PDF Methodology

Ease of Use	
Data Inputs	• National, regional and local laws and regulations for plastic waste treatment, specific to collection in the relevant region • Annual plastic waste collection and generation • All relevant costs and revenues
Outputs	• Penetration rate of collection activities (ratio between plastic waste collection and plastic waste production) • Baseline plastic waste collection (the amount of plastic waste that would have been collected in the absence of the project activity) • Project plastic waste collection (amount of plastic waste that is collected by the project activity) • Net plastic waste collected
Limitations	• No default values available • Does not provide guidance for estimating GHG impacts of waste collection and transport. However, it can be used to estimate waste collection rates, which are required inputs for GMI's SWEET and RTI's Municipal Solid Waste Decision Support Tool
Examples of Applicable SWM Recommendations	• Support the expansion of collection service coverage and frequency to underserved communities to prevent illegal dumping and open burning and reduce associated carbon dioxide and methane emissions • Support formalization of informal waste collection. Informal workers rely on collecting waste and recovering recyclables as a source of income
RTI INTERNATIONAL	**Municipal Solid Waste Decision Support Tool**: This desktop application allows users to *calculate the GHG emissions impacts from different transportation modes and distances*. However, it *does not have country-specific default values for vehicle distance traveled and vehicle type and fuel usage—all defaults rely upon U.S. data*. Users have the option to enter different collection scenarios, including collection schedules, fuel usage rates, transportation mode, and travel distance. The tool also includes an "optimization mode," in which users can see the scenario that best meets a user-defined optimization objective (e.g., minimize cost, minimize GHGs, etc.). Its accounting mode allows users to estimate cost and GHG impacts from different collection scenarios.
Type of Tool	Desktop application

Ease of Use	
Data Inputs	● Waste generation amounts (kg/week) for household or commercial waste generators ● Waste composition percentage ● Waste collection processes ● Select waste destinations (i.e., recycling, treatment or disposal) ● Allocation of waste among processes (optional) ● Define electrical energy grid and carbon accounting methodology (optional) **(includes U.S. default data)** ● Collection and transportation distances (optional) **(includes U.S. default data)** ● Process specific data or assumptions (e.g., energy consumption at processing and treatment facilities) (optional) ● Optimization objective and constraints (if running under the "optimization" mode)
Outputs	• A mass flow report showing the tonnage of waste collected and sent to each process. • A cost report showing the net total cost and net cost for each process. • A life cycle inventory analysis report showing the net total inventory flow and net flow for each process. • An impact assessment report showing the total impacts by category and for each process.
Limitations	● Users **must** enter all inputs regardless of the output desired. For example, users have to enter landfill data input even if they just want to get GHG emissions from collection and transportation ● Does not have embedded country-specific data. All default data, including energy consumption and emissions for different processing and treatment options, are based upon U.S. values. Users are advised to enter their own site-specific data for more accurate results
Examples of Applicable SWM Recommendations	● Support the expansion of collection service coverage and frequency to underserved communities to prevent illegal dumping and open burning and reduce associated carbon dioxide and methane emissions ● Support the transition to low- or zero-emission collection vehicles to reduce the carbon footprint of waste collection ● Optimize collection routes to maximize collection coverage and so that collection vehicles follow the most efficient paths, have full loads, and reduce fuel consumption

Key Resources	• **User Manual:** A Decision Support Tool for Assessing the Cost and Environmental Performance of Integrated Municipal Solid Waste Management Strategies • **Input Data:** Default Data and Data Input Requirements • **Tutorial:** Available Tutorials
UN-HABITAT	**WaCT:** This guide walks readers through *how to collect data on the amount of collected and uncollected solid waste.* However, this guide *does not provide guidance for calculating the GHG impacts of waste collection and transport.* Users can use the gathered data to estimate waste collection rates using the tool below.
Type of Tool	PDF Methodology
Ease of Use	
Data Inputs	• No input required. This document only provides guidance for data collection.
Outputs	• Outputs can be calculated using the complementary WaCT – Data Collection Tool discussed below
Limitations	• Does not have a specific section for quantifying GHGs from Collection and Transportation activities. However, it does have a detailed methodology for gathering data on amount of collected and uncollected waste, and a complementary Data Collection Tool for estimating waste collection rates
Examples of Applicable SWM Recommendations	• Support the expansion of collection service coverage and frequency to underserved communities to prevent illegal dumping and open burning and reduce associated carbon dioxide and methane emissions • Optimize collection routes to maximize collection coverage and so that collection vehicles follow the most efficient paths, have full loads, and reduce fuel consumption • Support formalization of informal waste collection. Informal workers rely on collecting waste and recovering recyclables as a source of income
Key Resources	• **Case Study:** o Waste Wise Cities Tools in Mangalore, India o Waste Wise Cities Tools in Thiruvananthapuram, India

UN-HABITAT	**WaCT – Data Collection Tool**: This Excel tool is *complementary to the above PDF guide. Users can enter the data they gathered on collected and uncollected waste to estimate the percentage of collected and uncollected waste, which are* required inputs for GMI's SWEET for purposes of estimating GHGs from improper disposal methods such as open burning and dumping of uncollected waste.
Type of Tool	PDF Methodology
Ease of Use	
Data Inputs	• MSW collected
Outputs	• Percentage MSW collected • Percentage MSW collected and sent to processing and treatment facilities
Limitations	Requires significant data gathering, which involves: • Determining sample size and selecting survey areas and households • Preparing consent letters explaining the purpose of the survey and how the information will be used • Preparing the survey team, equipment, and transport
Examples of Applicable SWM Recommendations	• Support the expansion of collection service coverage and frequency to underserved communities to prevent illegal dumping and open burning and reduce associated carbon dioxide and methane emissions • Optimize collection routes to maximize collection coverage and so that collection vehicles follow the most efficient paths, have full loads, and reduce fuel consumption • Support formalization of informal waste collection. Informal workers rely on collecting waste and recovering recyclables as a source of income
Key Resources	• **User Manual:** Guide to Using the WaCT Data Collection Application • **Tutorial:** How to Use the Data Collection Application

APPENDIX 5: PROCESSING AND TREATMENT (PRE-LAND DISPOSAL) TOOLS AND METHODOLOGIES

Global Methane Initiative	**SWEET**: This Excel tool calculates the *carbon dioxide, methane, and black carbon impacts of different waste processing and treatment options*, including composting, anaerobic digestion, waste-to-energy, and recycling. It allows users to enter up to four alternative scenarios in future years.
Type of Tool	Excel
Ease of Use	
Data Inputs	• Population in and out of formal collection zones • Average annual precipitation (mm/year) • Mean annual temperature (Celsius) • Per capita waste generation rate inside and outside formal collection zones (kg/capita/day) • Historical and projected average annual percentage growth rate in quantity of waste collected • Percentage of waste generated inside and outside formal collection zones • Total waste collected annually inside formal collection zones (MT) • Total waste generated annually inside collection zones (MT) • Average percentage composition of collected waste **(includes global regional default data)** • MT of waste delivered to diversion facility per year • Number of heavy- and light-duty diesel/gasoline/natural gas trucks in operation per year **(includes U.S. default data)** • Kilometers traveled by heavy- and light-duty diesel/gasoline/natural gas trucks in operation per year **(includes U.S. default data)** • Emission factors for heavy- and light-duty diesel/gasoline/natural gas trucks **(includes U.S. default data)** • Opening and closing years of disposal site • Annual disposal rate (MT/year) • Landfill category • Percentage of uncollected waste burned in the open by residents living inside and outside formal collection zones

	• Percentage of waste disposed of at landfills or dumpsites that is ultimately burned at the landfill or dumpsite • Number of diesel and gasoline waste handling equipment used
Outputs	• Total emissions (MTCO2e) from 1960 – 2100 • Emissions by waste management process (E.g., waste collection and transport, waste burning, landfills, etc.) (MTCO2e) from 1960 – 2011 • Total methane, sulfur oxides, particulate matter 2.5 and 10, and black carbon (MT) from 1960 – 2011 • Total emissions changes from business-as-usual (BAU) scenario from 1960 – 2100 • Total changes in methane, sulfur oxides, particulate matter 2.5 and 10, and black carbon (MT) from BAU scenario from 1960 – 2011
Limitations	• Users **must** enter all inputs regardless of the output desired. For example, users have to enter landfill data input even if they just want to get GHG emissions from collection and transportation • SWEET holds solid waste composition data constant over time. To model changes in GHG emissions from changes in waste composition, users must create and compare two individual SWEET spreadsheets • Does not include country-specific default values for vehicle distance traveled and vehicle type and fuel usage—all defaults rely upon U.S. data. USAID Missions and local partners must enter their own country-specific data for more accurate GHG estimates • Forecasting future conditions and scenario implementation dates represent large source of potential data error
Examples of Applicable SWM Recommendations	• Provide technical support for selecting and deploying technologies to treat organic and plastic waste • Provide technical support for the establishment and upgrade of MRFs to increase the quantity and quality of recycled materials, including plastics • Improve energy efficiency and transition to clean energy sources at processing and treatment facilities • Promote the treatment of organic waste at home, including yard waste and food waste from food preparation and leftovers, before they are sent for processing or to landfills • Provide technical, capacity building, and financial support for the establishment of "Waste Banks", decentralized and small-scale recycling facilities

Key Resources	● **User Manual:** SWEET User Manual ● **Data Collection Worksheet:** SWEET Data Collection Worksheet ● **Tutorial:** SWEET Advanced Tips ● **Case Study:** Scaling Up Organic Waste Management in Serbia's South Backa Waste Management Region
GHG Emissions Calculator 2.0: This Excel tool estimates the *avoided carbon dioxide, methane, and black carbon from integrating informal recyclers into formal waste recycling systems*. The tool calculates the amounts and types of materials that informal waste works manually sort and the avoided GHGs from using energy-intensive sorting technology. It also estimates the avoided GHGs from substituting virgin raw materials with recyclables cleaned and sorted by informal recyclers.	
Type of Tool	Excel tool
Ease of Use	
Data Inputs	● Country of operation ● Electricity consumed in sorting stations (kWh/year) ● Fossil fuel type ● Fossil fuel quantity (liters/year) ● Recyclables sorted in sorting station (MT/year) ● Recyclables hand sorted by waste pickers (metric/year)
Outputs	● GHG emissions avoided through informal waste sorting and recycling (MT CO2e/year)
Limitations	● Specifically intended for estimating the avoided GHGs from integrating informal waste workers into formal waste recycling activities ● Offers country-specific electricity emission factors; however, users should note that WIEGO's emission factors are taken from the International Energy Agency's 2009 database and do not represent the current electricity mix in a country. Users are advised to enter their own site-specific data for more accurate results
Examples of Applicable SWM Recommendations	● Provide technical support for selecting and deploying technologies to treat organic and plastic waste ● Provide technical support for the establishment and upgrade of MRFs to increase the quantity and quality of recycled materials, including plastics

	• Improve energy efficiency and transition to clean energy sources at processing and treatment facilities • Provide technical, capacity building, and financial support for the establishment of "Waste Banks", decentralized and small-scale recycling facilities
Key Resources	• **User Manual:** Reducing Greenhouse Gas Emissions through Inclusive Recycling
Global Methane Initiative **Anaerobic Digestion Screening Tool (AD-ST):** This Excel tool calculates *the potential quantity of biogas and digestate that an anaerobic digestion* project can produce annually and *estimates the carbon dioxide and methane reductions from the project*. The results from the tool are intended to help project developers and others decide whether an AD project will be technically and economically feasible.	
Type of Tool	Excel tool
Ease of Use	
Data Inputs	• Feedstock type • Feedstock total (kg/day) • Biogas composition **(includes default data based on literature review)** • Information about the planned AD system such as wet vs. dry, reactor temperature and dewatering equipment **(includes default data based on literature review)** • On-site methane utilization percentage **(includes default data based on literature review)** • Percentage of methane set to flare **(includes default data based on literature review)** • Electricity generation (kWh/day) • Electricity grid emissions factor (kgCO2/kWh) **(includes default data based on literature review)**
Outputs	• Annual biogas and digestate production (m3/year) • Annual project methane emission reductions (kgCH4/year or MT CH4/year) • Total digestate production (kg/day) • Total biogas production (m3/day)

	• Electricity production (cleaned biogas to natural gas quality) (MWh) • Renewable natural gas production (m3/year) • Cooking gas potential (homes/year) • Home heating potential (homes/year) • Gas lamps powered (lamps/year)
Limitations	• Intended to be used as a "pre-feasibility screening tool" to help users understand the approximate quantity of biogas that can be generated from different organic waste feedstocks and then determine whether developing an AD system is feasible. The biogas production estimates are based on a review of published literature on feedstock characteristics and have been calibrated against real-world data on biogas production values. However, actual biogas production values may vary greatly, depending on waste characteristics, reactor temperature, system design limitations, and daily operations. Therefore, users typically conduct additional modeling and analysis using site-specific data prior to determining whether to develop an AD system.
Examples of Applicable SWM Recommendations	• Provide technical support for selecting and deploying technologies to treat organic waste • Build the capacity of workers to operate and maintain organic waste treatment facilities[36] by establishing education programs that cover basic digestor operational fundamentals, process control, laboratory and leak testing, and maintenance • Improve energy efficiency and transition to clean energy sources at processing and treatment facilities • Promote the treatment of organic waste at home, including yard waste and food waste from food preparation and leftovers, before they are sent for processing or to landfills
Key Resources	• **User Manual:** Anaerobic Digestion (AD) Screening Tool User Manual • **Tutorial:** Anaerobic Digestion (AD) Screening Tool Training Video – Estimating Biogas Production

[36] Organic waste treatment facilities divert and convert organic waste (e.g., food waste, yard waste) into useful products. Composting and AD are common types of organic waste treatment facilities.

[Biological Treatment of Solid Waste Guidelines](#): This PDF methodology provides step by step *guidance for collecting data and calculating methane emissions from the biological treatment of organic waste.*[37] While not a GHG tool or calculator, it remains the gold standard for calculating GHG reductions and is widely used as the methodology for many GHG calculators, including GMI's SWEET, GMI's AD-ST, RTI's Municipal Waste Decision Support Tool, and WEIGO's GHG Emissions Calculator 2.0.

Type of Tool	PDF Methodology
Ease of Use	
Data Inputs	• Mass of organic waste treated by biological treatment type • Methane and nitrous oxide emission factors for treatment • Total methane recovered
Data Outputs	• Net methane and nitrogen dioxide emissions
Limitations	• Composting emissions vary based on the carbon and nitrogen content of the material. • Anaerobic digestion may unintentionally emit methane emissions through leakages, while data on N_2O are scarce. • Mechanical-biological (MB) treatment: methane and nitrous oxide emissions during the different phases of the MB treatment depend on the specific operations and the duration of the biological treatment. • Default values are provided for a number of data inputs, which allow for a Tier 1 assessment. • Additional country- or site-specific data could be used in place of the default values, allowing for a Tier 2 and/or Tier 3 assessment.
Examples of Applicable SWM Recommendations	• Provide technical support for selecting and deploying technologies to treat organic waste • Build the capacity of workers to operate and maintain organic waste treatment facilities[38] by establishing education programs that cover basic digestor operational fundamentals, process control, laboratory and leak testing, and maintenance • Promote the treatment of organic waste at home, including yard waste and food waste from food preparation and leftovers, before they are sent for processing or to landfills

[37] Biological treatment of solid waste, also known as organic waste treatment, refers to the conversion of degradable organic matter into other useful products. Composting and anaerobic digestion are examples of biological treatment processes.
[38] Organic waste treatment facilities divert and convert organic waste (e.g., food waste, yard waste) into useful products. Composting and AD are common types of organic waste treatment facilities.

Key Resources	• **Case Study:** [Accounting Greenhouse Gas Emissions from Municipal Solid Waste Treatment by Composting: A Case of Study Bolivia]

VERRA **[Methodology for Plastic Waste Recycling]**: This PDF methodology provides guidance for *estimating plastic waste recycled through chemical or mechanical recycling processes*. While it *does not provide guidance for calculating the GHG impacts of plastic waste recycling activities*, the methodology can be used to calculate diversion rates to recycling, which are required inputs for GHG calculators such as EPA SWEET, Ifeu SWM GHG Calculator, and RTI Municipal Solid Waste Decision Support tool.

Type of Tool	PDF Methodology
Ease of Use	
Data Inputs	• Baseline amount of recycled plastic waste by material type (MT) in a year without depolymerization • Adjustment factor for composite material **(includes default data based on literature review)** • Baseline amount of recycled plastic waste by material type (MT) with depolymerization in a year • Mass fraction of the output of the depolymerization process used for plastic production • Amount of plastic waste by material type (MT) recycled by project activity in a year without depolymerization • Amount of plastic waste by material type (MT) recycled by project activity in a year with depolymerization
Outputs	• Total amount of plastic waste recycled BAU (MT/year) • Total amount of plastic waste recycled by implemented recycling activity (MT/year)
Limitations	• Does not provide guidance for calculating the GHG impacts of plastic waste recycling activities, the methodology can be used to calculate diversion rates to recycling, which are required inputs for GHG calculators such as EPA SWEET, Ifeu SWM GHG Calculator, and RTI Municipal Solid Waste Decision Support tool • Written in highly technical language
Examples of Applicable SWM Recommendations	• Provide technical support for selecting and deploying technologies to treat plastic waste • Provide technical support for the establishment and upgrade of MRFs to increase the quantity and quality of recycled materials, including plastics

	• Provide technical, capacity building, and financial support for the establishment of "Waste Banks", decentralized and small-scale recycling facilities
SWM GHG Calculator – Lifecycle Approach: This Excel tool *calculates the carbon dioxide and methane impacts of different waste processing and treatment options*, inncluding composting, anaerobic digestion, recycling, and waste-to-energy. Users can enter and compare the GHG impacts of up to four different scenarios, and have the option to input country-specific waste composition and electricity emission factors.	
Type of Tool	Excel tool
Ease of Use	
Data Inputs	• Percentage waste composition **(includes country-specific default data based on literature review)** • Waste characteristics (low or high water content) • Percentage of inorganic materials (e.g., plastics) sent to recycling • Percentage of organic materials (e.g., food waste, garden and park waste) sent to composting and/or AD • Percentage methane content of biogas • Percentage biogas use for electricity, heat, biomethane generation • Country-specific GHG electricity emission factor (g CO2e/kWh) **(includes country-specific default data based on literature review)** • Methane correction factor • Oxidation factor • Efficiency of landfill gas collection • Cost of different waste processing and treatment option in Euro/MT (optional) **(includes country-specific default data based on literature review)**
Outputs	• Total waste recycled, composted, anaerobically digested, burned, landfilled (MT/year) • GHG emissions for waste recycled, composted, anaerobically digested, burned, landfilled (MT/year)
Limitations	• Cost data input requirement is in Euro/MT. Users have to convert currency if they have country-specific input

	• Default electricity emission factors represent the cohort of existing power plants and prospective future power plants. They should be assessed to determine the reliability and applicability of these emission factors for a given country • Default waste composition data are based on IPCC 2019. These should be assessed to determine the reliability and applicability for a given country because waste composition is highly variable over time
Examples of Applicable SWM Recommendations	• Provide technical support for selecting and deploying technologies to treat organic and plastic waste • Provide technical support for the establishment and upgrade of MRFs to increase the quantity and quality of recycled materials, including plastics • Improve energy efficiency and transition to clean energy sources at processing and treatment facilities • Promote the treatment of organic waste at home, including yard waste and food waste from food preparation and leftovers, before they are sent for processing or to landfills • Provide technical, capacity building, and financial support for the establishment of "Waste Banks", decentralized and small-scale recycling facilities
Key Resources	• **User Manual:** Manual SWM-GHG Calculator

Municipal Solid Waste Decision Support Tool: This desktop application allows users to *calculate the GHG emissions impacts from different waste processing and treatment options,* including anaerobic digestion, composting, material recovery, and waste-to-energy facilities. Users have the option to input their own facility design and operation data, including labor cost, electricity consumption and cost, etc. The tool's optimization mode allows users to see the solution that best meets the optimization objective (e.g., minimize cost, minimize GHGs). Its accounting mode allows users to estimate cost and GHG impacts from different processing and treatment options.

Type of Tool	Excel
Ease of Use	
Data Inputs	• Waste generation amounts (kg/week) for household or commercial waste generators • Waste composition percentage • Waste collection processes • Select waste destinations (i.e., recycling, treatment or disposal) • Allocation of waste among processes (optional)

	• Define electrical energy grid and carbon accounting methodology (optional) **(includes U.S. default data)** • Collection and transportation distances (optional) **(includes U.S. default data)** • Process specific data or assumptions (e.g., energy consumption at processing and treatment facilities) (optional) • Optimization objective and constraints (if running under the "optimization" mode)
Outputs	• A mass flow report showing the tonnage of waste collected and sent to each process. • A cost report showing the net total cost and net cost for each process. • A life cycle inventory analysis report showing the net total inventory flow and net flow for each process. • An impact assessment report showing the total impacts by category and for each process.
Limitations	• Users **must** enter all inputs regardless of the output desired. For example, users have to enter landfill data input even if they just want to get GHG emissions from collection and transportation • Does not have embedded country-specific data. All default data, including energy consumption and emissions for different processing and treatment options, are based upon U.S. values. Users are advised to enter their own site-specific data for more accurate results
Examples of Applicable SWM Recommendations	• Provide technical support for selecting and deploying technologies to treat organic and plastic waste • Provide technical support for the establishment and upgrade of MRFs to increase the quantity and quality of recycled materials, including plastics • Improve energy efficiency and transition to clean energy sources at processing and treatment facilities • Promote the treatment of organic waste at home, including yard waste and food waste from food preparation and leftovers, before they are sent for processing or to landfills • Provide technical, capacity building, and financial support for the establishment of "Waste Banks", decentralized and small-scale recycling facilities
Key Resources	• **User Manual:** A Decision Support Tool for Assessing the Cost and Environmental Performance of Integrated Municipal Solid Waste Management Strategies • **Input Data:** Default Data and Data Input Requirements • **Tutorial:** Available Tutorials

WaCT: This PDF guide walks readers through a set of approaches for *gathering data on waste generated and collected for processing and treatment facilities*. Users can use the gathered data to estimate waste generation and collection rates using the tool below.

Type of Tool	PDF methodology
Ease of Use	
Data Inputs	• No input required. This document only provides guidance for data collection.
Outputs	• Outputs can be calculated using the complementary WaCT – Data Collection Tool discussed below
Limitations	• Does not have a specific section for quantifying GHGs from Processing and Treatment activities. However, it does have a detailed methodology for gathering data on waste generated and collected for processing and treatment facilities. Users can use the gathered data to estimate waste generation and collection rates using the tool below
Examples of Applicable SWM Recommendations	• Provide technical support for selecting and deploying technologies to treat organic and plastic waste • Provide technical support for the establishment and upgrade of MRFs to increase the quantity and quality of recycled materials, including plastics • Promote the treatment of organic waste at home, including yard waste and food waste from food preparation and leftovers, before they are sent for processing or to landfills • Provide technical, capacity building, and financial support for the establishment of "Waste Banks", decentralized and small-scale recycling facilities
Key Resources	• **Case Study:** ○ Waste Wise Cities Tools in Mangalore, India ○ Waste Wise Cities Tools in Thiruvananthapuram, India

WaCT – Data Collection Tool: This Excel tool is *complementary to the above PDF guide. Users can enter the data they gathered on waste generation and collected for processing and treatment (diversion) to estimate waste generation and diversion rates, which are* required inputs for estimating GHGs from different processing and treatment rates using GHG tools such as EPA SWEET, Ifeu SWM GHG Calculator, and RTI Municipal Solid Waste Decision Support tool.

Type of Tool	Excel tool

Ease of Use	
Data Inputs	• MSW collected
Outputs	• Percentage MSW collected • Percentage MSW collected and sent to processing and treatment facilities
Limitations	Requires significant data gathering, which involves: • Determining sample size and selecting survey areas and households • Preparing consent letters explaining the purpose of the survey and how the information will be used • Preparing the survey team, equipment, and transport
Examples of Applicable SWM Recommendations	• Provide technical support for selecting and deploying technologies to treat organic and plastic waste • Provide technical support for the establishment and upgrade of MRFs to increase the quantity and quality of recycled materials, including plastics • Promote the treatment of organic waste at home, including yard waste and food waste from food preparation and leftovers, before they are sent for processing or to landfills • Provide technical, capacity building, and financial support for the establishment of "Waste Banks", decentralized and small-scale recycling facilities
Key Resources	• **User Manual:** Guide to Using the WaCT Data Collection Application • **Tutorial:** How to Use the Data Collection Application

APPENDIX 6: FINAL DISPOSAL (LAND DISPOSAL) TOOLS AND METHODOLOGIES

Global Methane Initiative	**SWEET**: This Excel tool calculates the GHG impacts of different waste treatment options, including composting, anaerobic digestion, waste-to-energy, and recycling. It allows users to enter up to four alternative scenarios in future years.
Type of Tool	Excel tool
Ease of Use	
Data Inputs	• Population in and out of formal collection zones • Average annual precipitation (mm/year) • Mean annual temperature (Celsius) • Per capita waste generation rate inside and outside formal collection zones (kg/capita/day) • Historical and projected average annual percentage growth rate in quantity of waste collected • Percentage of waste generated inside and outside formal collection zones • Total waste collected annually inside formal collection zones (MT) • Total waste generated annually inside collection zones (MT) • Average percentage composition of collected waste **(includes global regional default data)** • MT of waste delivered to diversion facility per year • Number of heavy- and light-duty diesel/gasoline/natural gas trucks in operation per year **(includes U.S. default data)** • Kilometers traveled by heavy- and light-duty diesel/gasoline/natural gas trucks in operation per year **(includes U.S. default data)** • Emission factors for heavy- and light-duty diesel/gasoline/natural gas trucks **(includes U.S. default data)** • Opening and closing years of disposal site • Annual disposal rate (MT/year) • Landfill category • Percentage of uncollected waste burned in the open by residents living inside and outside formal collection zones

	• Percentage of waste disposed of at landfills or dumpsites that is ultimately burned at the landfill or dumpsite • Number of diesel and gasoline waste handling equipment used
Outputs	• Total emissions (MTCO2e) from 1960 – 2100 • Emissions by waste management process (E.g., waste collection and transport, waste burning, landfills, etc.) (MTCO2e) from 1960 – 2011 • Total methane, sulfur oxides, particulate matter 2.5 and 10, and black carbon (MT) from 1960 – 2011 • Total emissions changes from business-as-usual (BAU) scenario from 1960 – 2100 • Total changes in methane, sulfur oxides, particulate matter 2.5 and 10, and black carbon (MT) from BAU scenario from 1960 – 2011
Limitations	• Users **must** enter all inputs regardless of the output desired. For example, users have to enter landfill data input even if they just want to get GHG emissions from collection and transportation • SWEET holds solid waste composition data constant over time. To model changes in GHG emissions from changes in waste composition, users must create and compare two individual SWEET spreadsheets • Does not include country-specific default values for vehicle distance traveled and vehicle type and fuel usage—all defaults rely upon U.S. data. USAID Missions and local partners must enter their own country-specific data for more accurate GHG estimates • Forecasting future conditions and scenario implementation dates represent large source of potential data error
Examples of Applicable SWM Recommendations	• Provide technical assistance to national governments to remediate or close existing dumpsites • Provide technical assistance in the design, siting, and construction of a sanitary landfill • Provide technical assistance to recover LFG from landfills • Advocate for landfill fees and bans to incentivize waste diversion for recovery through processing and treatment • Deploy cleaner landfill vehicles and equipment

Key Resources	• **User Manual:** SWEET User Manual
	• **Data Collection Worksheet:** SWEET Data Collection Worksheet
	• **Tutorial:** SWEET Advanced Tips
	• **Case Study:**
	  ○ Examining Health and Climate Impacts of Solid Waste Management in Accra, Ghana
	  ○ Estimating Short-Lived Climate Pollutants from Municipal Solid Waste in Tyre Caza, Lebanon

Global Methane Initiative	**Landfill Gas Screening Tool**: This Excel tool calculates *how much landfill gas a landfill site could collect* and whether this volume is sufficient to support a modest-sized landfill gas energy project (e.g., converting landfill gas to generate electricity or fuel vehicles).
Type of Tool	Excel tool
Ease of Use	
Data Inputs	• Opening year of disposal site • Closing year (actual or projected) • Annual disposal rate (MT/year) • Climate (precipitation level) • Landfill category
Data Outputs	• 2022 landfill gas recovery rate (m3/h) • Number of years post-2022 of landfill gas recovery at >600 m3/h • Number of years post-2022 of landfill gas recovery at >200 m3/h • Number of years post-2022 of landfill gas recovery at >50 m3/h
Limitations	• Relies heavily on several "global average" default assumptions for landfill gas generation, collection, and recovery. Without direct measurements of landfill gas generation in the field, it is not possible to validate generation estimates
Examples of Applicable SWM Recommendations	• Provide technical assistance to national governments to remediate or close existing dumpsites • Provide technical assistance in the design, siting, and construction of a sanitary landfill • Provide technical assistance to recover LFG from landfills • Advocate for landfill fees and bans to incentivize waste diversion for recovery through processing and treatment • Deploy cleaner landfill vehicles and equipment
Key Resources	• **User Manual:** Landfill Gas Screening Tool User Manual

GHG Emissions Calculator 2.0: This Excel-based tool estimates the *avoided carbon dioxide, methane, and black carbon resulting from transitioning from open burning and dumping to inclusive collection and recycling.* It calculates the types and quantities of degradable materials that informal waste collectors and recyclers divert, and the GHGs avoided from open burning and disposal at dumpsites.

Type of Tool	Excel tool
Ease of Use	
Data Inputs	• Waste composition and quantities that are openly burned (MT/year) • Percentage waste composition and quantities diverted by informal waste workers (MT/year)
Outputs	• Methane, black carbon, nitrous oxide emissions saved through informal waste worker intervention (MT/year) • Total CO2e emissions saved through informal waste worker intervention (MT/year)
Limitations	• Data on waste composition and quantities that are openly burned may be hard to obtain
Examples of Applicable SWM Recommendations	• Advocate for landfill fees and bans to incentivize waste diversion for recovery through processing and treatment
Key Resources	• **User Manual:** Reducing Greenhouse Gas Emissions through Inclusive Recycling

Solid Waste Disposal Guidelines: This PDF methodology provides step by step *guidance for collecting data and calculating carbon dioxide and methane from solid waste disposal.* While it is not a GHG tool or calculator, it remains the gold standard for calculating GHG reductions and is widely used to underpin many highly credible GHG tools, including GMI's SWEET, EPA's Landfill Gas Emissions Model (LandGEM), RTI's Municipal Waste Decision Support Tool, and WEIGO's GHG Emissions Calculator 2.0.

Type of Tool	PDF Methodology
Ease of Use	
Data Inputs	• Recovered methane

	• Oxidation factor • Mass of waste deposited • Degradable organic carbon (DOC) in the year of deposition • Fraction of DOC that can decompose • Methane correction factor • Mass of decomposable DOC (DDOC) deposited • Fraction of methane in generated landfill gas • DDOCm accumulated at the end of previous year • DDOCm accumulated at the end of year • Reaction constant • DDOCm deposited into the SWDS in inventory year • DDOCm decomposed in the SWDS in inventory year • Fraction of DOC in waste type • Fraction of waste type
Data Outputs	• Methane emissions from solid waste disposal site
Limitations	• Default values are provided for a number of data inputs, which allow for a Tier I assessment • Additional country- or site-specific data could be used in place of the default values, allowing for a Tier 2 and/or Tier 3 assessment • Written in highly technical language
Examples of Applicable SWM Recommendations	• Provide technical assistance to national governments to remediate or close existing dumpsites • Provide technical assistance in the design, siting, and construction of a sanitary landfill • Provide technical assistance to recover LFG from landfills • Advocate for landfill fees and bans to incentivize waste diversion for recovery through processing and treatment

Key Resources	• **Case Studies:**
	  ○ Accounting Greenhouse Gas Emissions from Municipal Solid Waste Treatment by Composting: A Case of Study Bolivia
	  ○ Emissions of Greenhouse Gases from Municipal Solid Waste Management System in Ho Chi Minh City of Viet Nam

	Incineration and Open Burning of Waste Guidelines: This PDF methodology provides step by step *guidance for collecting data and calculating carbon dioxide and methane emissions from the open burning of waste.* While it is not a GHG tool or calculator, it remains the gold standard for calculating GHG reductions and is widely used to underpin many highly credible GHG tools, including GMI's SWEET, EPA's Landfill Gas Emissions Model (LandGEM), RTI's Municipal Waste Decision Support Tool, and WEIGO's GHG Emissions Calculator 2.0.
Type of Tool	PDF Methodology
Ease of Use	
Data Inputs	**Data Inputs:** • Amount of solid waste incinerated or open burned, by type/material • Total MSW Amount Incinerated or Open Burned • Dry matter content in the waste • Fraction of carbon in the dry matter • Fraction of fossil carbon in total carbon • Oxidation factor • Conversion factor from carbon to carbon dioxide • Fraction of waste type/material in MSW • Methane and nitrous oxide emission factors for treatment • Nitrous oxide emission concentration in flue gas from the incineration of waste type • Flue gas volume by amount of incinerated waste type • Population, fraction of population burning waste, per capita waste generation • Fraction of waste amount that is burned relative to amount treated
Data Outputs	• Carbon dioxide, methane, nitrous oxide emissions from incineration and open burning.
Limitations	• Default values are provided for a number of data inputs, which allow for a Tier I assessment

	• Additional country- or site-specific data could be used in place of the default values, allowing for a Tier 2 and/or Tier 3 assessment • 2019 Refinement has updated emission factors and additional guidance about other technologies, including pyrolysis, gasification, and plasma
Examples of Applicable SWM Recommendations	• Provide technical assistance to national governments to remediate or close existing dumpsites • Provide technical assistance in the design, siting, and construction of a sanitary landfill • Provide technical assistance to recover LFG from landfills • Advocate for landfill fees and bans to incentivize waste diversion for recovery through processing and treatment
	Waste Model: This Excel tool *calculates methane emissions from solid waste disposal from 1950 to 2030*. This tool has complete default data for different countries and regions. Users may also enter their own input data.
Type of Tool	PDF Methodology
Ease of Use	
Data Inputs	**Data Inputs:** • Geographical region • Degradable organic carbon • Methane generation rate constant • Methane correction factor • Fraction of methane in developed gas • Conversion factor C to CH4 • Oxidation factor • Parameters for carbon storage • Population, waste per capita, waste generation rate • Waste composition and tonnage of waste by material • GDP

	• CH_4 recovery
Data Outputs	• CH_4 emissions from solid waste disposal and harvested wood products • Long-term stored carbon
Limitations	• Requires significant data inputs • Written in highly technical language
Examples of Applicable SWM Recommendations	• Provide technical assistance to national governments to remediate or close existing dumpsites • Provide technical assistance in the design, siting, and construction of a sanitary landfill • Provide technical assistance to recover LFG from landfills • Advocate for landfill fees and bans to incentivize waste diversion for recovery through processing and treatment
Relevant Examples and Case Studies	• **Case Studies:** ○ Application of the IPCC Waste Model to solid waste disposal sites in tropical countries: case study of Thailand ○ Estimating National Landfill Methane Emissions: An application of the 2006 IPCC Waste Model in Panama ○ Study of Estimation Methane Emissions from Municipal Solid Waste Landfill Based on IPCC Model (Case Study: Klotok Landfill, Kediri)
	Landfill Gas Destruction and Beneficial Use: This PDF methodology *provides guidance for calculating methane emissions reductions from projects* that convert landfill gas to energy; destroy landfill gas in open or closed flares; enhance landfill gas for injection into natural gas pipelines; process landfill gas for use in fleet vehicles, trucks, and cars; and increase landfill gas collection via automated collection systems.
Type of Tool	PDF Methodology
Ease of Use	
Data Inputs	**Data Inputs:** • Volume of methane combusted • Methane generation rate • Measured methane collection

	• Measured landfill gas collection efficiency • Modeled gas collection system efficiency • Calibrated collection efficiency based on landfill area • Average calibrated collection efficiencies • Updated calibrated collection efficiencies • Automated collection system (ACS) Increment • Increase in volume of methane combusted • Net mass of methane destroyed • Correcting landfill gas flow temperature • Carbon dioxide emissions from fossil fuel combustion • Emissions from project specific electricity consumption
Data Outputs	• Baseline emissions • Project emissions • Leakage • Emission reduction
Limitations	• Methodology is applicable only to US landfills. Other countries could use this methodology as a model to create a country-specific methodology to understand emissions and emission reductions
Examples of Applicable SWM Recommendations	• Provide technical assistance to national governments to remediate or close existing dumpsites • Provide technical assistance in the design, siting, and construction of a sanitary landfill • Provide technical assistance to recover LFG from landfills • Advocate for landfill fees and bans to incentivize waste diversion for recovery through processing and treatment
giz	**SWM GHG Calculator – Lifecycle Approach:** This Excel tool *calculates the carbon dioxide and methane impacts of different waste disposal options*, inncluding landfilling and burning. Users can enter compare the GHG impacts of up to four different scenarios.
Type of Tool	PDF Methodology

Ease of Use	
Data Inputs	• Percentage waste composition **(includes country-specific default data based on literature review)** • Waste characteristics (low or high water content) • Percentage of inorganic materials (e.g., plastics) sent to recycling • Percentage of organic materials (e.g., food waste, garden and park waste) sent to composting and/or AD • Percentage methane content of biogas • Percentage biogas use for electricity, heat, biomethane generation • Country-specific GHG electricity emission factor (g CO2e/kWh) **(includes country-specific default data based on literature review)** • Methane correction factor • Oxidation factor • Efficiency of landfill gas collection • Cost of different waste processing and treatment option in Euro/MT (optional) **(includes country-specific default data based on literature review)**
Data Outputs	• Total waste recycled, composted, anaerobically digested, burned, landfilled (MT/year) • GHG emissions for waste recycled, composted, anaerobically digested, burned, landfilled (MT/year)
Limitations	• Cost data input requirement is in Euro/MT. Users have to convert currency if they have country-specific input • Default electricity emission factors represent the cohort of existing power plants and prospective future power plants. They should be assessed to determine the reliability and applicability of these emission factors for a given country • Default waste composition data are based on IPCC 2019. These should be assessed to determine the reliability and applicability for a given country because waste composition is highly variable over time
Examples of Applicable SWM Recommendations	• Provide technical assistance to national governments to remediate or close existing dumpsites • Provide technical assistance in the design, siting, and construction of a sanitary landfill • Provide technical assistance to recover LFG from landfills • Advocate for landfill fees and bans to incentivize waste diversion for recovery through processing and treatment

	• Deploy cleaner landfill vehicles and equipment
Relevant Examples and Case Studies	• **User Manual:** Manual SWM-GHG Calculator
	Municipal Solid Waste Decision Support Tool: This desktop application allows users to *calculate the GHG emissions impacts from different waste processing and treatment options,* including anaerobic digestion, composting, material recovery, and waste-to-energy facilities. Users have the option to input their own facility design and operation data, including labor cost, electricity consumption and cost, etc. The tool's optimization mode allows users to identify the solution that best meets the optimization objective (e.g., minimize cost, minimize GHGs). Its accounting mode allows users to estimate cost and GHG impacts from different processing and treatment options.
Type of Tool	Desktop software
Ease of Use	
Data Inputs	• Waste generation amounts (kg/week) for household or commercial waste generators • Waste composition percentage • Waste collection processes • Select waste destinations (i.e., recycling, treatment or disposal) • Allocation of waste among processes (optional) • Define electrical energy grid and carbon accounting methodology (optional) **(includes U.S. default data)** • Collection and transportation distances (optional) **(includes U.S. default data)** • Process specific data or assumptions (e.g., energy consumption at processing and treatment facilities) (optional) • Optimization objective and constraints (if running under the "optimization" mode)
Data Outputs	• A mass flow report showing the tonnage of waste collected and sent to each process. • A cost report showing the net total cost and net cost for each process. • A life cycle inventory analysis report showing the net total inventory flow and net flow for each process. • An impact assessment report showing the total impacts by category and for each process.

Limitations	• Users **must** enter all inputs regardless of the output desired. For example, users have to enter landfill data input even if they just want to get GHG emissions from collection and transportation • Does not have embedded country-specific data. All default data, including energy consumption and emissions for different processing and treatment options, are based upon U.S. values. Users are advised to enter their own site-specific data for more accurate results
Examples of Applicable SWM Recommendations	• Provide technical assistance to national governments to remediate or close existing dumpsites • Provide technical assistance in the design, siting, and construction of a sanitary landfill • Provide technical assistance to recover LFG from landfills • Advocate for landfill fees and bans to incentivize waste diversion for recovery through processing and treatment • Deploy cleaner landfill vehicles and equipment
Relevant Examples and Case Studies	• **User Manual:** A Decision Support Tool for Assessing the Cost and Environmental Performance of Integrated Municipal Solid Waste Management Strategies • **Input Data:** Default Data and Data Input Requirements • **Tutorial:** Available Tutorials
Landfill Gas Emissions Model (LandGEM): This Excel tool *quantifies carbon dioxide and methane emissions, as well as other air pollutants* from the decomposition of solid waste at landfills.	
Type of Tool	Excel tool
Ease of Use	
Data Inputs	• Landfill open year • Landfill closure year • Methane generation rate **(includes U.S. default data)** • Potential methane generation capacity (m3/Mg) **(includes U.S. default data)** • Non-methane organic compound (parts per million volume) **(includes U.S. default data)** • Methane content (percentage by volume) **(includes U.S. default data)**

Outputs	• Total landfill gas, methane, carbon dioxide, non-methane organic compound (mg/year, m3/year, av ft3/min)
Limitations	• U.S. default data may not be applicable and realistic for other countries; however, they can be used to obtain a rough estimate of total landfill gas generated if no site-specific data are available
Examples of Applicable SWM Recommendations	• Provide technical assistance to national governments to remediate or close existing dumpsites • Provide technical assistance in the design, siting, and construction of a sanitary landfill • Provide technical assistance to recover LFG from landfills • Advocate for landfill fees and bans to incentivize waste diversion for recovery through processing and treatment
Key Resources	• **User Manual:** Landfill Gas Emissions Model (LandGEM) Version 3.0 User's Guide
UN-HABITAT	**WaCT:** This PDF guide *walks readers through how to collect on waste sent to landfill disposal sites*. It does not provide guidance for quantifying GHGs emitted at landfills. Users can use the gathered data to estimate the percentage of waste sent to landfills using the tool below.
Type of Tool	PDF Methodology
Ease of Use	
Data Inputs	• No input required. This document only provides guidance for data collection.
Outputs	• Outputs can be calculated using the complementary WaCT – Data Collection Tool discussed below
Limitations	• Does not have a specific section for quantifying GHGs from Final Disposal activities. However, it does have a detailed methodology for gathering data on waste sent to landfill disposal sites. Users can use the gathered data to estimate percentage of waste sent to landfills using the tool below
Key Resources	• **Case Study:** ○ Waste Wise Cities Tools in Mangalore, India ○ Waste Wise Cities Tools in Thiruvananthapuram, India

Examples of Applicable SWM Recommendations	• Advocate for landfill fees and bans to incentivize waste diversion for recovery through processing and treatment
WaCT – Data Collection Tool: This Excel tool is *complementary to the above PDF guide. Users can enter the data they gathered on waste generation, as well as collected for landfilling to estimate the percentage of waste sent to landfill, which is a required input* for GHG calculators, such as EPA SWEET, Ifeu SWM GHG Calculator, and RTI Municipal Solid Waste Decision Support tool.	
Type of Tool	Excel tool
Ease of Use	
Data Inputs	• MSW collected
Outputs	• Percentage MSW collected and sent to landfills
Limitations	Requires significant data gathering, which involves: • Determining sample size and selecting survey areas and households • Preparing consent letters explaining the purpose of the survey and how the information will be used • Preparing the survey team, equipment, and transport
Examples of Applicable SWM Recommendations	• Advocate for landfill fees and bans to incentivize waste diversion for recovery through processing and treatment
Key Resources	• **User Manual:** Guide to Using the WaCT Data Collection Application • **Tutorial:** How to Use the Data Collection Application

APPENDIX 7: POLICY, REGULATORY, GOVERNANCE SUPPORT TOOLS AND METHODOLOGY

GMI Policy Maker's Handbook for Measurement, Reporting, and Verification (MRV): This PDF guide helps policymakers establish *an MRV system that measures and tracks GHG emissions and emissions reductions from projects* that capture methane emissions in the waste sector (e.g., anaerobic digestion and landfill gas energy projects).	
Type of Tool	PDF Methodology
Ease of Use	
Data Inputs	• No input required
Outputs	• No outputs
Limitations	• Not intended as a comprehensive implementation guide for conducting MRV. Rather, it draws on technical guidance and tools from a range of protocols developed by other organizations, such as the IPCC, AgSTAR program, and California Air Resources Board and integrates waste-sector-specific considerations
Examples of Applicable SWM Recommendations	• Build capacity for local and regional governments to include GHG mitigation considerations and opportunities when developing SWM plans, which are often required by law
Key Resources	• **Tutorials:** o MRV Webinar Series: The Role and Importance of MRV for Biogas Projects o MRV Webinar Series: Measuring Methane Emissions from the Waste Sector o MRV Webinar Series: Measurement, Reporting, and Verification Best Practices for Biogas Projects
WaCT: This PDF guide walks readers *provides step-by-step guidance for governments to collect data and calculate GHG emissions from waste prevention and minimization, collection and transportation, processing and treatment, and final disposal*. It includes templates for data collection (e.g., household waste sampling and waste composition sheets), questionnaires for waste generators and processing and treatment and disposal facility operators, and other useful resources to support the measurement of GHGs from the solid waste sector.	
Type of Tool	PDF Methodology
Ease of Use	

Data Inputs	• No input required
Data Outputs	• No outputs
Limitations	Requires significant data gathering, which involves: • Determining sample size and selecting survey areas and households • Preparing consent letters explaining the purpose of the survey and how the information will be used • Preparing the survey team, equipment, and transport
Examples of Applicable SWM Recommendations	• Provide technical assistance on the design and implementation of EPR policies that transfer the responsibility of managing the end-of-life of products to producers (e.g., raw material manufacturers, packers or fillers, brand companies, retailers) • Support the development and implementation of "Pay-As-You-Throw" (PAYT) programs that impose waste collection fees on waste generators, which can disincentivize waste generation and offer a source of finance for waste collection • Provide technical assistance on the design of recycled content standards, certification schemes, or product standards that require producers to specify that a certain percentage of their products or packaging is made from recycled materials • Provide technical assistance on the design and implementation of national strategies to reduce food loss and waste • Build capacity for local and regional governments to include GHG mitigation considerations and opportunities when developing SWM plans, which are often required by law
Key Resources	• **User Manual:** Guide to Using the WaCT Data Collection Application • **Tutorial:** How to Use the Data Collection Application
GREENHOUSE GAS PROTOCOL	**Policy and Action Standards:** This PDF guide is designed to help *countries and local governments design, track, and evaluate policies and programs for reducing GHGs*. This high-level resource is applicable across economic sectors, including the waste sector. Policymakers can use this guide to evaluate the effectiveness of extended producer resposibility (EPR), pay-as-you-throw (PAYT), and other climate focused SWM policies and programs.
Type of Tool	PDF Methodology
Ease of Use	
Data Inputs	• No input required

Data Outputs	• No outputs
Limitations	● Intended to help countries and local governments evaluate GHG mitigation policies and programs from *any* economic sector, not specifically the waste sector
Examples of Applicable SWM Recommendations	● Provide technical assistance on the design and implementation of EPR policies that transfer the responsibility of managing the end-of-life of products to producers (e.g., raw material manufacturers, packers or fillers, brand companies, retailers) ● Support the development and implementation of "Pay-As-You-Throw" (PAYT) programs that impose waste collection fees on waste generators, which can disincentivize waste generation and offer a source of finance for waste collection ● Provide technical assistance on the design of recycled content standards, certification schemes, or product standards that require producers to specify that a certain percentage of their products or packaging is made from recycled materials ● Provide technical assistance on the design and implementation of national strategies to reduce food loss and waste ● Build capacity for local and regional governments to include GHG mitigation considerations and opportunities when developing SWM plans, which are often required by law

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