

Assessing Household Food Waste Data for Sustainable Policy and Environmental Impact: An applied analysis Using UNEP's Food Waste Index Data Challenge

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I. Introduction

According to the World Food Program (WFP), one-fifth of food produced for human consumption is lost or wasted globally. This amounts to one billion meals a day (World Food Program, 2024). Wasting food isn't just a humanitarian or social issue - it's also an environmental one. When food is produced but unnecessarily wasted, all the resources used to grow the food – water, energy, fertilizers – are wasted as well (United States Environmental Protection Agency, 2025). The food cycle doesn't just end at our trash cans. Food waste that ends up in landfills and rots produces a large amount of methane – a more potent greenhouse gas than even CO₂. Food loss and waste generates up to ten percent of global greenhouse gas emissions – almost five times the total emissions compared to the aviation sector (World Food Program, 2024)

While the potential sources of food waste are at the production stage, retail stage (due to overproduction by restaurants and grocery stores) and/or by consumers, this research focuses on food waste generated by households in 214 countries worldwide. This is because WFP reports that sixty percent of food waste happens at household level. **This study attempts to identify data gaps that could influence sustainability activities and policy decisions by assessing the dataset's promises and pitfalls.**

This project assesses the food waste data from UNEP's Food Waste Index (FWI) and delves into the environmental data challenge with generating this report. Specifically, the project focuses on countries that UNEP has “Very Low Confidence” in that data estimates. The lack of confidence indicates significant concerns around the reliability, consistency, and robustness of the reported figures.

This calls for infrastructure inversion to understand the history of how data collection has been conducted over the years within the context of changing standards, institutions, and communication techniques, is crucial for determining data homogeneity. Edwards (2010) argues that data is not data until you have turned the infrastructure upside down to find out how it works. Accurate data collection is essential to maintaining the integrity of scientific research (Sapsford and Jupp, 2006).

The paper is outlined as follows: it begins with the problem statement presented in section II, followed by the stakeholder ecosystem and interactions in section III, and analysis and

discussion in section IV. The paper concludes with a conclusion in section V and recommendations stated in section VI.

II. Problem Statement

Despite several commitments under the United Nations Sustainable Development Goals target 12.3 to halve food waste by 2030, significant gaps in measuring waste at the household level still exist. The United Nations Environment Programme (UNEP), which monitors food waste through the FWI, has classified data confidence as “Very Low” in several countries due to methodological inconsistencies and reliance on central governments rather than localized data collection. This lack of reliable household-level data limits the effectiveness of policy interventions (Forbes et al., 2021).

At the household level, food is wasted in two primary ways: purchase waste, where households buy excessive food that goes uneaten, and preparation waste, where edible portions are discarded due to inefficient meal planning or cultural habits (Parfitt et al., 2010). Without accurate, localized data, policymakers might find it difficult to design interventions tailored to consumer behavior. This issue is further made complex by UNEP’s data collection approach, which gives priority to national statistics agencies over direct engagement with municipalities and local communities. A study by the (National Research Council, 2015) indicates that decentralizing data collection to local governments and civil society organizations enhances accuracy and policy relevance.

To this end, there is an urgent need for developing standardized, scalable methods for household-level food waste measurement. Lessons can be drawn from local initiatives such as the UB Food Lab, which links food systems research with urban policy planning (UB Food Lab, 2023). Thus, this project aims to identify data gaps in UNEP’s current model, explore scalable alternatives rooted in local participation, and develop a pathway that strengthens household food waste data for environmental action.

III. Stakeholder Ecosystem and Interactions

Based on the data challenge described above, these stakeholders are critical to the study. The researchers classified them as primary and secondary stakeholders (see figure 1). Classification of stakeholders aids in understanding the level of influence/power or interest the actors may have in addressing the household food waste data challenge as illustrated in figure 2.

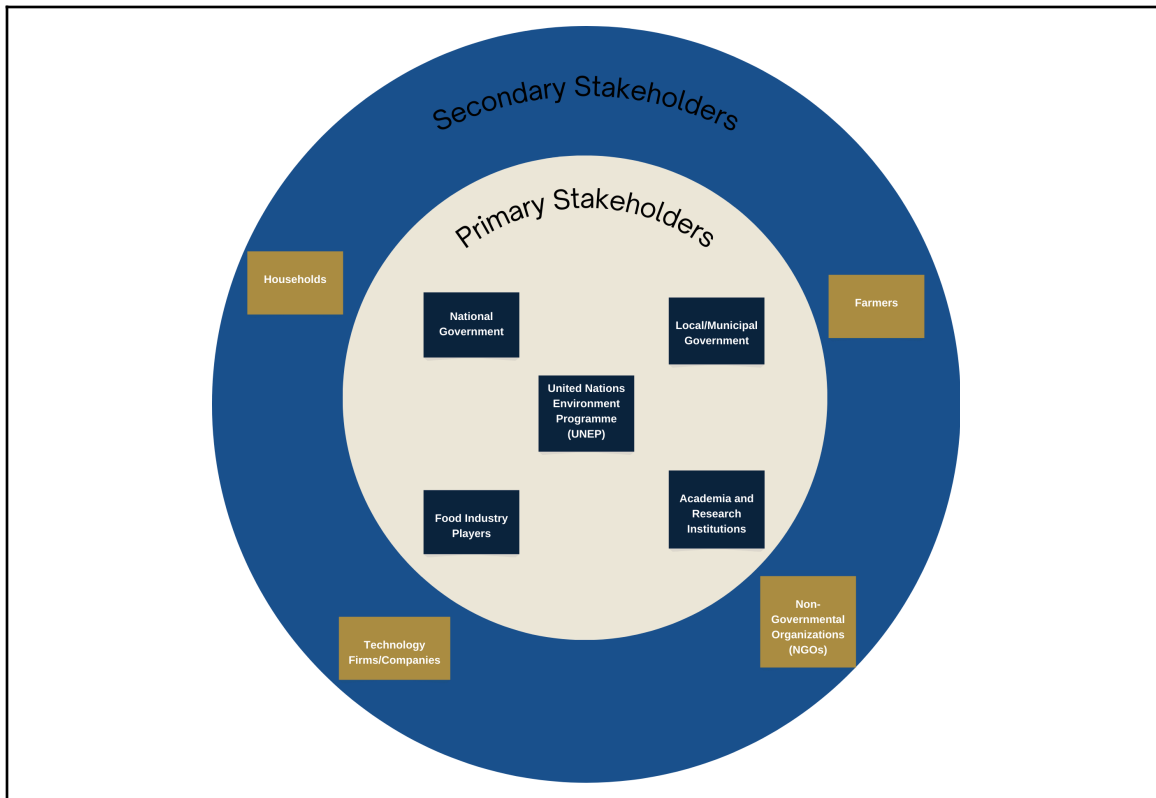
Primary stakeholders

These actors have direct policy influence on the problem at hand. They include:

- **Governments:** they could potentially design food waste management policies and enforce them.

- *National*: they have a countrywide reach and set laws, policies and regulations that govern a country.
- *Local/Municipal*: they have a local/grassroots reach and set local laws that govern the municipalities or the local administration zones(e.g. county, state, district, province e.t.c). They have access to parts of a country where the national government may not have the capacity to reach.

Figure 1: Stakeholder Map



- **United Nations Environment Programme (UNEP):** it currently researches and publishes the FWI Report every three years. As an international organization, it has the global platform to coordinate, set the standards and manage global data. UNEP's core mission is to find solutions to the triple planetary crisis. As the leading global authority on the environment, the institution helps its 193 Member States to foster climate stability, live in harmony with nature and forge a pollution-free future, supporting the achievement of all 17 SDGs (UN Environment Programme, n.d.). **Additionally, it could also provide a universal definition of what food waste is.**
- **Food industry players:** could provide data on how much food is produced annually. The comparison between how much food is produced versus how much is wasted could inform policies around how much food should be produced to avoid unnecessary wastage.

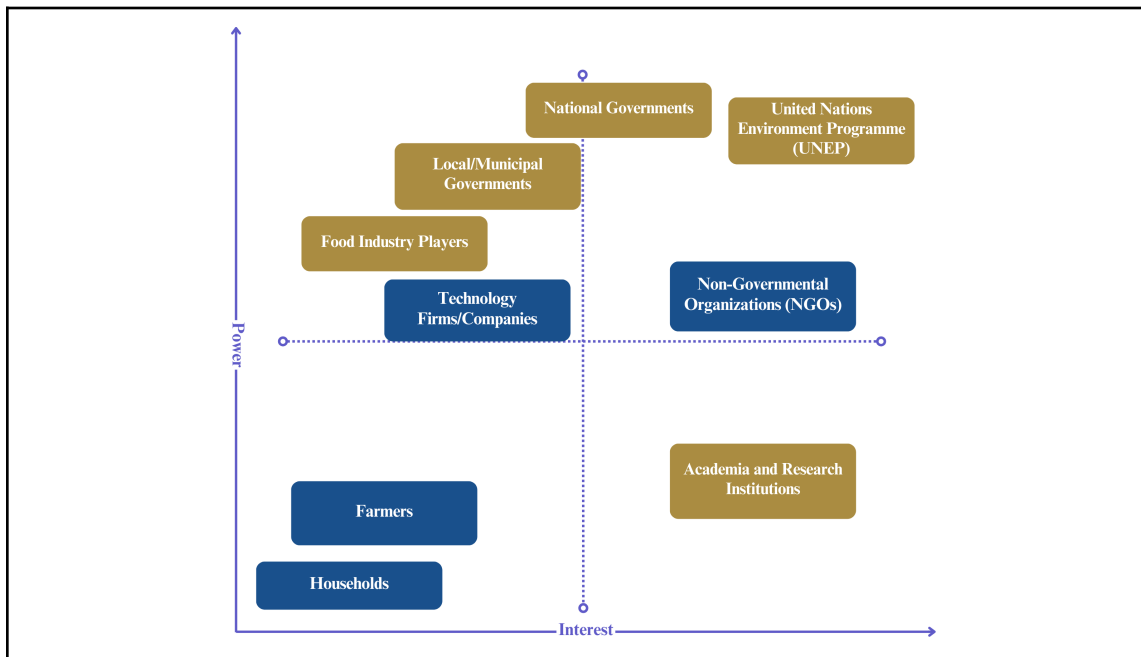
- **Academia and research institutions:** they can study household behavior and measure effectiveness of policy interventions. They develop the research methodology.

Secondary stakeholders

These actors are affected by the problem or contribute to it but do not have policy influence. They may or may not be interested in addressing the challenge but have little to no power to do so. They include:

- **Households.** In the context of our research, these are the consumers that contribute to food waste. They can help in collecting the data. (For the sake of consistency, we will refer to them as households through the paper.)
- **Farmers.** They produce most of the food that feeds the world. They can provide data on how much food is produced at the farm-level.
- **Non-governmental organizations (NGOs).** They can advocate for policy food production and distribution reforms.
- **Technology firms.** They could potentially create artificial intelligence tools or mobile applications that could be used to track food waste at the household level. This could potentially aid in data analysis and interpretation. They could also help to integrate data sources into the data workflow.

Figure 2: Stakeholder Power and Influence Map



Beyond the independent roles that these actors play, they also interact with each other. However these interactions can be strengthened to avoid duplication of roles, tasks falling through the cracks and ultimately ensure the data challenge is addressed.

a) Governments and other actors:

National governments are member countries to UNEP, they can avail national household food waste data to UNEP. National governments disburse funds for local governments' operations. Municipal governments can aggregate local data and relay it to the national government. UNEP sets global targets on food waste reduction and provides guidelines on what type of data they are looking for. National governments regulate the operations of all the stakeholders within a country's boundaries and collect demographic data of its populace. Technology firms/companies provide technology and software support to national and local governments and can also provide recommendations on the role of technology in addressing the data challenge experienced at the grassroots level. Academic and research institutions conduct research and provide governments with recommendations on pertinent data issues.

b) UNEP and other actors

The larger UN body sets the Sustainable Development Goals that provide guidance in attaining sustainability in the planet we call home. The contribution of the food industry to the SDGs has been a subject of particular interest since the onset of the targets because food production is closely associated with many of the SDGs (Ducker, 2022). UNEP can also provide guidelines for sustainable food production and consumption to farmers and consumers respectively. Technology firms have the potential to work with UNEP to address food waste and data collection. By 2030, the United Nations wants to cut the amount of food wasted worldwide in half, and technological solutions have shown promise in achieving that objective (Aggarwal, 2023). Researchers may contribute through published reports or expert consultations.

c) Food industry players and other actors

Food industry players rely on sustainability targets set by the UN. They publish sustainability reports to show how they are changing their production methods to achieve sustainability agenda.

d) Academia & research and other actors

Technology firms collaborate with academic and research institutions to research on the nexus between data collection and technological innovation to support the endeavor.

e) NGOs and other actors

NGOs may act as food banks to households. They also work with local administrations to raise awareness around food waste. Additionally, they participate in UN processes negotiation by providing expert advice and consultation. NGOs work with farmers to train them on sustainable food production methods.

Table 1: Stakeholder Interaction Matrix–Current and Proposed Interactions

Stakeholder Pair	Current Interaction	Improved Interaction for Data Challenge
UNEP ↔ National Governments	Top-down reporting; inconsistent data quality	Collaborate on standardized local-level reporting frameworks
UNEP ↔ Local Governments	Minimal direct interaction	Engage municipalities in direct household waste monitoring
UNEP ↔ Food Industry Players	Indirect through sustainability reports	Form task forces to define/report household-level impacts
UNEP ↔ Academia and Research	Used for methodology guidance	Support open data initiatives and collaborative data validation
National Governments ↔ Local Governments	Data flows upward; limited support downward	Decentralize data collection, enable local funding and tools
Governments ↔ Food Industry	Regulatory compliance	Data-sharing partnerships, incentive schemes for transparency
Local Governments ↔ NGOs	Case-by-case collaboration	Institutionalize partnerships for ongoing waste monitoring
Local Governments ↔ Tech Firms	Rare pilot projects	Scale up digital tools for community-level tracking and reporting
Academia and Research Institutions ↔ Tech Firms	Research prototypes	Co-develop scalable food waste estimation proxies
Academia and Research Institutions ↔ Food Industry Players	Limited access to proprietary data	Structured data-sharing under academic agreements
NGOs ↔ Households	Awareness campaigns	Community science initiatives for food waste self-reporting

Tech Firms ↔ Households	Applications	Build household food waste dashboards with incentives
Food Industry Players ↔ Households	Market influence (e.g., promotions, packaging)	Co-create education campaigns, smarter packaging, real-time feedback
Food Industry Players ↔ NGOs	Corporate Social Responsibility partnerships	Collaborate on waste reporting and redistribution platforms
Farmers ↔ Food Industry Players	Supply contracts	Share upstream surplus data to estimate consumer risk of waste
Farmers ↔ Academia and Research Institutions/NGOs	Interviews or studies	Engage in full-system food flow modeling for predictive analytics

Overall, the cross-sectoral interactions build a community, consensus, and universal understanding of what food waste is.

IV. Analysis and Discussion

Definition of Food Waste

The UNEP’s FWI Report 2024 provides a standardized, operational definition of “food waste” as food and the associated inedible parts removed from the human food supply chain, including destinations such as composting, landfill, sewer, and others (United Nations Environment Programme, 2024). UNEP further defines “food” as any substance – whether processed, semi-processed or raw – that is intended for human consumption. “Food” includes drink, and any substance that has been used in the manufacture, preparation or treatment of food. Therefore, food waste includes both: “edible parts”: i.e. the parts of food that were intended for human consumption, and “inedible parts”: components associated with a food that are not intended to be consumed by humans. This clarity is important not just for measurement but for organizing collective actions among concerned stakeholders.

Having a shared universal definition of food waste as adopted by the UNEP framework serves as a unifying foundation that enables different actors across the food system (governments, businesses, researchers, and civil society) to align their understanding and measurement approaches.

Benefits of having a UNEP definition of food waste

- a) **UNEP has a global reach:** UNEP is the leading global authority on the environment. It works closely with its 193 Member States and representatives from civil society, businesses, and other major groups and stakeholders to address environmental challenges through the UN Environment Assembly, the world's highest-level decision-making body on the environment (United Nations Environment Programme, n.d.). Global reach ensures that stakeholders are aligned on meaning and limits confusion that may arise with different regions defining it differently (Munesue et al., 2014).
- b) **Enables comparability:** With a consistent framework, countries and organizations can compare food waste data across borders and sectors, track progress toward *SDG 12.3*, and share lessons learned. This is especially important given that food waste patterns are influenced by cultural, economic, and infrastructural differences.
- c) **Standardization of terms enhances universality:** in the case of food waste, the UNEP standardized definition covering both edible and inedible parts removed from the human food supply chain allows countries, organizations, and sectors to speak the same language. This universality makes it possible to compare data across borders and sectors, track progress towards SDG 12.3, and identify best practices that are transferable. Without such standardization, efforts would remain fragmented, making coordinating global efforts and benchmarking impossible.
- d) **Supports measurability and accountability:** According to the UNEP's FWI Report 2024, one benefit of having a unified definition of food waste is that it encourages countries to move from modeled estimates (Level 1) to nationally representative measurement (Level 2 and 3). This ensures that even subnational or city-level efforts are contributing data in a form that supports national and global benchmarking.
- e) **Fosters integrated, systemic solutions:** Since food waste involves multiple sectors—retail, food service, and households, a common definition ensures that all parts of the chain are addressed holistically. This is necessary to ensure effective public-private partnerships (PPPs), which the report highlights as a proven model for achieving reductions through shared goals and data reporting mechanisms.

How it supports a shared take on a problem

a) Limits Under/Over Reporting of Data

The UNEP FWI uses a standardized definition of food waste, which includes both edible and inedible parts removed from the human food supply chain (see pg.V). The

methodology ensures consistency in what is counted, so that food waste measurements are comparable and reliable:

“To track levels of food waste over time... only studies that involved direct measurement of food waste were considered... avoiding methodologies with substantial biases.” (p. 8 of the UNEP report)

This help prevents skewed data from diary-based or proxy approaches, allowing a more accurate representation of the problem.

b) Multiple Uses of the Same Data – Usability

By following a common protocol, a single dataset can serve multiple stakeholders: policy makers, researchers, businesses, and civil society:

“Standardized measurement supports cities and countries to... increase food security, cut costs and support climate targets” (p. XII).

This shared usability means the same data can inform climate strategies, food redistribution, circular economy efforts, and more.

c) Interoperability

The UNEP FWI emphasizes that a unified definition allows interoperability across reporting systems and between public-private partnerships (PPPs), government monitoring, and global indicators like SDG 12.3:

“The Secretariat captures, anonymizes, and aggregates data from businesses to assess progress towards the targets, and publicly reports on this progress” (p. XIX).

Because all parties measure the same way, their data can be pooled and synthesized across platforms and levels, from local city waste systems to global environmental dashboards. The development of gateway technologies and standards is crucial for allowing previously incompatible systems to interoperate (Edwards, 2010).

Data Gaps and Current Methodological Challenges

Despite growing global attention, significant data gaps and methodological challenges persist in assessing household food waste, undermining the ability of governments and institutions to design and implement effective food waste reduction policies. The UNEP FWI Report 2024 offers critical insights into these challenges and the necessary steps to overcome them.

Insufficient Nationally Representative Data: While the number of household-level data points has almost doubled to 194 across 93 countries since the 2021 report, a large majority of these are subnational and not robust enough for tracking national trends (p. 10–11). Many of the newly added data points originate from academic studies or urban pilot projects, which do not reflect

the full national picture, especially in rural areas where food system dynamics differ significantly.

Inconsistent Measurement Methodologies: There remain wide discrepancies in how household food waste is measured. While UNEP encourages direct measurement approaches, many countries still use diaries or self-reported data, which often underestimate food waste due to recall bias and social desirability bias.

“Studies that formed estimates based on proxy data or waste factors... were not included... to encourage countries to use more robust methods.” (p. 8)

Moreover, differences in classification, such as how "inedible" parts are defined, further complicate comparisons across countries and regions.

Urban Bias and Lack of Rural Insights: Most new estimates come from urban centers, often due to easier access and higher landfill visibility. However, food waste practices are often lower and more circular in rural areas (e.g., feeding scraps to animals or home composting). This introduces a bias that skews national estimates and policies toward urban-centric solutions.

The Need for Standardization with Decentralization

To reduce food waste around the world, we need to agree on what food waste means and how to measure it, but also give room for local communities and cities to collect and act on their data. The UNEP FWI Report (2024) explains that having a shared definition of food waste, including both food we could eat and parts we usually don't eat, like bones or peels—helps countries compare their progress and work toward common goals like halving food waste by 2030 (UNEP, 2024). But at the same time, most new food waste data comes from local cities or regions, not from national governments. That's because food waste habits can be very different in rural and urban areas or different cultures. Experts like Hanson et al. (2016) say that while it's important to have shared rules for measuring food waste, how we collect the data can be flexible so it fits local needs. This combination of standard rules with local action helps make the data more useful and accurate. It also gives power to local governments and communities, who are often in the best position to deal with food waste on the ground (FAO, 2019). A major requirement for the sharing of collected data is the compliance with existing standards and formats (Wohner et al., 2022).

Measuring the Unmeasurable: Addressing Capillarity through Proxies

In many places, especially in low- and middle-income countries, it can be really hard to measure household food waste directly. This is often because food waste is not collected through formal systems or happens in small, scattered ways, which experts call “capillarity”. This means waste is thrown away in bits and pieces: some is fed to animals, some composted at home, some tossed

into informal dumps. Because of this, researchers and governments sometimes need to use proxies, or indirect ways, to estimate how much food is being wasted. For example, they might look at how much food is bought and how much ends up in landfills to guess what isn't being eaten. However, the UNEP Food Waste Index Report (2024) warns that relying too much on these proxies can be risky unless they are based on solid data and adjusted properly (UNEP, 2024, p. 8).

To deal with this challenge, UNEP encourages countries to gradually move from proxy-based estimates to more direct measurements, like waste composition studies or smart weighing tools in households. This helps improve accuracy over time, while still using proxies in the short term where direct methods are too costly or difficult (Yang, Sun, & Ni, 2021). So, while it may seem like food waste is "unmeasurable" in some areas, with the right mix of tools and local understanding, we can still make good estimates that support better policies.

Multi-sectoral engagement

Why multi-sectoral engagement? Food waste spans the entire food system, from farm to fridge, and addressing it touches on issues of consumer behavior, supply chains, waste management, and even cultural norms. A multisectoral approach acknowledges that household food waste data is influenced by many actors (e.g., how retailers market food, municipal waste collection systems, community habits, etc.), and that solutions require coordinated efforts. Since the FWI 2021 launch, there has been a strengthening of the global data infrastructure, with the number of household food waste studies and data points almost doubling as more countries and organizations begin tracking this metric (UNEP 2024). Still, many nations, especially low- and middle-income countries, lack robust systems for monitoring household food waste. This is where engaging a broad set of stakeholders becomes essential: it mobilizes the needed capacity, funding, and knowledge to fill data gaps. As discussed in section III above, we explore the roles of key stakeholders in collecting and acting on household food waste data and the mechanisms that enable them to work together.

Additionally, the private sector can support in solving food waste data challenges by leveraging their expertise in data governance and stewardship. However, relying solely on the private sector to manage and steward food waste data presents several challenges. First, given that private sector actors are profit-driven, there is a risk that access to food waste data could be monetized, potentially limiting availability to members of the public or researchers who cannot afford to pay. Second, concerns around data privacy arise: private companies may have incentives to sell household data or data exhaust to third parties for marketing purposes or to use the information in ways that could disadvantage certain demographics. Finally, questions about fair compensation emerge, particularly regarding how households' contributions to data collection would be recognized or rewarded in a system primarily driven by commercial interests. Public-private partnerships can overcome these challenges.

V. Conclusion

This paper highlights the major needs for accurate, standardized, and localized data in addressing the global household food waste challenges. While UNEP's food waste index gives us a foundational knowledge for defining and measuring food waste, major data gaps, especially in low and middle-income countries, hinder the effectiveness of policies. The paper shows that combining global standardization and localized actions is important for developing a robust, actionable dataset. Making strong multi-stakeholder engagement, especially involving the municipal governments and community-level actors, is a major key to improving data accuracy and usability. It is important to note that tackling food waste requires not only technical innovations and methodological rigor but also inclusive governance structures that empower local actors and ensure sustainability at all levels.

VI. Recommendations

Based on the analysis and discussion of the food waste data challenge discussed in section IV, this project proposes the below actionable recommendations to the stakeholders, particularly primary since they have the power to initiate change.

Building a new data pathway to collect food waste data from multiple sources and relay it to the national governments' bureau of statistics agency is paramount for addressing the food waste data challenge. Stakeholder interactions should be strengthened to ensure a seamless data collection process.

- To begin with, municipal governments should be engaged as they are the authority closest to households. They could be trained on data management and developing metadata for ease of searching data. Local governments should also be stewards of the data and have it in their publicly accessible websites.
- Secondly, the stakeholders should co-develop a standardized toolkit to collect data from the households. Academia, NGOs, local government, and tech companies should work together to study how households currently dispose of food waste using ethnography and surveys. This could determine if data collection mechanisms are through self-reporting, food waste mobile applications or smart bins. Classification rules can be adapted by region and the level of household comfort level with technology. As Edwards (2010) underscored, absence of standardized technology will result in numerous different systems governed by a loose patchwork of conflicting national, regional, and international standards.
- Create data collection models and simulate to determine the feasibility within a household context. This should be piloted in different parts of the world for comparison before scaling. Edwards (2010) alluded that simulation models can highlight the needs and gaps in data collection. By identifying which data are most critical for understanding

the dynamics of global food waste and for producing reliable projections or evaluating interventions, modeling efforts can provide valuable feedback to guide future data collection initiatives and prioritize standardization efforts. Versatile and thought-out data models are therefore the key for efficient data collection systems (West, 2011) and thus a precondition for the collection and storage of accurate data.

- Additionally, establish data collection points at the household level. This is a form of citizen science where communities are directly engaged in research. By involving community members in data collection, citizen science increases public awareness of environmental issues (Kinchy & Kimura, 2019).
- Moreover, UNEP, the governments, NGOs, academia and tech companies should have data-sharing forums where they exchange knowledge and share lessons learned. Such fora could also be used to streamline metadata to enhance usability.

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