COMPREHENSIVE ASSESSMENT OF CONVENTIONAL PRACTICES AND SUSTAINABLE PATHWAYS FOR SOLID WASTE MANAGEMENT: INTEGRATING PERSPECTIVES, PRACTICES AND ENVIRONMENTAL IMPACT

Shoaib Muhammad, Taimur Mazhar Sheikh, and Musharib Khan

(CGP # 06-092)

5TH RASTA CONFERENCE
Wednesday, January 26 & Thursday, January 27, 2025
Roomy Signature Hotel, Islamabad

This document is unedited author's version submitted to RASTA.

RESEARCH FOR SOCIAL TRANSFORMATION & ADVANCEMENT
Competitive Grants Programme for Policy-oriented Research
Pakistan Institute of Development Economics

ABSTRACT

Solid waste generation is escalating globally due to population growth, urbanization, and technological advancements, posing environmental, economic, and public health challenges. Developing nations like Pakistan face exacerbated issues due to limited resources. Solid Waste Management in Pakistan is characterized by inefficient collection and lack of waste treatment, leading to unsustainable practices. This study comprehensively assesses the components of sustainable solid waste management, focusing on Wah Cantt City. Key objectives include waste characterization, shortlisting treatment options based on waste composition and expert opinions, evaluating formal and informal sector integration, analyzing public knowledge, attitudes, and practices, and conducting a cost-benefit analysis, and environmental life cycle assessment of treatment options. Findings reveal: i) 55% organic waste composition, ii) composting and material recovery facilities as preferred treatment options, iii) minimal integration of formal and IS, iv) public preference for Public-Private Partnership operations, v) door-to-door collection as more effective, vi) good public knowledge (90%) but lower attitudes (73.3%) and practices (64.7%), and vii) nearly self-sustaining operations despite no monthly fees. Policy recommendations include adopting Public-Private Partnership nationwide, transitioning to door-to-door collection, formalizing informal sector access to waste, mandating composting and material recovery facilities, curriculum reforms to include SWM education, promoting awareness campaigns, and introducing gate fees at dumpsites. The findings are applicable to Pakistan and similar socio-economic contexts, serving as a reference for researchers exploring solid waste management systems.

PREFACE

Pakistan generates close to 49.6 million tons of solid waste per year with an annual increase rate of 2.4 percent. As of early 2024, only four operational sanitary landfills exist, with three in Karachi and one in Lahore. Most of the waste is dumped openly or burnt, both being non-sustainable and risking the health of the population. In short, the country's responsible stakeholders are failing to manage solid waste, and there are no indications of any future improvement in solid waste management in Pakistan.

Managing solid waste is a complex and multi-tiered issue, with involvement from all stakeholders. There is a significant lack of waste management equipment and technology, limited awareness of waste production and consumption by the public, and bureaucratic delays in waste management policy implementations. While several studies have explored solid waste management in the country, these efforts often focus on isolated aspects of the problem, limiting their utility in driving practical solutions and policy formulation. The need for a comprehensive assessment of the solid waste management landscape is both pressing and unmet—a gap this study aims to fill.

This research provides a holistic evaluation of solid waste management by examining five critical components: technical, institutional, social, economic, and environmental. The urban city of Wah Cantt was selected as the focal point of this study. Its relatively smaller population allowed for an in-depth investigation of these components, while its urbanized setting, high literacy rates, and operational waste treatment facilities presented a microcosm of larger Pakistani cities. It is expected that the findings of this research are not only highly representative of the city, but translatable to urban cities in Pakistan and other developing countries. For instance, examining the social component in a socio-economically diverse city sheds light on the lack of public engagement in waste management, while analysis of the economic component reveals the cost and revenue dynamics of existing facilities, offering a basis for feasibility studies in larger urban areas. In summary, this study is the first in Pakistan to provide a comprehensive assessment of multiple solid waste management components and their interlinkages, which are used to draft practical and holistic policies for effective waste management.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Municipal Solid Waste[1] is being generated at an alarming pace, with an annual global generation of more than 2 billion tonnes, and if the status quo continues, this generation is forecasted to cross 4 billion tonnes. Approximately, if the currently globally generated solid waste is put in standard shipping containers and the trucks are lined, it will cover a distance equivalent to the trip distance from Earth to the moon and back (UNEP, 2024a). The situation in developing countries, particularly Pakistan, is even more concerning regarding solid waste generation and management. Although there are no official statistics, up to 32 million tonnes of annual solid waste is generated in Pakistan, with a yearly increase rate of 2.4% (Batool & Ch, 2009; Ejaz & Janjua, 2012; Majeed et al., 2018). The collection rate is less than 50% in the major metropolitan cities and non-existent in the rural areas. There is overemphasis on manual sweeping and collection, and treatment options such as incineration, composting, and anaerobic digestion are neglected. Currently, there is no operating sanitary landfill in Pakistan, a comparatively inexpensive method of waste treatment, and solid waste is managed through open dumping and open burning (Iqbal et al., 2022; Devadoss et al., 2021; Nadeem et al., 2023).

Consequently, this mismanagement of solid waste is leading to accelerated pollution of the local environment and subsequently impacting the global climate (Misganaw, 2023). A recent report by UNEP linked solid waste to the triple planetary crisis of climate change, biodiversity loss, and pollution (UNEP, 2024a). The primary reasons for the dilapidated state of solid waste management in Pakistan include political negligence, lack of resources, public awareness & behavior, outdated regulatory framework, and administrative issues (Loizia et al., 2021; Molina & Catan, 2021; Zia et al., 2020). Considering the interconnection of waste management with the Sustainable Development Goals and the updated Nationally Determined Contributions[2] (NDCs), it is imperative to revisit the outdated national waste management policies urgently. The formulation of policies requires a comprehensive, holistic, reliable, and site-specific assessment of the baseline situation of the various interconnected components of solid waste management (Muhammad et al., 2023). Given the abovementioned, this research study involves a comprehensive determination of the waste composition, waste treatment options & its environmental impact, role & significance of the IS, cost-benefit analysis, and a public survey regarding the knowledge, attitude, and practices about the solid waste management thus covering the major components of sustainable solid waste management. The research study's findings will enable the relevant stakeholders, including the municipalities, cantonments, and waste management authorities, to make informed and data-driven decisions.

[1] Municipal Solid Waste refers to the solid waste coming from residential and commercial sources but does not include industrial waste.

[2] Nationally Determined Contributions are the commitments/pledges made by the countries to reduce the green house emissions to mitigate the climate change.

LITERATURE REVIEW

According to Seadon (2010), a sustainable solid waste management (SWM) system refers to responsible & efficient generation, collection, transport, and waste treatment, including recycling, anaerobic digestion, composting, and disposal of waste material while considering the following:

- Environmental friendliness
- Economically feasible and self-reliant state of affairs
- Socially aware and inclusive communities
- The institutional capability of the management units

Thus, a sustainable SWM system comprises of technical, institutional, social, environmental, and economic components, with comprehensive assessments incorporating all the sustainability components essential for successful planning and management (Muhammad et al., 2023). Multiple studies have been conducted in isolation on different aspects of SWM. The subsequent section includes a critical analysis of the studies undertaken on the various aspects of solid waste management.

A Waste Audit or Waste Analysis and Characterization Study (WACS) is essential to a reliable and effective Solid Waste Management System. It involves determining and characterizing the generated waste (Bilal et al., 2022). Amir et al. (2023) and Iqbal (2021) studied the composition of the waste generated in Higher Education Institutes (HEIs); however, the nature of the waste generated in HEIs is entirely different from municipal solid waste; moreover, the installation of the waste treatment units for the HEIs is not economically feasible considering the comparatively less amount of generated waste. Some waste audit studies conducted on municipal solid waste include (Bilal et al., 2022; Nadeem et al., 2023; Zia et al., 2017). The methodology adopted in these studies included collecting waste samples from the households directly over one week; the issues with the sample collection from the households include privacy concerns, sampling bias, labour intensiveness, and Social Desirability Bias[3] (SDB). An alternate methodology adopted in our research study to overcome the shortcomings of sample collection from households is based on the American Society for Testing and Materials (ASTM) D 5231-92, i.e., a standard method for determining the composition of municipal solid waste.

The increasing solid waste generation is resulting in detrimental effects on the environment and is a significant cause of climate change. Therefore, environmentally sustainable treatment of the generated solid waste is critical, and Life Cycle Assessment is the most reliable and commonly used methodology to determine the environmental effects of different treatment technologies (Mulya et al., 2022). Batool & Chaudhry (2009) utilized the Integrated Waste Management-2, a Life Cycle Inventory (LCI) model to determine the environmental impacts of the following treatment methods for Data Ganj Bakhsh Town in Lahore: Material Recovery Facility (MRF), Composting, Biogasification, and Landfilling. The model used in the study is basic; moreover, the literature recommends using SimaPro software, the most commonly used software for determining environmental impacts (Mulya et al., 2022). Ali et al. (2018) studied the environmental impacts of the following technologies for

[3] Social Desirability Bias is a phenomenon where the people give responses based on their belief that they will be viewed favourably by others.

Gujranwala City: open dumping, sanitary landfill, composting, recycling, and incineration. Anaerobic digestion, a very relevant technology considering the predominantly organic nature of waste in Pakistan, was not considered; also, the methodology used to determine the impacts included secondary sources, including data from other countries, which are more likely to generate less accurate & reliable results. Atta et al. (2020) utilized the SimaPro software to determine the environmental impacts, but only the existing practices of the Rawalpindi Waste Management Company were taken into account, and no major waste treatment technologies were taken into account.

Literature suggests that communities' knowledge, attitude, and practices (KAP) significantly impact Solid Waste Management (Eshete et al., 2023). Although some studies, for instance, Haider et al. (2015) conducted a KAP survey for Lahore, the literature lacks studies on Pakistan with detailed methodology published in renowned journals.

Another important stakeholder in the SWM system (SWMS), particularly in the context of developing countries, is the IS (IS), and the determination of its role and significance holds significant importance (Sigcha et al., 2024). Some studies on IS in Pakistan include those conducted by Kamran et al. (2016) and Majeed et al. (2017). The fact that the various components of the SWM system do not remain static and are evolving with each passing year necessitates the study of the current state of affairs (Muhammad et al., 2023). Moreover, the recent change in the country's socio-economic affairs makes new studies necessary.

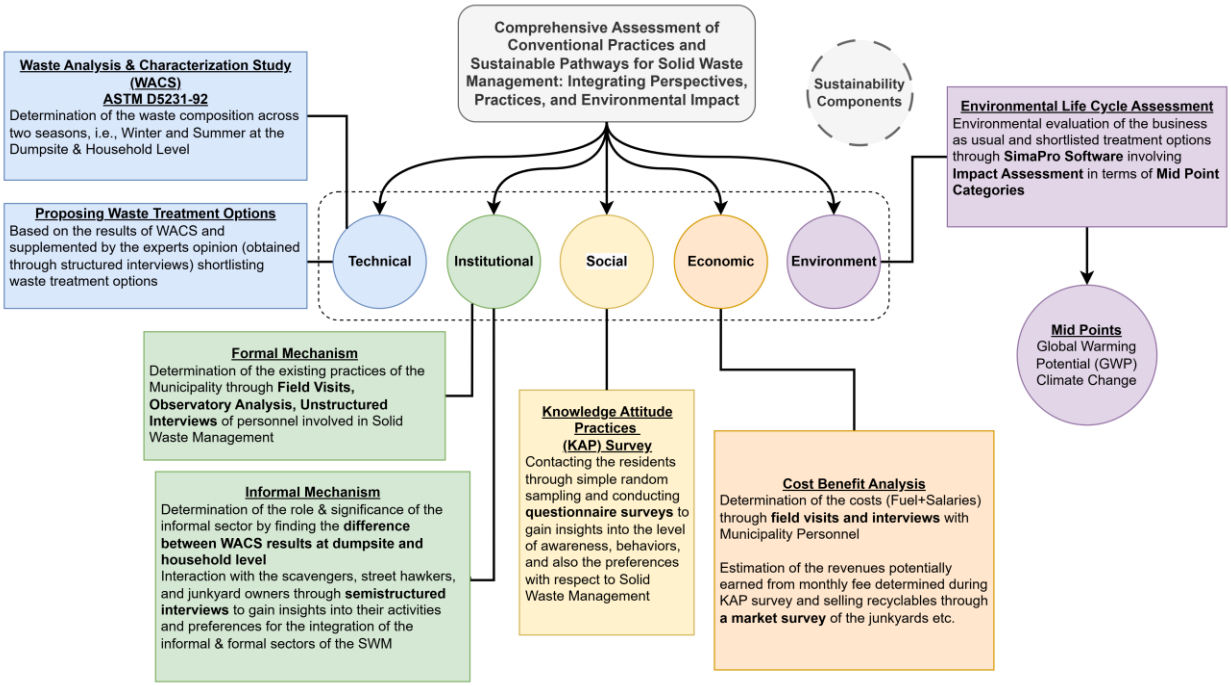
The existing approach undertaken includes breaking down a problem into smaller pieces and then visiting each problem in isolation, which results in the resolution of that problem but the generation of other issues due to the interconnected nature of the system. Approaching smaller understandable issues is increasingly problematic; moreover, multiple research necessitates the undertaking of integrated studies (Joos et al., 1999; Marshall & Farahbakhsh, 2013; Merker et al., 2015; Seadon, 2010; Zarate et al., 2008).

RESEARCH METHODOLOGY

The methodological framework followed in this research study is presented in Figure 1. The adopted methodology encompasses the five aspects, i.e., Technical, Social, Institutional, Economic, and Environmental, of the sustainability of solid waste management. Firstly, within the technical component, the composition of the solid waste at the dumpsite across two seasons was determined by following the ASTM D5231-92 standard (ASTM, 2016). According to the standard, a representative sample from the trucks arriving at the dumpsite is taken, and then, by following the coning and quartering method, as represented in Figures 2 & 3, the composition of the solid waste is determined. The composition of the solid waste provides vital insights into the consumption behaviors of the public and, more importantly, informs the selection of the treatment processes. The procurement of samples directly at the dumpsite ensures accurate representation of solid waste for management. Multiple experts' opinions were sought via Google Forms and email to finalize the selected treatment options.

The institutional component included the (i) determination of existing practices regarding the collection, transportation, and management of solid waste through site visits, (ii) unstructured interviews of the personnel involved in the SWMS, and (iii) investigation of the role & significance of the IS in SWM via semi structured interviews and waste audit result analysis. It is pertinent to mention here that one of the reasons for the selection of Wah Cantt City for the research purpose was that the solid waste management of the city is designed in such a way that the solid waste is managed by the Pakistan Ordinance Factories (POF), which has partnered with a private sector company which performs door to door collection of the generated solid waste, and Cantonment Board Wah which performs the conventional practice of collecting the waste from tubs and skips. This allows for greater insight on the role of multiple waste management entities towards efficient SWM. The aforementioned key feature was utilized in the research study to determine the role and significance of the IS by determining the difference in the quantity of recyclables. The role of the IS covered in the research study also investigated how the IS can be integrated with the formal sector of solid waste management. The said objective was achieved by following the framework proposed by (Velis et al., 2012). The data for the framework was collected through semi-structured interviews with the key stakeholders of the IS, including scavengers, street hawkers, and junkyard owners (as presented in Figure 4). The sampling method adopted was the snowball technique, as recommended in the literature for the IS due to the lack of official records (Gall et al., 2020; Sigcha et al., 2024; Yıldız-Geyhan et al., 2017).

Figure 1: Methodological Framework



Source: Authors compilation.

Figure 2: Arrival and Offloading of the Municipal Solid Waste from the Trucks

Source: Authors compilation.

Figure 3: Coning and Quartering of the Municipal Solid Waste

Source: Authors compilation.

The social component of the sustainable SWM system was assessed by determining the Knowledge Attitude and Practices (KAP) survey of the residents of Wah Cantt utilizing a simple random sampling method and through structured questionnaires. The questionnaire was developed after a rigorous literature review; some of the studies that provided vital design guidelines included the following: (Aryal & Adhikary, 2024; Baawain et al., 2019; Baba-Nalikant et al., 2023; Debrah et al., 2021; Desa et al., 2011 and 2012; Eshete et al., 2023; Ferronato et al., 2022; Haider et al., 2015; Hamzah et al., 2022; Kiran et al., 2015; Laor et al., 2018; Lema et al., 2019; Limon & Villarino, 2020; Wang et al., 2020). After developing an initial draft of the survey, it was sent to experts (via email, LinkedIn) and they were requested to review the questionnaire. Multiple social scientists and environmental experts were chosen to review the questionnaire draft. The questionnaire was then revised in light of the reviews received; the comments received by each reviewer and the finalized questionnaire (English and Urdu versions) are provided in the appendices. The questionnaire was also translated into Urdu, keeping in view the local language preferences.

The economic component of sustainable SWM was assessed through a basic Cost Benefit Analysis (CBA) approach in which the costs determined were limited to the Operational and Management (O&M) expenses, whereas the benefits included the potential earnings through recyclables and the monthly fee (if any). Finally, the environmental aspect of the sustainable SWMS was assessed by conducting an environmental Life Cycle Assessment (LCA) of the business as usual and the shortlisted treatment options via SimaPro software analysis, to determine the environmental impacts in terms of midpoint categories.

Figure 4: IS survey

Source: Authors compilation.

FINDINGS AND DISCUSSION

The findings of this study are listed in the same order as outlined in the research methodology.

4.1. Technical Components

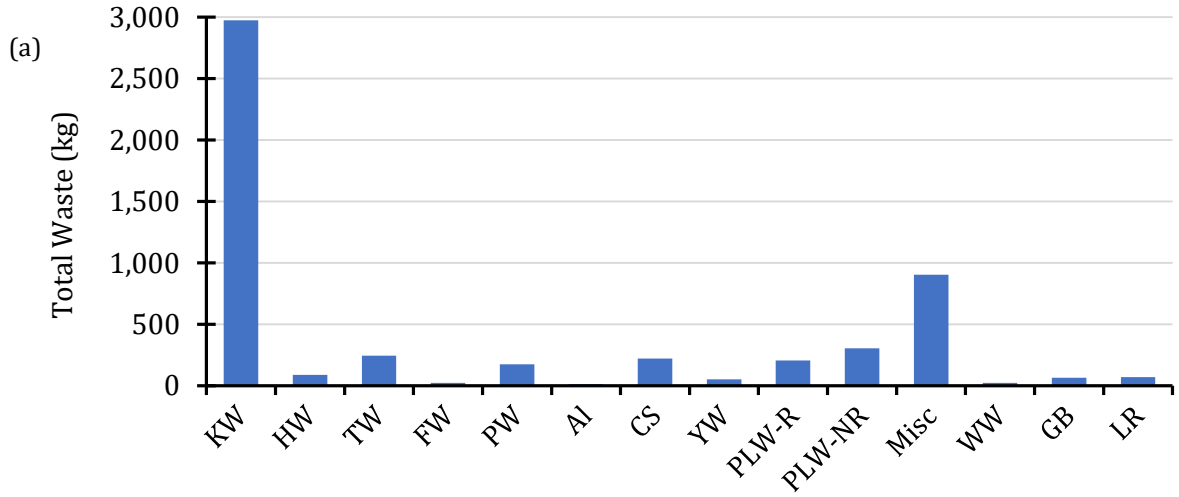
4.1.1. Waste Analysis and Characterization Study (WACS)

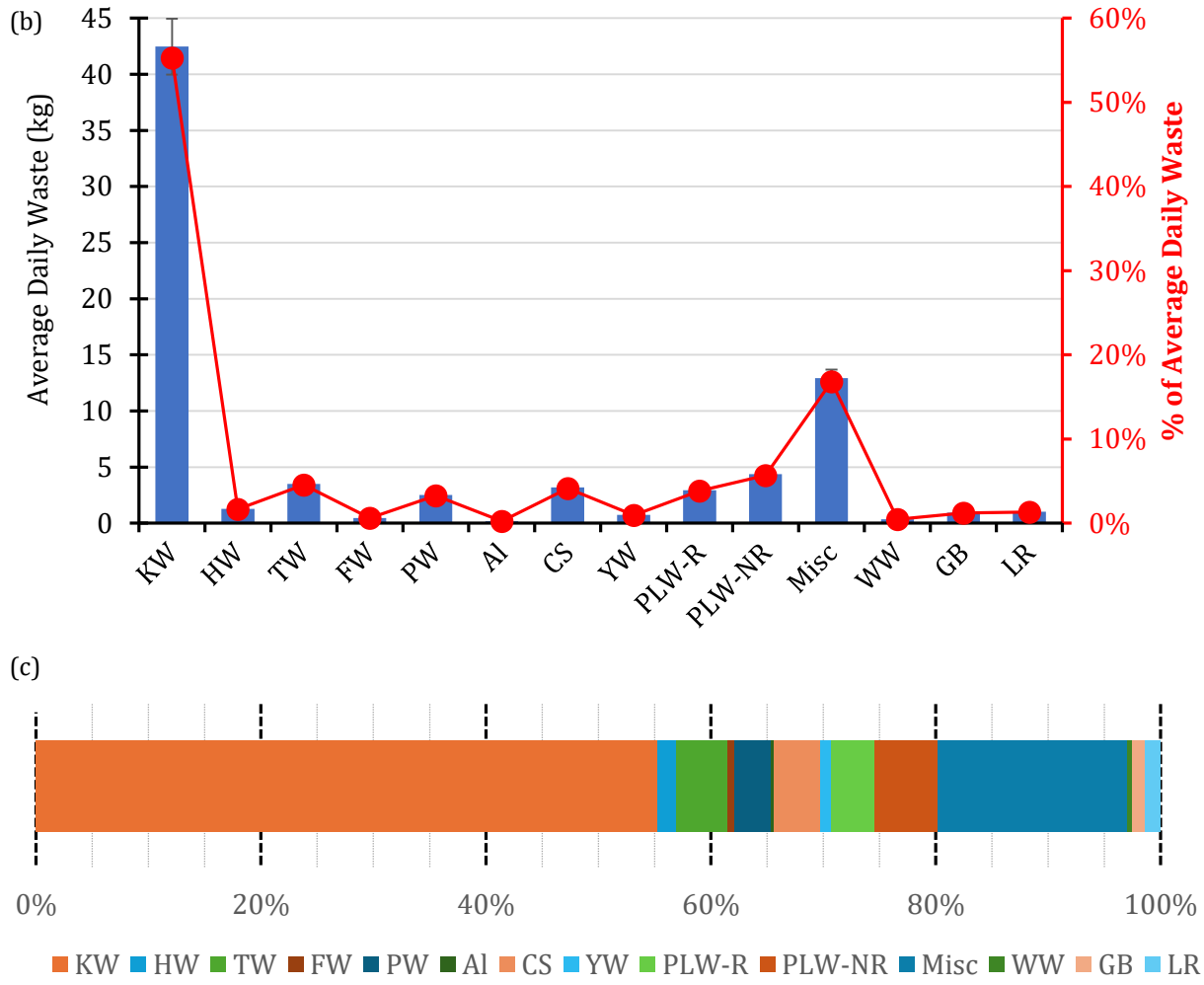
The ASTM-D5231 was performed on household and dumpsite waste across the winter and summer periods to develop a baseline assessment of the various wastes produced in Wah Cantt. Solid waste is characterized into 14 types as per the following (ASTM, 2016; Bilal et al., 2022; Nadeem et al., 2023) and the statistical descriptives of the tests are summarized in Figure 5. These values are also tabulated in the Appendix as Appendix Tab. 1.

Of note are the labels assigned to each waste category type, as these will be used in analyzing the main findings in this section. Figure 5 shows the overall distribution of waste across seasons and collection types. Figure 5(a) shows the total amount of waste characterized for each category in kilograms. Kitchen Waste (KW) and Miscellaneous (Misc) dominate the categories, with approximately 2950 kg and 900 kg, respectively. These are followed by Plastic Waste No-Recyclable (PLW-NR), Textile Waste (TW), Ceramics and Stones (CS), Recyclable Plastic Waste (PLW-R), and Paper Waste (PW), respectively. The least waste was found for Aluminum (Al), Ferrous Waste (FW) and Wood Waste (WW), in ascending order.

A more helpful term instead of Total Waste (kg) is Average Daily Waste (ADW), collected in kg or as % of the average waste collected daily for each waste category. The latter is notated as "% of Total Average Daily Waste (%TADW)", and both ADW and %TADW are illustrated in Figure 5(b). The distribution is like that of Total Waste collected in Figure 5(a), with KW and Misc being collected the most daily at roughly 55 %TADW and 17 %TADW of the total waste composition. All remaining waste categories contribute less than 10% TADW each. Finally, Figure 5 (c) breaks down the 100 %TADW composition, better visualizing the proportions of each waste category. Al is almost indiscernible in the total waste. This composition of waste is in good agreement with the research literature.

Figure 5: Summary of WACS: (a) total amount of waste recorded in kg, the (b) average daily waste collected in kg and %age, and the (c) breakdown composition of the different waste categories over the total waste collected as a %age (% TADW)





Source: Authors computations.

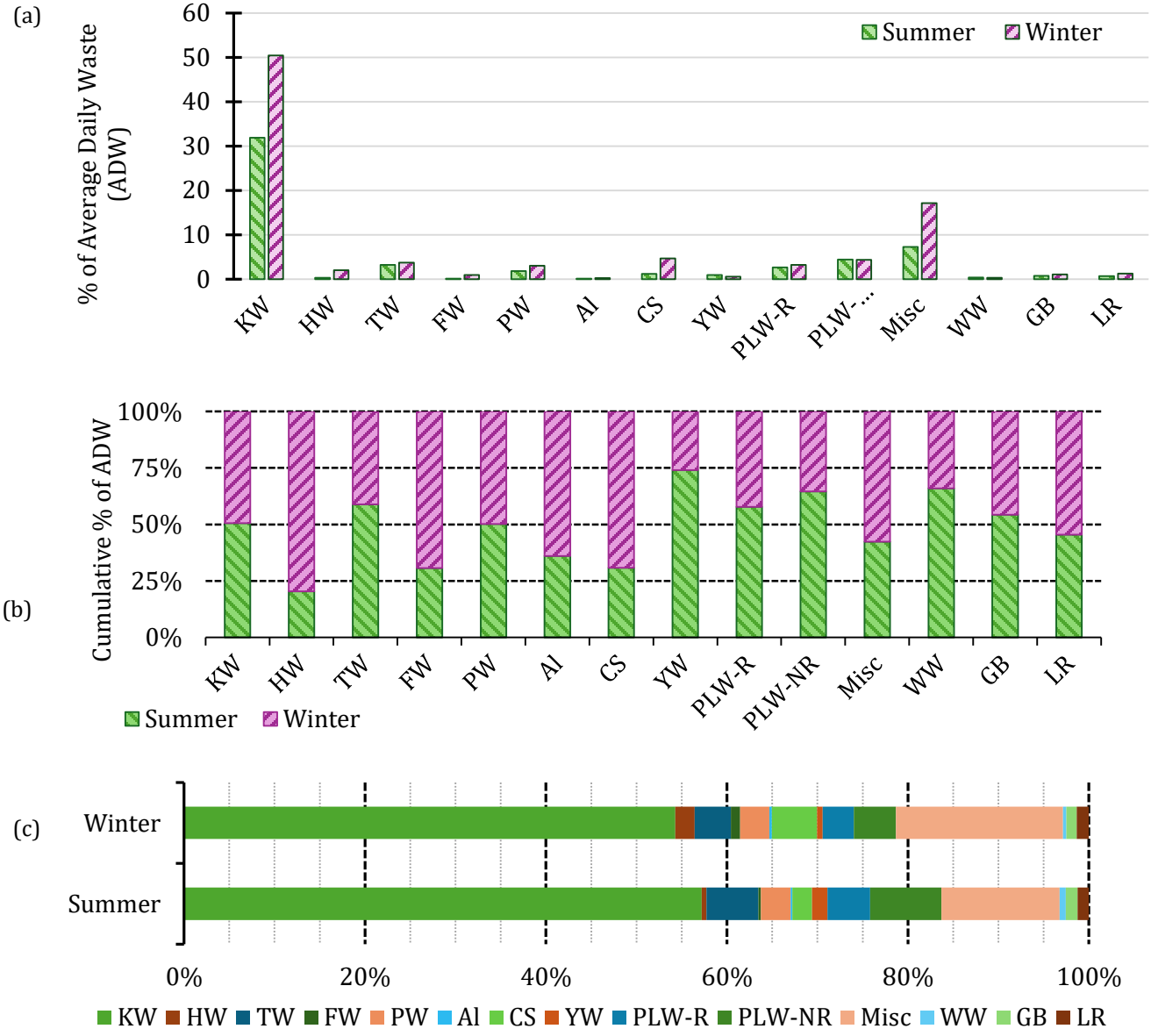
The following sections further segregate the waste categories over summer/winter periods. And the dumpsite/household collections.

4.1.2. WACS during Summer and Winter

Figure 6 visualizes the difference in waste compositions across summer and winter periods. From Figure 6(a), notable differences in waste compositions can be observed. TW, PLW-R, PLW-NR, and Glass and Bottles (GB) show higher % TADW in the summer period, while Hazardous Waste (HW), CS and Misc show higher collections in the winter. Figures 6(b) and 6(c) further illustrate the difference in % TADW across the waste categories. HW and Yard Waste (YW) are the most visibly different distributions, with about 75% of %TADW being collected in the summer period for the latter. Also of note, KW, PW, GB and Leather and Rubber (LR) show similar %TADW for both summer and winter periods.

Figure 6: Waste Characterization across the Summer and Winter Periods.(a) shows the %TADW for all waste categories of both periods, while (b) shows the relative %TADW between the periods for each

waste category. Finally, (c) is a breakdown composition of the different waste categories for winter and summer periods.



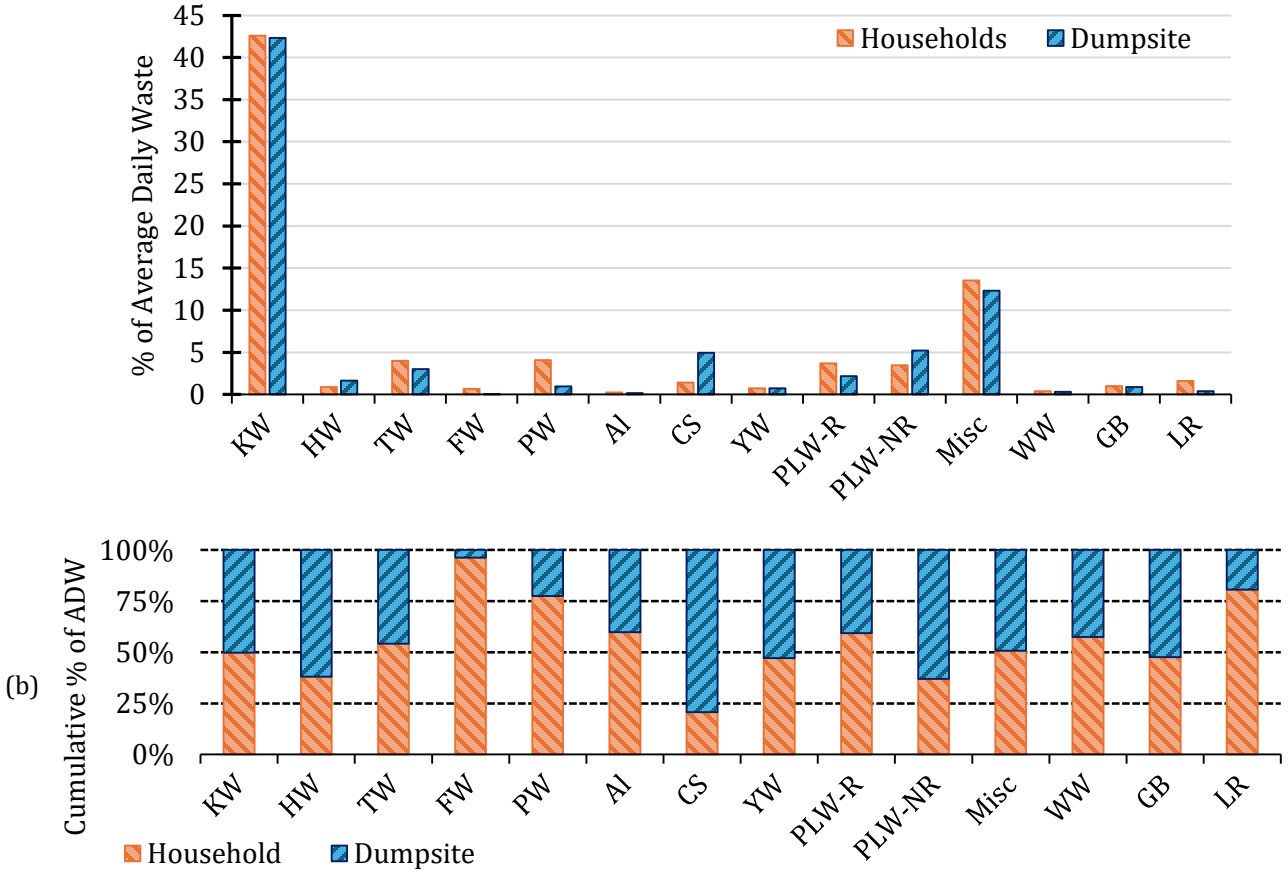
Source: Authors computations.

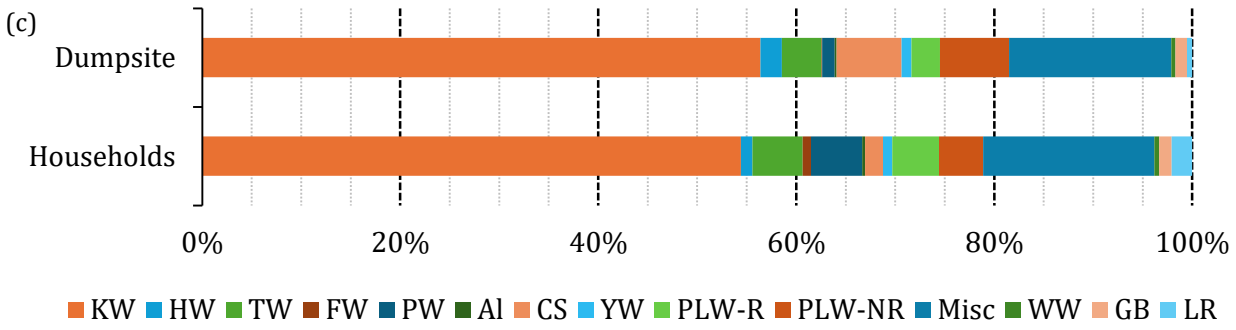
4.1.3. WACS of Household and Dumpsite Waste Collection

Figure 7 visualizes the difference in waste compositions across household and dumpsite waste collections. From Figure 7(a), notable differences in waste compositions can be observed. A relatively higher %TADW can be seen for dumpsite collections of CS and PLW-NR, while higher amounts of PW, TW, PLW-R, and LR can be observed for household collections. As dumpsite waste is collected from large containers such as skips and bins, a higher number of fines is expected, and it is also difficult to separate it from the organic waste, so it is reflected partly in the organic waste of the dumpsite waste audit. Figure 8 shows the distribution of waste categories across the weekdays (Mon to Fri), and a buildup of CS can be seen as the week progresses. Moreover, dumpsite collection occurs around

commercial areas, where higher amounts of PLW-NR, such as plastic bags, will be found. Conversely, households do not tend to throw plastic bags often, leading to fewer amounts observed in Figures 7(b) and 7(c). Surprisingly, KW is consistent across both waste collection types. CS and Misc show higher collections in the winter. Figure 7(b) further illustrates that over 90% of FW comes from household collections. KW, YW, Wood Waste (WW) and Misc show approximately the same amount of %TADW for both waste collection types.

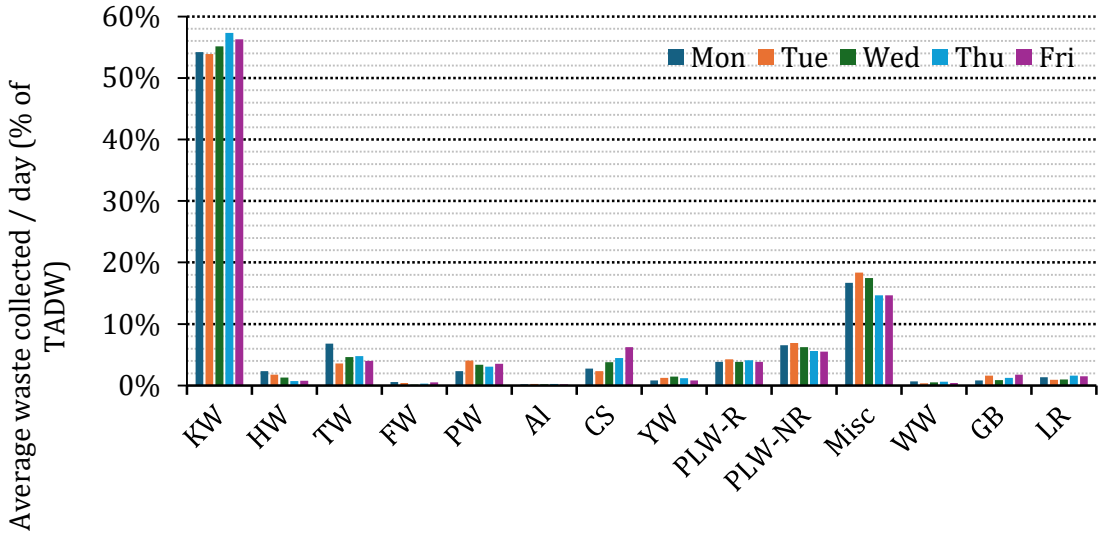
Figure 7: Waste characterization across households and dumpsite collection.(a) shows the %TADW for all waste categories of both collection types, while (b) shows the relative %TADW between the collection types for each waste category. Finally, (c) is breakdown composition of the different waste categories for household and dumpsite waste collections.





Source: Authors computations.

Figure 8: Distribution of each waste category across the weekdays (Monday to Friday)



Source: Authors computations.

4.1.4. Experts Opinion on the Waste Treatment Options

As mentioned in Figure 1, experts' opinions were sought to finalize the waste treatment options. A Google form was created and shared (via email) with the field's experts, primarily comprising environmental engineers with relevant field experience. In-person meetings with the municipality experts were also conducted to obtain perspectives regarding the waste treatment options. A total of 30 experts were contacted, and the results of WACS were shared with them. Moreover, relevant literature evidence was presented to obtain their perspectives. The online Google form can be accessed at the following link: https://forms.gle/RT1fWNsAGK72Ag2j7

According to the expert's opinion, the following waste treatment options have been shortlisted, which will be assessed in the later part of the study for the environmental impacts:

- Open dumping (Existing Practice)
- Sanitary Landfill
- Recycling/Material Recovery Facility

- Composting
- Anaerobic Digestion
- Incineration

One specific observation shared about the treatment of organic matter was the preference for composting over anaerobic digestion due to the advanced technologies required for the latter, which is pertinent for developing economies like Pakistan.

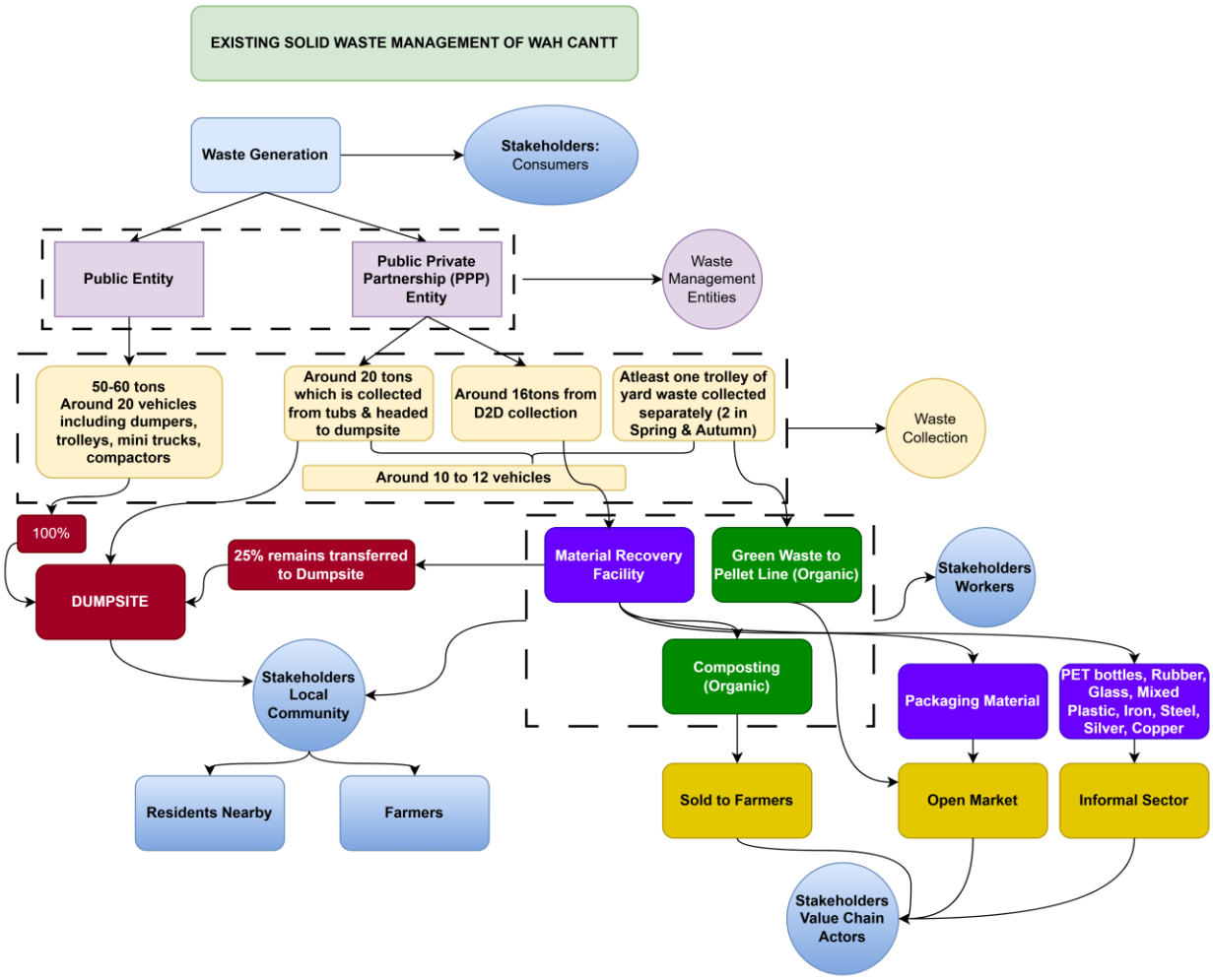
4.2. Institutional Components

4.2.1. Formal Mechanism – Existing Practices by WMEs

Wah Cantt is a small city situated in the province of Punjab, 30 km to the north-west of Islamabad. It is known to be one of Pakistan's most literate, developed, and industrialized cities. The rapid urbanization and industrialization of the city results in the production of a larger amount of solid waste. The area is known to have a waste collection system in Pakistan (outlined in Figure 9), and the presence of diverse management entities offers a unique exploration venue and an authentic set for analysis. The Pakistan Ordinance Factories (POF) and Cantonment Board Wah (CBW) manage the solid waste generated in the Wah Cantt. The POF functions under the Public Private Partnership (PPP) model, and the CBW is a public entity. The city is divided into two areas: (i) State Area: This area has the highest population density, and the area mainly inhabits the employees of POF and(ii) Private Area: This area inhabits the people with private jobs and businessmen. The PPP manages the State Area, and the public entity manages the Private Area (Zia et al., 2020).

The following insights were obtained based on information gathered with the help of field visits and unstructured interviews with the officials of the waste management entities. The PPP offers door-to-door collection to 12000 households within the state area, and the collection frequency (per the officials' claim) is every alternate day with no collection on weekends (Sunday only). Moreover, in addition to the door-to-door collection, the PPP collects the waste from the skips and tubs placed near households, commercial areas, and hospitals, performs street cleaning, and separately collects yard waste. On the other hand, the public entity collects waste only from the skips and tubs placed within the private area, and the collection frequency (per the officials' claim) is every alternate day with no collection on the weekend (Saturday and Sunday). The collection process starts early in the morning, and the collected waste by both entities is transported to a common venue on the city's outskirts, located in the village of Budho. The PPP has set up a waste treatment facility with the options of composting for kitchen waste, a Material Recovery Facility (MRF) for recovering recyclables, and a Pellet Line for yard waste, whereas the public entity transports all the waste directly to a dumpsite which is located a little further from the waste treatment facility of the PPP.

Figure 9: An Overview of the Existing Solid Waste Management of the City



Source: Authors computations.

The PPP has also set up a weighing bridge, which both PPP and Public Entity vehicles utilize. However, the weighing bridge is used only to record the incoming weights, and there is no limitation on the weights or any concept of a tipping fee/gate fee that is essential for promoting management initiatives. The vehicles start arriving at the facility from 0900hrs with regular intervals till 1300hrs in Winters, and for Summers, the vehicles under PPP follow the same schedule, whereas the public entity's vehicles' arrival at the site continues till 1700-1800hrs. The primary reason for the difference in the operations of both entities (concerning collection mode, number of operating days in a week, and adherence to specific times throughout the year) was the presence of the treatment facility, due to which the PPP had a vested interested in the quality and quantity of collected waste. Since the Public entity was dumping all the waste into the dumpsite, they had no concern for the quality and quantity of waste collected, thus leading to a variable waste collection schedule. Through the Material Recovery Facility (MRF), the PPP recovers the recyclables and sells them to various Value Chain Actors, as mentioned in Figure 9. Moreover, the PPP also has the option of composting, but there are some challenges faced by the PPP in getting high-quality compost due to the prevalent public practice of disposing of mixed waste despite the provision of separate bins for the collection. The PPP officials stressed the need to educate the public and ensure strict implementation of waste segregation, for which the public's role is paramount. The PPP also sells pellets from the Pellet Line to nearby

companies. The PPP also showed strong interest in the access to the waste collected by the public entity such that instead of dumping all the waste into the dumpsite, some waste, especially the waste from commercial areas having high recyclables and comparatively better quality, should be processed at the facility. Moreover, the PPP officials stressed the need for a complete shift to door-to-door waste collection as opposed to collection from skips and tubs due to the following two reasons: (i) Collection from home means that there is no informal activity and thus offers maximum recyclables, which are essential for the sustainability of PPP mode of operations, (ii) The door to door collected waste is comparatively fresh and is thus more advantageous for various treatment options such as Composting and Anaerobic Digestion. A diagrammatic overview of the existing practices is represented in Figure 8. The main components of the treatment facility, such as weighing bridge, MRF, Composting, and Pellet Line, are shown in Figure 10.

Figure 10: Treatment Facility Components.(a) A truck being weighed at the weighing bridge, (b) Pellet Line, (c) MRF, (d) Composting, (e) Recovered recyclables (Plastic bottles, rubber, glass) storage place, and (f) Packaging material storage

Source: Authors computations.

During the site visits, indiscriminate disposal and open burning were observed in various parts of the city, specifically in the private area. The provision of skips and tubs was also more prevalent in high-income areas than low-income areas. Many tubs were damaged, and the waste was dumped around the tubs instead of in the tubs. The IS was also more prevalent in Private Area than in State Area, with PPP allowing controlled access at the facility and actively discouraging uncontrolled access. Moreover, waste management regarding the observed indiscriminate disposal and open dumping was better in areas served by the PPP than the public entity. Indiscriminate disposal and open burning significantly worsen the environment and ultimately aggravate climate change. The key observations from the field visit are also shown in Figure 11.

Figure 11: Observations from Field Visits.
(a) Open Burning, (b) & (c) Non-Existent waste collection points in low-income areas, (d) Indiscriminate disposal, (e) Waste Dumping around the tub, and (f) IS Activity

Source: Authors computations.

4.2.2. Informal Mechanism

4.2.2.1. Role & Significance of IS

As evident from Figure 7, the number of recyclables in the dumpsite audited waste is considerably less than household audit waste, which shows an active role of the scavengers at various skips & tubs. This was also verified during the IS survey in which scavengers were found recovering the recyclables from the collection points, i.e., tubs and skips. Hence, the IS is further investigated to see if their role may be better integrated with the formal sector.

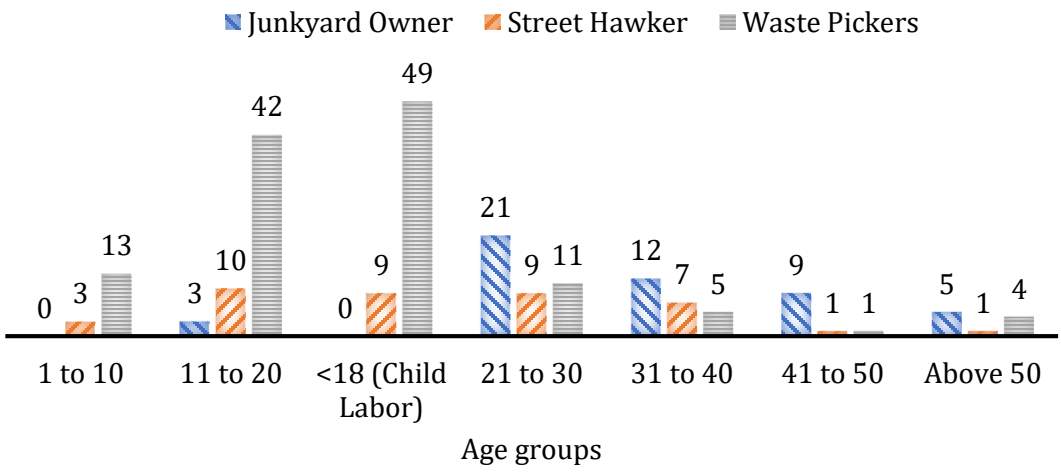
4.2.2.2. Integration of the IS with the Formal Sector

The IS, one of the important stakeholders in the developing countries, is often unrecognized, and their contributions are not valued. In this regard, integrating the IS with the Formal Sector is an under researched topic in the context of developing countries in general and Pakistan in particular. The subject above is one of the main objectives of this research study, and to fulfil this objective, the framework suggested by Velis et al. (2012) was adopted. The utilized framework is comprehensive and covers all the essential interfaces of the IS with the formal Solid Waste Management Sector, Materials & Value Chain, and Society. In addition to these three interfaces, the framework also covers the interface related to the empowering actions or the enabling factor, which can assist in better integrating the IS with the Formal Sector. The details of how each interface is adopted with the present study are tabulated in the Appendix (Appendix Tab. 2 Interface A- Between the IS and the Formal SWM Sector, modified after (Velis et al., 2012).

A semi-structured questionnaire survey was conducted to gather data about the interfaces. A total of 157 respondents were contacted, comprising 76 waste pickers/scavengers, 31 street hawkers, and 50 junkyard owners. The age-wise distribution of the respondents is shown in Figure 12, and with other characteristics in Source: Authors computations.

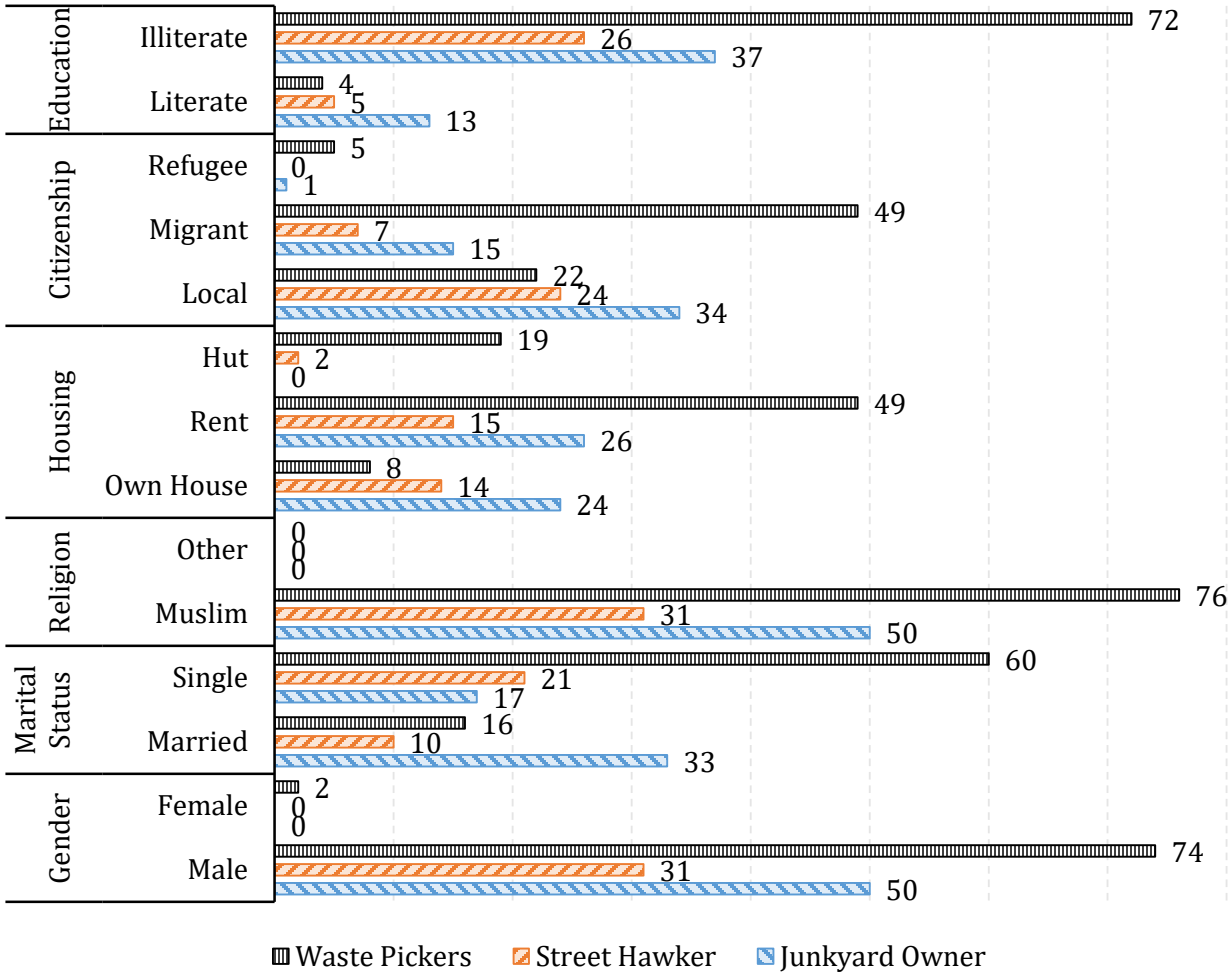
Figure 13. These characteristics are further explained in the interface scoring system.

Figure 12: Age-wise Distribution of Respondents



Source: Authors computations.

Figure 13: Distribution of Respondents' Characteristics

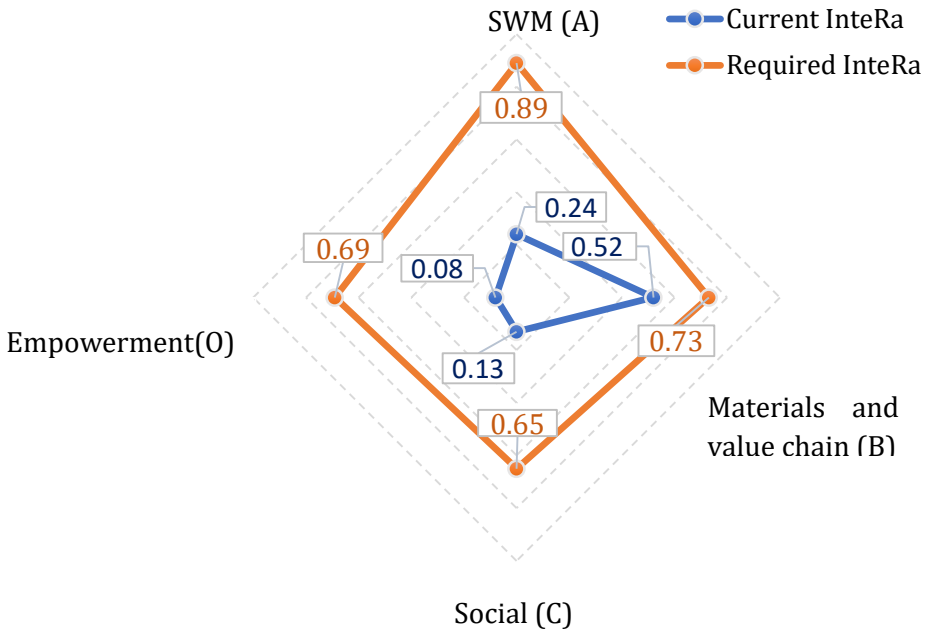


Source: Authors computations.

The intervention points mentioned in Appendix Tab. 2-5 were assessed based on the semi-structured interviews and field visits, and the detailed scoring may be seen in Appendix Tab. 6 Current &

Required Assessments of the IS Interface with the Formal SWM Sector. In the scoring, if the intervention point was found to be implemented, then it was assigned a value of K=1; if the intervention was found to be having a medium level application then it was assigned a value of C=0.5, and if the intervention was found to be ignored or the data was not available then it was assigned a value of I=0. In addition to the existing situational assessment, an assessment was also made for the required state of affairs, i.e., better integration of informal and formal sectors based on the socioeconomic characteristics of Pakistan. The assigned scores are represented through a radar diagram known as InteRa, which visually displays and communicates the findings in Figure 14.

Figure 14: Current and Required InteRa



Source: Authors computations.

Currently, there is a significant lack of SWM, empowerment and social interfaces for integration. However, the material and value chain interface show a higher score, which underscores the role of IS plays in the SWM of the region. The justification behind these scores is included in the Appendix as Appendix Tab. 6 Current & Required Assessments of the IS Interface with the Formal SWM Sector, however, a summary is provided in the following Table 1.

Table 1 Summary of Current and Required State justifications for IS SWM integration

		Current State and Observations	**Required State and Actions**
1	SWM Interface	• No controlled access to waste • No acknowledgement of the IS services • Repression, neglection, and collusion of IS • IS not consulted at all on planned initiatives or imposition of fines	• Provision of controlled access at the transfer station/ dumpsite/ treatment facility, as followed by PPP per the research study findings • Acknowledging and commending the positive role played by the IS by publishing their positive contributions from an environmental perspective

		• Uncontrolled access of IS to hazardous waste at the dumpsite • Limited waste management services in the residential areas of IS • No policies to promote recycling	• Accepting the role of IS and commending and facilitating them to a maximum level instead of repressing them • Inclusion of junkyard owners in the planning phase of key initiatives • Curbing the uncontrolled activity of IS at the dumpsite through strict fines and penalties • Provision of equal waste management services in all areas of the city • Introduction of gate fee after installing weighing bridge at the dumpsite as done by PPP per the research study findings
2	Material and Value Chain Interface	• Improving the quality of waste by taking active measures to promote waste segregation at the household level • No facilitation to IS members in terms of large containers • No washing of recyclables by the IS members • No primary recycling industry in small cities, and the materials have to be transported to Lahore, incurring major costs	• Replacing the three bins with two bins i.e., dry and wet waste, that is more user-friendly and will improve the recyclable and organic waste quality • Provision of large containers to registered IS members • Encouraging and educating IS members to wash the recyclables for better recyclable quality • Facilitating the establishment of recycling industries in small cities by offering tax reliefs and other incentives
3	Social Interface	• Issue of illegal Afghan nationals in the IS • No ID cards or uniforms (vests) provided to IS members • No consultation with the public representatives in planning various initiatives • Prevalent child labour • No use of PPEs by the IS • Limited access to healthcare facilities	• Crackdown against illegal Afghan nationals to facilitate the registration process of IS • Provision of ID cards and uniforms to IS • Inclusion of public representatives such as Counsellors in planning key initiatives that could ultimately affect formal and informal sectors equally • Crackdown against child labour and offering incentives to the parents such as exclusive access to waste subject to admitting their children to school • Mandating the wearing of masks by first educating and informing them, followed by the imposition of fines for noncompliance • Provision of easily accessible and affordable healthcare facilities to IS stakeholders

4	Empowerment Interface	• No unions or associations • No NGOs • No financial assistance provided to IS in terms of accessible and affordable loans • No regulation of recyclable prices resulting in the exploitation of IS • No training or awareness sessions for IS • No database of waste pickers and street hawkers, only junkyard owners recorded	• Facilitating and encouraging the union formation • Inviting and facilitating NGOs • Provision of affordable financial assistance to registered IS members • Regulation of prices with the consultation of all stakeholders • Training and educating the registered IS members on key environmental issues and how to augment utility • Registering the waste pickers and street hawkers by mandating the already documented junkyard owners to buy from documented waste pickers and street hawkers

4.3. Social Component

4.3.1. Knowledge, Attitude, and Practices (KAP) Survey

A KAP survey was conducted to determine the residents' awareness of and behaviors toward SWM. This covers the social component of this study. The simple random sampling technique was utilized to perform a structured questionnaire survey of the residents of Wah Cantt. An initial survey draft was prepared with the help of the literature and then sent to experts as part of the pretesting to ensure that the design survey encompasses all the relevant aspects. The experts' responses and the finalized questionnaire (English and Urdu versions) are included in the Appendices. The questionnaire was divided into the following five sections: (i) Demographic Information, (ii) Existing Situation Assessment, iii) Public Knowledge, (iv) Public Attitudes, and (v) Public Practices.

The sample size was calculated based on the Wah Cantt population per the Census 2023 results, with a 95% confidence level and 5% marginal error; the sample size came out to be 405. The following equation was used for the determination of sample size (Almasi et al., 2019) :

$$n=\frac{N.Z^2_{1-\frac{\alpha}{2}}.\sigma^2}{(N-1)e^2+Z^2_{1-\frac{\alpha}{2}}.\sigma^2} \qquad \text{Equation 1}$$

The survey team collected 504 responses. The chi-square test was used to check the statistically significant association between the questions. Moreover, the Cramer V test was used to quantify the strength of the association between the variables. This association test was used as many survey questions encompass nominal (non-ordinal) data. The survey results are detailed in the subsequent sections.

4.3.2. Demographic Information

The results of the first section, which was related to the demographics of the respondents, are shown in Table 2. Most respondents (73.5%) were male despite the survey team's efforts (such as female members in the survey team) to include maximum female representation. Moreover, the

respondents within the age group of 18-30 were 56% of the total respondents, which could probably be attributed to the reason that SWM is a topic that has gained importance in recent times, and the current generation is more familiar with it. Furthermore, most respondents (56.3%) had bachelor's degree & above. There was an almost equal representation of respondents on the basis of employment. The household income was categorized into low income (below the 25th percentile), lower middle income (between 25th and 50th percentile), upper middle income (between 50th and 75th percentile), and high income (above 75th percentile). Most households (55.1%) had between 4-6 members which is comparatively lower than the mentioned value of 6.3 in the Census 2023. Most respondents were residing in Wah Cantt for more than 10 years (49%) and had their own homes (60%).

Table 2: Demographic Information

ID	Section 1: Demographic Information	Count	%
A1	**Gender**		
	Male	369	73.5%
	Female	133	26.5%
A2	**Age**		
	18-30	277	55.4%
	31-45	150	30.0%
	46-60	60	12.0%
	> 60 years	13	2.6%
A3	**Education**		
	No Education	23	4.6%
	Diploma	74	14.8%
	Primary Education	62	12.4%
	Secondary Education	60	12.0%
	Bachelor's degree & above	282	56.3%
A4	**Employment**		
	Self Employed	116	23.4%
	Government Employed	109	22.0%
	Private Institute	106	21.4%
	Other	165	33.3%
A5	**Household Income Category**		
	Low-income (less than PKR 50,000)	125	25.5%
	Lower-middle income (between PKR 50,000 and PKR 90,000)	133	27.1%
	Upper-middle income (between PKR 90,000 and PKR 150,000)	111	22.6%
	High-income (higher than PKR 150,000)	122	24.8%

A6	**No. of Household members**		
	>10	29	5.8%
	1-3	85	16.9%
	4-6	277	55.1%
	7-9	112	22.3%
A7	**Number of household members with job**		
	0	0	0.0%
	1	212	23.6%
	2	314	35.0%
	3	204	22.7%
	4	92	10.3%
	5	45	5.0%
	>5	30	6.0%
A8	**Living in the region for**		
	<2 years	43	8.6%
	2-5 years	99	19.8%
	6-10 years	113	22.6%
	>10 years	246	49.1%
A9	**Own House or Rented House**		
	Own House	301	60.6%
	Rented House	196	39.4%

4.3.3. Existing Situation Assessment

The existing situation assessment was conducted to determine the current waste collection methods, waste management entities involved, waste collection frequency, waste collection on weekends, satisfaction with the waste management services, problems faced by the residents due to improper waste collection, willingness to pay, and the preferred media type by the residents. The results of the existing situation assessment are shown in Table 3. The majority of respondents had access to the door-to-door collection (54.2%); however, among the formal waste management entities, the Pakistan Ordinance Factories (POF), which was operating under the Public Private Partnership (PPP) model provided mostly the door-to-door waste collection services. The waste management entities were POF (providing services to 30.7% of respondents) and Cantonment Board Wah (CBW), a public entity providing services to 32.6% of the residents. Of note, the IS was actively engaged in waste management and provided services to 36.7% of the respondents, reinforcing the need to integrate with the formal sector.

Moreover, most respondents received daily waste collection or collection on alternate days. The waste collection services were offered on weekends to 47.1% of the respondents. Furthermore, most

respondents (55.7%) had waste dumping points near their homes. Regarding the satisfaction with the waste management services, 52.6% of respondents expressed their satisfaction. 51.2% of respondents were not paying for the waste management services and that was due to the provision of free services under the PPP model as the PPP was meeting its expenditures from the recyclables recovered from the door-to-door collected waste. The public entity and the IS were charging for the waste management services. The public entity charged between 200 to 500PKR for waste management services and other services such as street lighting. The charges of the IS were variable depending on the frequency of services. Regarding the willingness to pay, the majority expressed willingness. A significant percentage of respondents (69.2%) were using plastic bags for their waste, and the major issues faced by the respondents due to improper collection were Odor (46.4%) and mosquitoes (35.7%). Social media was the preferred media type by most respondents (70.56%), followed by the TV (25.81%).

Table 3: Existing Situation Assessment

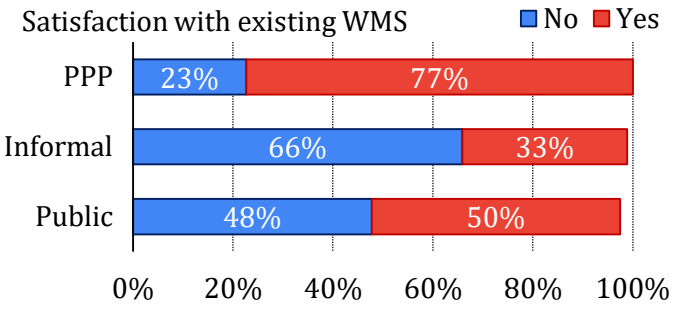
ID	Section II: Existing Situation Assessment	Count	%
B1	**Waste Collection Method**		
	Door to Door Collection	271	54.2%
	No access to waste collection services	90	18.0%
	Roadside/Kerbside collection from skips & tubs	139	27.8%
B2	**Waste Collection Entity**		
	Cantonment Board Wah	159	32.6%
	IS (Scavengers)	179	36.7%
	POF	150	30.7%
B3	**Waste Collection Frequency**		
	Daily	158	31.5%
	Alternate Days	200	39.8%
	Once a week	98	19.5%
	No Collection	46	9.2%
B4	**Is waste collected on weekends?**		
	Yes	234	47.1%
	No	263	52.9%
B5	**Are there waste dumping points near your home?**		
	Yes	277	55.7%
	No	220	44.3%
B6	**Are you satisfied with your current SWMS?**		
	Yes	261	52.6%
	No	235	47.4%

B7	**Do you use garbage (plastic) bags for your waste?**		
	Yes	346	69.2%
	No	154	30.8%
B8	**Any problems encountered due to improper SW collection?**		
	Aesthetics	51	10.2%
	Mosquitoes/Flies	178	35.7%
	Odor/Smell	231	46.4%
	Rodents	38	7.6%
B9	**How much do you pay for existing SWMS?**		
	0	243	51.2%
	1-200	36	7.6%
	201-400	96	20.2%
	401-600	49	10.3%
	>600	51	10.7%
B10	**Willingness to pay**		
	No, I can't afford it	72	14.5%
	No, it's the duty of the governing authority	158	31.9%
	Yes	265	53.5%
B11	**Choice of media type**		
	Newspaper	11	2.22%
	Radio	07	1.41%
	Social media	350	70.56%
	TV	128	25.81%

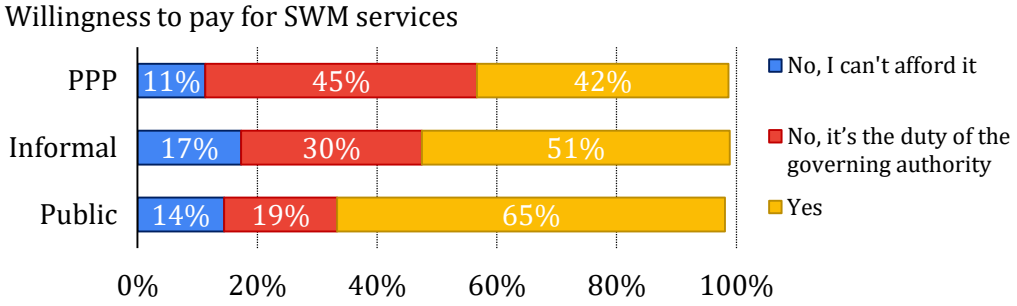
The satisfaction with the services and willingness to pay were analyzed with reference to waste management entities, and the results are shown in Figure 15. The respondents served by the PPP expressed maximum willingness owing to the comparatively frequent waste collection reported by most respondents; however, these respondents were comparatively less willing to pay and considered it the duty of the government.

Figure 15: Satisfaction & Willingness vs Responsible Entity(a) Satisfaction with WMS, (b) Willingness to Pay, and (c) Waste Collection Frequency

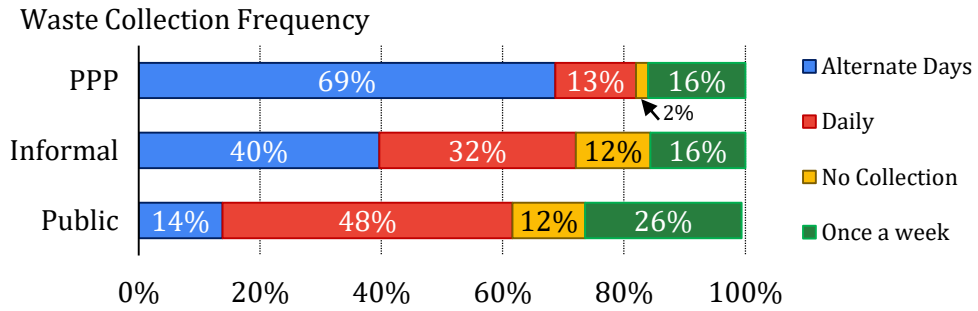
(a)



(b)



(c)



4.3.4. Public Knowledge

The respondents were asked about the important aspects/factors of SWM, and the responses were classified into poor (less than 50%), medium (50% to 75%), and good (more than 75%, as mentioned by Almasi et al. (2019). The same criteria were also applied to the sections of attitudes and practices. The results of public knowledge are shown in Table 4: Public Knowledge.

Table 4: Public Knowledge

ID	SECTION III: PUBLIC KNOWLEDGE	Count	%
C1	**Is solid waste a source of pollution for the environment?**		
	No	23	4.6%
	Yes	476	95.4%
C2	**Have you ever heard about 3R's (Reduce, Reuse, and Recycle)?**		
	No	180	36.1%
	Yes	319	63.9%

C3	**Burning solid waste can lead to respiratory health issues.**		
	No	33	6.6%
	Yes	466	93.4%
C4	**Open dumping of waste can cause health-related problems such as diarrhea, typhoid, and cholera.**		
	No	30	6.0%
	Yes	471	94.0%
C5	**Paper waste, plastic bottles, and metal are recyclable.**		
	No	66	13.2%
	Yes	434	86.8%
C6	**Compost or organic fertilizers can be prepared from solid waste.**		
	No	118	24.0%
	Yes	374	76.0%
C7	**The amount of solid waste can be reduced by reusing it at the household level.**		
	No	179	36.0%
	Yes	318	64.0%
C8	**Sorting of solid waste at home can help the SWM Authorities by turning waste into something of value.**		
	No	104	21.1%
	Yes	388	78.9%
C9	**Plastic bags (shoppers) are a threat to the environment.**		
	No	59	11.9%
	Yes	437	88.1%
C10	**Electronic waste and Chemical waste (batteries, paints etc.,) are considered hazardous waste.**		
	No	60	12.1%
	Yes	436	87.9%

The respondents showed an overall good knowledge of SWM with a score of 95.4% for C1, 93.4% for C3, 94% for C4, 86.8% for C5, 76% for C6, 78.9% for C8, 88.1% for C9, and 87.9% for C10. The only queries to which respondents showed a medium level of knowledge were C2 and C7, which were related to 3Rs and reduction in the generated solid waste by reuse at home.

4.3.5. Public Attitudes

The respondents' attitudes were also evaluated; the results are shown in Table 5. Contrary to the results of Public Knowledge, where most respondents showed good knowledge of most questions, the scores of public attitudes were comparatively lower.

Table 5: Public Attitudes

ID	Section IV: Public Attitudes	Count	%
D1	**Solid waste is anything without value.**		
	Strongly Disagree	88	17.7%
	Disagree	103	20.8%
	Neutral	69	13.9%
	Agree	194	39.1%
	Strongly Agree	42	8.5%
D2	**Considering the health and environmental effects of household solid waste is important in the disposal of waste.**		
	Strongly Disagree	41	8.2%
	Disagree	30	6.0%
	Neutral	44	8.9%
	Agree	286	57.5%
	Strongly Agree	96	19.3%
D3	**Solid waste is one of the environmental problems that needs immediate attention.**		
	Strongly Disagree	43	8.7%
	Disagree	23	4.6%
	Neutral	26	5.2%
	Agree	243	48.9%
	Strongly Agree	162	32.6%
D4	**Waste Segregation is the job of sweepers only nd not the households.**		
	Strongly Disagree	85	17.1%
	Disagree	163	32.7%
	Neutral	57	11.4%
	Agree	149	29.9%
	Strongly Agree	44	8.8%
D5	**The role of media is important in understanding the management of household solid waste and its importance.**		
	Strongly Disagree	34	6.9%

	Disagree	50	10.1%
	Neutral	48	9.7%
	Agree	255	51.5%
	Strongly Agree	108	21.8%
D6	**Cleanliness drives and campaigns on the importance of SWM arranged by the city authorities can prove beneficial for spreading awareness among the residents.**		
	Strongly Disagree	45	9.0%
	Disagree	29	5.8%
	Neutral	43	8.6%
	Agree	276	55.3%
	Strongly Agree	106	21.2%
D7	**Will you be willing to pay for biodegradable bags; an amount of 10-15Rs, for carrying groceries?**		
	Strongly Disagree	53	10.6%
	Disagree	64	12.9%
	Neutral	53	10.6%
	Agree	243	48.8%
	Strongly Agree	85	17.1%
D8	**Do you approve of punishments (such as fines) for indiscriminate/random household solid waste disposal?**		
	Strongly Disagree	33	6.6%
	Disagree	38	7.6%
	Neutral	61	12.2%
	Agree	250	50.1%
	Strongly Agree	117	23.4%
D9	**Do you approve of people paying for the services provided for the management of solid waste?**		
	Strongly Disagree	44	8.9%
	Disagree	80	16.1%
	Neutral	72	14.5%
	Agree	240	48.3%
	Strongly Agree	61	12.3%
D10	**Do you approve of measures such as the container deposit scheme, i.e., an extra amount is paid by customers on the purchase of beverages which is returned on the return of the bottle?**		

	Strongly Disagree	39	7.8%
	Disagree	60	12.1%
	Neutral	84	16.9%
	Agree	241	48.5%
	Strongly Agree	73	14.7%
D11	**Will you be willing to keep a cloth bag for carrying groceries instead of plastic bags, considering that cloth bags are environmentally friendly?**		
	Strongly Disagree	30	6.0%
	Disagree	36	7.2%
	Neutral	38	7.6%
	Agree	284	57.0%
	Strongly Agree	110	22.1%
D12	**The city government should conduct regular supervision and control on illegal dumping of solid waste in the town.**		
	Strongly Disagree	33	6.6%
	Disagree	29	5.8%
	Neutral	25	5.0%
	Agree	243	48.9%
	Strongly Agree	168	33.8%

The respondents recorded good attitudes to D2, D3, D6, D11, and D12, with more than 75% recording the environmentally friendly option. The queries to which the respondents recorded medium attitudes were D5, D7, D8, D9, and D10. Finally, the queries to which the respondents recorded poor attitudes were D1 and D4; the responses validate the observation of Olukoju (2018) and Marshall & Farahbakhsh (2013) regarding the negative attribution of waste.

4.3.6. Public Practices

The respondents recorded comparatively lower levels of scores for the practices than for knowledge and attitudes. The scores for different questions on public practices are shown in Table 6.

Table 6: Public Practices

ID	SECTION V: PUBLIC PRACTICES	Count	%
E1	**Do you separate/sort solid wastes before disposal?**		
	No	342	71%
	Yes	141	29%
E2	**How do you get rid of solid wastes from home?**		
	Dumped along roadsides/gully	94	20%

	Dumped in the backyard with sacs	71	15%
	Dumped in the collection points designated by the authorities	310	65%
E3	**How often do you dispose waste from your home?**		
	Every alternate day	199	40%
	Everyday	216	44%
	Once a week	81	16%
E4	**What specific solid waste item is present in the greatest amount in your household generated solid waste?**		
	Kitchen waste	330	67%
	Others (Pampers, Dirt, Debris)	76	15%
	Paper waste	21	4%
	Plastic Waste	67	14%
E5	**Do you make any deliberate effort to keep your house surroundings clean?**		
	No	80	16%
	Yes	414	84%
E6	**What do you prefer for carrying purchased items during grocery shopping?**		
	Cloth bag	241	48%
	Plastic Bag	51	10%
	Whichever is available, No preference	205	41%
E7	**Do you separately collect and sell recyclable items of solid waste to junkyards or street hawkers?**		
	No	239	48%
	Yes	257	52%
E8	**Do you reuse plastic bottles and glass bottles in your house?**		
	No	195	39%
	Yes	301	61%
E9	**Do you burn solid waste?**		
	No	351	70%
	Yes	148	30%

The respondents recorded good scores for E3 (daily or alternate waste disposal from homes considering the utility of fresh waste) and E5 (making deliberate efforts to keep house surroundings clean). The queries to which respondents expressed medium levels were E1, E2, E7, E8, and E9. There

were some stark observations in the public practices as the people, despite having good knowledge about open burning and indiscriminate disposal of waste, were performing the same. The respondents showed poor levels of scores to E6 (regarding their preference for carrying groceries); the same observation was also noticed during the existing situation assessment, thus pointing towards an alarming situation, especially considering the fact that Pakistan has been declared as one of the eight hotspots with regard to SWM. The statistically significant associations using the Chi-Square test and Cramer V are shown in Table 7.

Table 7: Statistical Test Results of KAP associations (Only the associations with Cramer V > 0.15 included)

Sr. No	Question	Demographic and Existing Situation Factors	Result	Chi Square Value	Cramer's V
1	Knowledge about 3Rs (C2)	Age (A2)	Age groups vs (C2) 18-30 (72% aware) 31-45 (58% aware) 46-60 (38% aware)	27.18	0.234
2	Willingness to pay for the services (B10)	Education (A3)	Education vs (B10) Bachelor's degree & above (60% willing) Diploma (50%) Primary & Secondary Education (44%) No Education (40%)	39.85	0.201
3	Choice of media type (B11)	Education (A3)	Education vs (B11) Bachelor's degree & above (83% prefer social media) Diploma (65% prefer social media) Secondary Education (65% prefer social media) Primary Education (52% prefer TV & 43% social media) No Education (74% prefer TV)	80.48	0.233
4	Knowledge about 3Rs (C2)	Education (A3)	Education vs (C2) Bachelor's degree & above (78% aware) Diploma (50% aware) Secondary Education (54% aware) Primary Education or No Education (33% aware)	64.83	0.361
5	Knowledge about compost preparation(C6)	Education (A3)	Education vs (C6) Bachelor's degree and above (84% aware) Diploma & Secondary (72% aware) Primary Education (61% aware) No Education (45% aware)	28.38	0.241
6	Waste collection method (B1)	Household Income (A5)	Household Income vs (B1)	158.17	0.398

			High Income (64% with Door-to-Door collection) Upper Middle Income (56% with Door-to-Door collection) Lower Middle Income (58% with Door-to-Door collection) Low Income (39% with Door to Door collection & 34% with no services)		
7	Waste Collection frequency (B3)	Household Income (A5)	<u>Household Income vs (B3)</u> High Income (83% with daily/alternate day collection) Upper Middle Income (72% with daily/alternate day collection) Lower Middle Income (67% with daily/alternate day collection; 24% with once-a-week collection) Low Income (60% with daily/alternate day collection; 25% with once-a-week collection and 15% with no collection)	217.59	0.380
8	Willingness to pay for the services (B10)	Household Income (A5)	<u>Household Income vs (B10)</u> High Income (64% willing) Upper Middle Income (60% willing) Lower Middle Income (50% willing) Low Income (39% willing)	162.08	0.405
9	Knowledge about 3Rs (C2)	Household Income (A5)	<u>Household Income vs (C2)</u> High Income (79% aware) Upper and Lower Middle Income (67% aware) Low Income (44% aware)	90.28	0.425
10	Knowledge about compost preparation(C6)	Household Income (A5)	<u>Household Income vs (C6)</u> High Income (87% aware) Upper and Lower Middle Income (78% aware) Lower Income (56% aware)	84.77	0.415
11	Solid waste is anything without value (D1)	Household Income (A5)	<u>Household Income vs (D1)</u> High Income (50% disagreeing) Upper Middle Income (42% disagreeing) Lower Middle Income (38% disagreeing) Low Income (24% disagreeing)	296.72	0.387
12	Knowledge about compost preparation(C6)	Employed Household Members (A7)	<u>Employed Household Members vs (C6)</u> Respondents with two household members employed were most aware (85%), however no clear trend	22.40	0.213
13	Amount currently paid for services (B9)	SWM Entity (B2)	<u>SWM Entity vs (B9)</u> Max respondents served by Private Entity were not paying (71%)	98.28	0.430

14	Knowledge about compost preparation(C6)	SWM Entity (B2)	SWM Entity vs (C6) Private Company (78% aware) Public Company (76% aware) Informal (75% aware)	113.48	0.544
15	Waste sorting at home Useful (C8)	SWM Entity (B2)	SWM Entity vs (C8) Private Company (74% aware) Public Company (81% aware) Informal (80% aware)	117.46	0.550
16	Do you sort waste before disposal (E2)	SWM Entity (B2)	SWM Entity vs (E2) Private Company (29% sorting) Public Company (35% sorting) Informal (25% sorting)	103.26	0.469
17	Method of waste riddance from home (E3)	SWM Entity (B2)	SWM Entity vs (E3) Private Company (78% aware) Public Company (76% aware) Informal (75% aware)	104.99	0.358
18	Willingness to pay for the services (B10)	Satisfaction with the services (B6)	Satisfaction with Services vs Willingness to Pay 56% satisfied respondents were willing to pay 50% unsatisfied respondents were willing to pay	13.41	0.165
19	Knowledge about 3Rs (C2)	Willingness to Pay (B10)	Willingness to Pay vs (C2) 56% willing to pay and 48% unwilling to pay were aware	24.18	0.222

Although the public knowledge scores observed in the survey were good, the same was not evident in the attitudes and practices scores. Moreover, most youth undertook the survey, and the scores of higher age groups were comparatively lower. A negative perception of waste was recorded in the attitudes section result. There is a strong need to include SWM topics in curriculums at all levels of education. Furthermore, there is a strong need for awareness campaigns utilizing social media and TV, as evidenced by the media choices of the respondents. Considering the performance of waste management entities, it is evident that the PPP mode of operations is more socially acceptable, and the government should facilitate public entities in this regard. Considering the level of threat Pakistan is facing, it is paramount that the importance of SWM is realized, and measures are undertaken to reduce waste from a public perspective, such as awareness and knowledge about the 3Rs, harmful impacts of open burning and dumping are taken on war footings.

4.4. Economic Component

4.4.1. Cost Benefit Analysis

The Cost-Benefit Analysis (CBA) was initially planned for both the waste management entities (PPP and the Public entity) of the Wah Cantt but considering the delays in obtaining the permissions required for getting the desired data, the CBA was limited to the PPP who facilitated the access to the facility and permission to conduct interviews with the personnel. However, the CBA performed for

the PPP gives a fair idea about the system's overall health where investment has been made for the waste treatment facility and the under researched potential of solid waste through recyclables.

Operational and management (O&M) costs were considered only when calculating the costs; a market survey was performed to estimate the recyclables' worth to determine the revenue. Certain assumptions were made during the analysis where the exact data was unavailable. The PPP runs a waste treatment facility named "Zero Waste Recycling Facility," in which the primary treatment options are a Material Recovery Facility and Pellet Line; the Composting option is available, but it's in the developing stage and is facing challenges due to waste segregation not being practiced which leads to low-quality compost. The MRF starts functioning once the door-to-door collected waste is transported to the facility by 1400hrs, and after that, it typically runs for 5 hours till 1900hrs. The pellet line, however, typically runs during the day. Moreover, the PPP offers door-to-door waste collection to 12000 households and collects waste from skips and tubs. In addition to those mentioned above, the PPP separately collects the city's yard waste and carries out street cleaning.

The PPP employs a total of 80 people for their complete operations. A fixed salary of PKR 30,000 is provided, with free meals and residence offered to those who belong to far-flung areas. A total of 10 garbage trucks are owned by PPP, consisting of Trolleys, Dumper trucks, Compactor, and Mini trucks, all diesel operated. Four garbage trucks are used for door-to-door waste collection purposes, while 6 are used for collection from skips and tubs. During the site visits, it was observed that one odd garbage truck conducts two trips per day, whereas the rest of the garbage trucks conduct one trip per day. The average fuel consumption for garbage collection trucks is 1.8 L/ km (Nguyen & Wilson, 2010). Garbage/waste trucks consume much more fuel than regular trucks as they halt at appointed stops on the collection routes, leading to increased fuel consumption. The selected value from the literature was compared with the insights obtained from discussions with the drivers of the garbage trucks, according to whom they refill the tank on almost every 3rd day, which is approximately in line with the selected value from the literature. The average trip distance for each garbage collection truck is around 15km. Moreover, the MRF and Pellet line are electrically operated, with MRF requiring 5kWh, whereas the pellet line comprises 4 units, i.e., Shredding, Hammering, Mixing, and Pelleting, with each unit requiring 50kWh. Additionally, the pellet line requires approximately 1000kg of Molasses per month. The cost calculation based on the discussion mentioned above is shown in Table 8.

Table 8: Cost Calculation

Sr. No	Item Description	Calculation	Cost/Month (PKR)
1.	Salaries	30,000/worker/month x 80 workers	24,00,000
2.	Fuel Expenditure	1.8 Litre/km x 15 km x 10 trucks x 30 days x 255.38*	20,68,578

3.	Electricity Expenses **	4 Rooms at the Facility with one Ceiling and one Tubelight in each room = 4 Ceiling Fans and 4 Tubelights Each Ceiling Fan (80 Watts), Each Tubelight (50 Watts) Ceiling Fans and Tubelights are assumed to run for the whole month with 24 hours and 12 hours, respectively. *4 Ceiling Fans x 80 Watts/Fan x 26 working days/ month x 24 hours/day = 199.68 kWh / month* *4 Tubelights x 50 Watts/ Tubelight x 26 working days/ month x 12 hours/day = 62.4 kWh/ month* *MRF requires 5kWh and is functional from 1400-1900hrs* *5kWh x 5 hours/day x 26 working days/ month = 650 kWh/month* Pellet Line is typically operated in such a way that 2 components of the setup run at a time i.e., Shredding and Hammering or Mixing and Pelleting with each component requiring 50kWh *100 kWh x 2 hours/day x 26 working days/ month = 5200 kWh/ month* Total kWh consumed in a month = 199.68 + 62.4 + 650 + 5200 = 6112.08 kWh / month x 35.22 PKR / kWh	2,15,267
	Total Costs		**46,83,845**

**Diesel rate in Pakistan on 16th December 2024*

*** Electricity rates are calculated through the Electricity Consumption Calculator of National Energy Efficiency & Conservation Authority: Ministry of Energy (Power Division)*

The revenue collection was performed regarding the waste audit and the quantity of waste that arrived at the MRF and Pellet Line. The compost prepared at the facility was usually given away free of cost due to substandard quality, so it doesn't contribute to the revenue generation however if waste segregation is practiced and the existing 3 bins system is replaced with 2 bin system, that could also result in the production of a quality compost that could be sold to increase the revenue. The recyclables' worth was obtained from the PPP officials, and the junkyards' market survey was used to validate the information. Currently, the PPP doesn't charge any charges for the services from the public, so the calculations have been done for the existing conditions where no fee is charged and also for an assumed scenario where a nominal fee of PKR 100 is charged after educating the public on the importance of efficient SWM. The detailed calculations for the revenue are shown in Table 9.

Table 9: Revenue Calculation

Sr. No	Item Description	Percentage %	Rate (PKR/kg)	Calculations	Revenue/Month (PKR)
1.	Ferrous Waste	0.55	135	0.55/100 x 12000* x 135 x 30	2,67,300
2.	Paper Waste	4.26	60	4.26/100 x 12000 x 60 x 30	9,20,160
3.	Aluminium	0.22	150	0.22/100 x 12000 x 150 x 30	1,18,800
4.	Recyclable Plastic Waste	4.65	95	4.65/100 x 12000 x 95 x 30	15, 90,300

5.	Glass & Bottles	1.06	5	1.06/100 x 12000 x 5 x 30	19,080
6.	Leather & Rubber	2.30	50	2.30/100 x 12000 x 50 x 30	4,14,000
7.	Pellets*	-	70	340** x 70 x 30	7,14,000
8.	Monthly Fee	-	100	(20/100 x 479,000 x 100)***	95,80,000
				Total Revenue	**40,43,340 (Without Monthly Fee)** **1,36,23,340 (With Monthly fee)**

**16 tons of waste arrives at the MRF, 25% of which is diverted to dumpsite, so the remaining is 12 tons or 12,000kg*

***The pellet production depends on the weight of leaves and the moisture; 1ton of yard typically produces 200kg of pellets, as the weight of yard waste that arrives at the site is 1.7 tons, so pellet production is assumed as 340kg*

****The state area's population is roughly 20% of the Wah Cantt population*

So, the revenue generated is approximately 6,80,000 PKR, less than the O&M costs. However, it is pertinent to mention that it doesn't include the price of compost, which can generate significant revenue if produced and sold to nearby farmers. Also, currently, the system is not running at its full capacity in view of the limited waste of the State Area and no access to the waste of the public area. Granting access of public entity's collected waste to PPP is expected to increase revenue. Moreover, a nominal monthly fee, currently not charged, can significantly improve the economic health of the municipalities and aid them in setting up more sophisticated/advanced treatment options that require higher capital costs. Even if the municipality charges the households based on economic classification, such that low-income households are offered free services and middle-income and high-income households are charged the suggested amount, the revenue generated will be much more than the O&M costs. It is also evident that if the municipalities make the initial investment (capital), the set-up could recover the investment quickly.

4.5. Environmental Component

4.5.1. Environmental Life Cycle Assessment

Pakistan has been identified as one of the eight countries where more than half of the projected increase in global population up to 2050 will be concentrated (UNEP, 2024b). Consequently, municipal waste generation will also increase significantly, thus requiring sustainable management. Currently, the waste generated is either open-dumped or burnt, which harms the environment and public health. As a result, there is a strong need for the implementation of environmentally friendly waste treatment options (Ayub et al., 2024). The Environmental Life Cycle Assessment (E-LCA) has been recognized as a suitable and reliable approach for evaluating the potential environmental impacts of the various waste management/treatment options, such as landfilling, recycling, and Refuse Derived Fuel (RDF) (Mulya et al., 2022). The E-LCA results can assist the relevant stakeholders, such as policymakers and municipal authorities, in the selection of environmentally friendly waste management options.

In view of the importance of the adoption of environmentally sustainable waste treatment options, a software-based analysis of the shortlisted waste management/treatment options was carried out using SimaPro software. The waste treatment options shortlisted based on the WACS result and

experts' opinions as discussed in the 4.1.4. Experts Opinion on the Waste Treatment Options section and provided below:

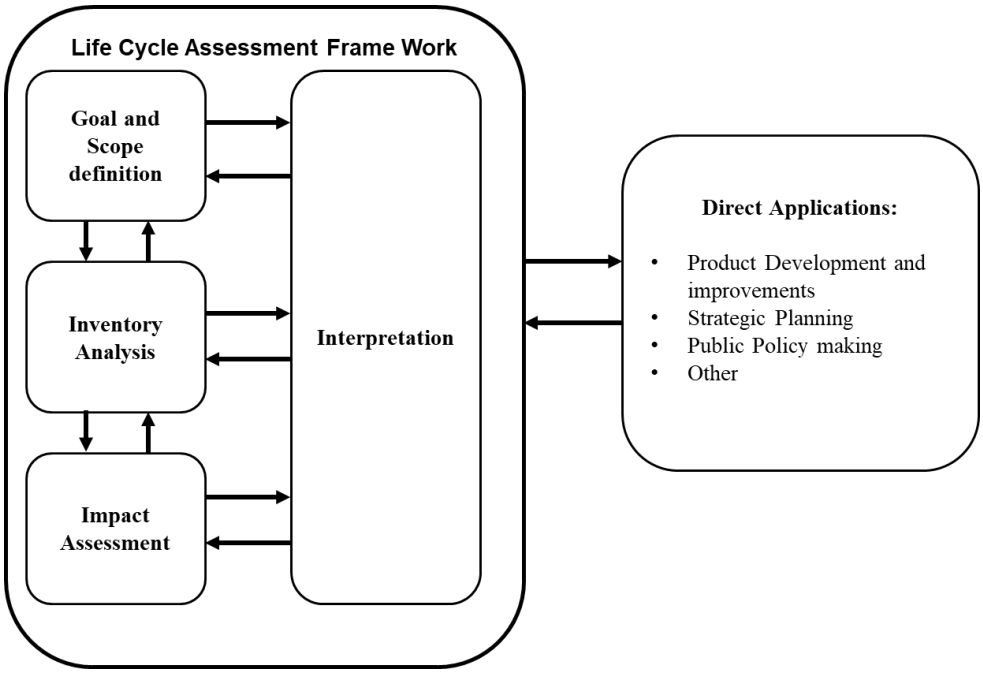
- Open dumping (Existing Practice)
- Sanitary Landfill
- Incineration
- Recycling/Material Recovery Facility
- Composting
- Anaerobic Digestion

Different scenarios were assumed in view of the waste composition determined as a result of WACS, which had already been discussed at length in the results of Objective 1. The scenarios selected for the software simulation are provided below, along with a brief description:

- S0_Open Dumping: 100% of waste being diverted to the dumpsite.
- S1_Recycling + Open Dumping: 12.19% of the recyclables will be transferred to recycling and 87.81% to the dumpsite.
- S2_Recycling + Sanitary Landfill: 12.19% of the recyclables will be transferred to recycling and 87.81% to the sanitary landfill.
- S3_Anaerobic Digestion + Recycling + Sanitary Landfill: 53.1% of the organic fraction will be sent to anaerobic digestion, 12.19% of the recyclables to recycling, and 34.71% will be sent to the sanitary landfill.
- S4_Composting + Recycling + Sanitary Landfill: 53.1% of the organic fraction will be sent to composting, 12.19% of the recyclables to recycling, and 34.71% will be sent to the sanitary landfill.
- S5_Recycling + Incineration: 12.19% of the recyclables will be recovered, and the remaining 87.81% will be transferred to incineration.

The E-LCA process is guided by ISO 14040 and 14044, and the framework entailing the salient steps of the process is provided in Figure 16*: Life Cycle Assessment Framework*.

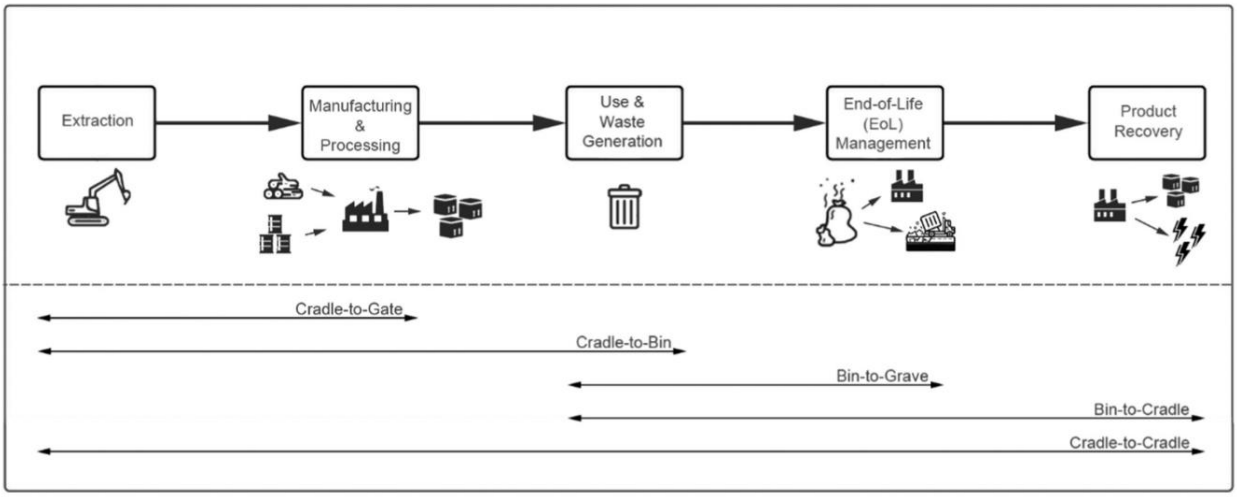
Figure 16: Life Cycle Assessment Framework



4.5.2. Goal and Scope

The goal of the study was to carry out a comparative evaluation of the environmental impacts of different scenarios based on various combinations of the shortlisted waste treatment options. The system boundary under consideration was "Bin to Grave." The various system boundaries used in LCA studies are shown in Figure 17. Moreover, the evaluation was conducted in terms of mid-point categories. The Functional Unit used for the study was "one ton of Municipal Solid Waste (MSW)".

Figure 17: System Boundaries



Source: Mulya et al. (2022).

4.5.3. Life Cycle Inventory / Inventory Analysis

The data utilized for the inventory stage primarily comprised of the waste compositions determined in WACS, and the fuel expenses of the vehicles were determined by taking the average of the two

routes currently used by the vehicles for transporting the waste to the dumpsite. The two currently utilized routes were tracked and are shown in Figure 18 and Figure 19.

Figure 18: Route 1 (9.29 km)

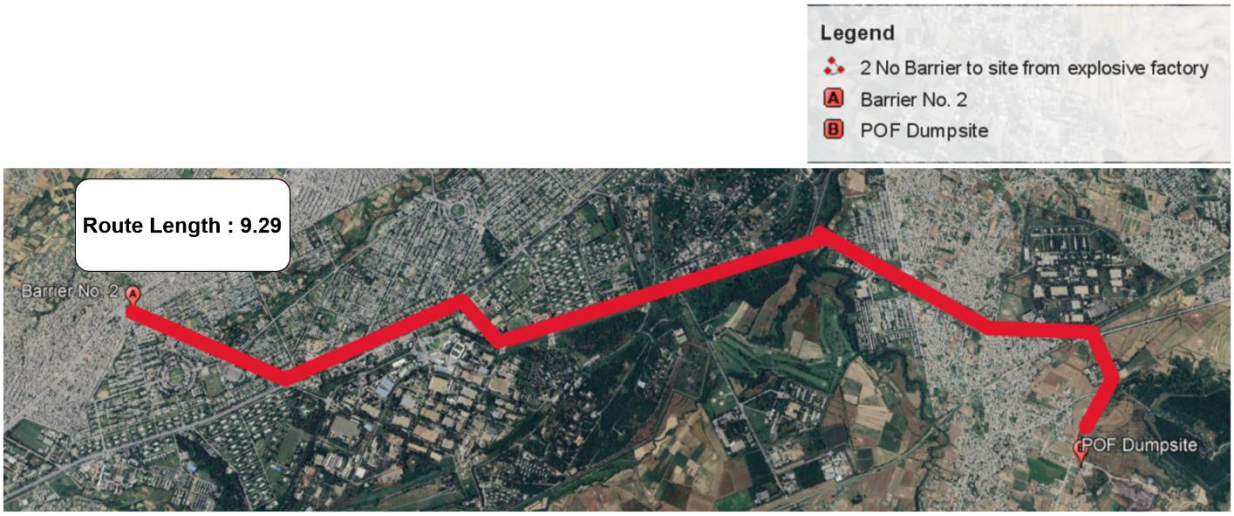


Figure 19: Route 2 (11.6 km)

The other data related to the different treatment options, such as electricity and fuel requirements, were obtained from secondary sources such as published literature.

4.5.4. Life Cycle Impact Assessment

The scenarios were assessed using the ReCiPe Midpoint (H) method, and 13 midpoint categories were considered for the comparative evaluation of the different scenarios. The 13 midpoint categories are provided in Table 10: Mid-Point Categories Description.

Table 10: Mid-Point Categories Description

Sr No.	Impact Category	Label	Unit
1	Global Warming	GWP	Kg CO_2 eq.

2	Stratospheric Ozone Depletion	SOD	Kg CFC_{11} eq.
3	Ozone Formation	OF	Kg NO_x eq.
4	Fine Particulate Matter Formation	PM	Kg $PM_{2.5}$ eq.
5	Terrestrial Acidification	TA	Kg SO_2 eq.
6	Freshwater Eutrophication	FEn	Kg P eq.
7	Marine Eutrophication	MEn	Kg N eq.
8	Freshwater Ecotoxicity	FEy	Kg 1,4 - DCB
9	Marine Ecotoxicity	MEy	Kg 1,4 - DCB
10	Human Carcinogenic Toxicity	HCT	Kg 1,4 - DCB
11	Human Non-Carcinogenic Toxicity	HNCT	Kg 1,4 - DCB
12	Land Use	LU	M^2a crop eq.
13	Water Consumption	WC	M^3

The results of the 13 Mid-Point Categories for the different scenarios are shown in Table 11.

Table 11: Mid-Point Impact Category Results for Different Scenarios

Sr No.	Impact Category	Unit	S0	S1	S2	S3	S4	S5
1	GWP	Kg CO_2 eq.	963	1.20E+03	585	303	311	457
2	SOD	Kg CFC_{11} eq.	0	1.57E-06	8.06E-05	0.000231	0.000237	0.000456
3	OF	Kg NO_x eq.	0.000864	0.0486	0.0913	0.074	0.076	0.29
4	PM	Kg $PM_{2.5}$ eq.	0.00804	0.0175	0.0397	0.0468	0.0478	0.0559
5	TA	Kg SO_2 eq.	0.0277	0.0444	0.0943	0.118	0.123	0.145
6	FEn	Kg P eq.	2.82	2.48	2.48	0.989	0.992	0.11
7	MEn	Kg N eq.	0.896	0.787	0.855	0.34	0.43	0.00991
8	FEy	Kg 1,4 - DCB	480	422	422	167	174	250
9	MEy	Kg 1,4 - DCB	635	558	558	222	231	326
10	HCT	Kg 1,4 - DCB	9.69	12.4	12	10.9	11.4	75.7
11	HNCT	Kg 1,4 - DCB	1.11E+04	9.78E+03	9.83E+03	3.90E+03	3.98E+03	4.80E+03
12	LU	M^2a crop eq.	3.14	1.49	1.75	1.34	1.34	0.928
13	WC	M^3	0	0.004	0.004	-1.27	-1.19	0.961

A diagrammatic description of the results is also presented in Figure 16.

4.5.5. Interpretation

The software analysis of the scenarios showed that Scenarios 3 and 4, i.e., Anaerobic Digestion + Recycling + Sanitary Landfill and Composting + Recycling + Sanitary Landfill, were the top two environmentally friendly waste treatment options, respectively. A limited sensitivity analysis was

performed by checking for both the operating routes; however, the results were still the same about environmentally friendly scenarios, i.e., S3 and S4 performed better. Further analysis can be performed by altering the percentages of the recyclable fractions and combustible fractions, but this was not performed due to the limited time required for the research project. However, the findings were more or less in line with the literature. Of note, it is worth mentioning that although Anaerobic Digestion performed comparatively better than Composting, the literature suggests that Anaerobic Digestion is a complicated process and requires more skill and resources to install and operate; therefore, scenario S4, which includes Composting Alongside Recycling and Sanitary Landfill should be preferred in developing countries like Pakistan.

CONCLUSIONS

The following conclusions were drawn after the investigation of the different components of the Municipal SWM (MSWM):

1. Organic fraction, comprising kitchen and yard waste, was the predominant component (55% of the Total Average Daily Waste) of the solid waste generated, consequently establishing a need and a potential venue for the respective treatment options such as Composting and Anaerobic Digestion.
2. The number of recyclables in the door-to-door collected waste was significantly more than that collected from the skips and tubs, thus establishing an active role of the IS (IS) and signifying the need for and importance of the door-to-door waste collection.
3. Significant amounts of plastic bags were present (5.68% of the Total Average Daily Waste), necessitating their discontinuation due to their harmful environmental effects.
4. According to the experts, the shortlisted waste treatment options were sanitary landfill, material recovery facility/recycling, composting, anaerobic digestion, and incineration. Moreover, composting was preferred over anaerobic digestion due to the required resources and user-friendliness.
5. Two waste management entities are currently functional in the city i.e., PPP and the public entity, with PPP offering door-to-door waste collection, conventional collection of waste from the skips and tubs, and separate collection of yard waste from the city. Moreover, the PPP has also set up a treatment facility comprising a weighing bridge, MRF, Compost Line, and Pellet Line. In contrast, the public entity dumps all the waste into the dumpsite.
6. The weighing bridge is only used to record the incoming weights, and there was no limitation on the quantity of waste coming in or on the concept of a gate fee/ tipping fee.
7. Compared to the public entity, the PPP demonstrated a regular and uniform waste collection schedule throughout the year due to its vested interest in the requirement of fresh waste for the different parts of the treatment facility.
8. Compost quality was not the desired quality due to waste segregation not being practiced despite the provision of separate bins for waste components at the source, thus showing that the existing practice of providing three bins is ineffective.
9. Despite being willing and interested in managing some of the waste (from commercial areas) collected and brought to the dumpsite, an environmentally friendly measure, the PPP was not allowed access to it, pointing to the bureaucratic barriers in the system.
10. Door-to-door waste collection was seen as a better input material for the treatment options than waste collected from the skips and tubs, necessitating a maximum possible transition to door-to-door waste collection across the city, a point also stressed by the PPP.
11. The provision of waste collection bins was more prevalent in high-income areas than in low-income areas.
12. Open dumping, open burning, and IS activity were more prevalent in the areas managed by the public entity. Moreover, PPP waste management was significantly better than the public entity.
13. The Informal Sector is a reality and plays a crucial and positive role in the city's waste management, offering services to 37% of the residents. However, an almost non-existent

level of integration was observed between the formal and IS of SWM. The key issues related to the integration were the following: i) Lack of controlled access of IS to waste, ii) repression/neglection/collusion of IS, iii) No database of waste pickers and street hawkers, iv) Discrimination and lack of public acceptance of IS, v) No facilitation on part of the authorities to the IS, vi) Prevalent child labor, vii) Lack of informed initiatives, viii) No fines on open burning, ix) Absence of recycling-friendly policies, x) Absence of NGOs supporting IS rights, xi) No usage of PPEs, xii) Limited access to health-care facilities, xiii) Exploitation of IS at the hands of recycling industries, and xiv) Lack of financial support to IS.

14. The level of public knowledge (90%) was considerably higher than the public attitudes (73.3%) and practices (64.7%). Moreover, there was a negative perception of waste and less knowledge about waste management essentials like the 3Rs and waste segregation. Additionally, the younger respondents were more knowledgeable than the higher age groups, and the respondents with higher qualifications were more willing to pay than those with lower levels of education. Social media and TV were the preferred media choices among higher education and lower education, respectively. The respondents reported a higher satisfaction level served by the PPP, also corroborated by a higher reported waste collection frequency of the PPP as compared to that of public entity. However, the respondents served by PPP were comparatively less willing to pay than those served by public entity. The level of practices regarding open burning and plastic usage was alarming, considering the environmental threat faced by Pakistan.
15. The CBA showed significant revenue-earning potential, with revenues only 6,00,000PKR short of the O&M costs; moreover, revenues could significantly increase if waste segregation is practiced so that compost can also be sold to interested parties also, if the treatment options are run at full potential by incorporating the public entity's managed waste as well.
16. Scenarios 3 and 4, i.e., Anaerobic Digestion + Recycling + Sanitary Landfill and Composting + Recycling + Sanitary Landfill were the top two environmentally friendly treatment options. Considering the advanced technology setup required for anaerobic digestion, as highlighted by the experts' survey, the existing PPP setup is the best possible environmentally waste management scenario for Pakistan.

RECOMMENDATIONS

The following is recommended, given the findings of the research study:

1. The PPP mode of operations with basic treatment options such as MRF and Composting is the way forward as it results in regular and frequent collection of waste with the vested interest of the PPP in better quality of waste as opposed to the conventional management of waste by public entities with all the waste directed towards dumpsite in which there is no incentive for regular and frequent collection. Also, the above-mentioned treatment options are self-sustainable and would not require significant government funding other than the initial capital cost, which too can be met over time through the revenues or, at most, a minimal monthly fee.
2. The existing waste collection method from the skips and tubs needs to be replaced to a maximum level with door-to-door waste collection to limit the IS's uncontrolled access. Moreover, open burning incidents and the presence of plastic bags that residents use to dump their waste in nearby skips and tubs, which cause harmful environmental effects, can also be limited if timely door-to-door waste collection is ensured. Additionally, door-to-door waste collection benefits the PPP's interests, thus helping them to be self-sustainable.
3. The government must install the weighing bridge at the dumpsite and introduce a tipping or gate fee to encourage recycling initiatives.
4. The existing three-bin placement at the residences must be replaced with two bins for dry waste and wet waste, which is more user-friendly and will yield better waste management results.
5. To reduce open burning incidents, the government must ensure better waste management facilities (placement of bins and frequent collection) for low-income areas where the less privileged, including IS stakeholders, reside.
6. To facilitate the integration of the formal and IS of SWM, the following must be ensured by the government:
    a. Provision of controlled access to waste at the transfer or treatment facility,
    b. Registration of waste pickers and street hawkers by mandating the junkyard owners to buy only from registered waste pickers and street hawkers,
    c. Provision of larger containers/ sacs, and bicycles to the registered IS members in order to encourage their registration and also facilitate them
    d. The IS stakeholders, including the junkyard officials and staff, registered street hawkers, and registered waste pickers, should be given ID cards and vests for their identification,
    e. A crackdown against the unregistered waste pickers and street hawkers, and also those IS members who are engaged in open burning and accessing waste other than the transfer stations or treatment facilities or dumpsite,
    f. The activities of IS (except those engaged in open burning) should be commended, and regular stats about them and their positive role regarding the reduction of burden on dumpsites should be published on different media options to facilitate their recognition and mitigate the discrimination,

g. The IS members in particular, the junkyard owners should be informed and consulted on key policy issues,
h. Regulation of recyclable prices to limit the IS exploitation at the hands of recycling industries,
i. Mandating wearing of masks for IS members,
j. Affordable healthcare facilities to IS,
k. Encouraging the parents of underage children engaged in waste picking to enroll them in government schools by offering them exclusive controlled access to waste; the children should be taught religious education (their clear preference) along with the basic school curriculum to tackle child labor,
l. Provision of affordable loan options to registered IS members, and
m. Encourage the formation of unions at least for the junkyards.

7. SWM essentials should be included in the curriculum at every level of education, from primary to graduation, regardless of specialization. Moreover, social media and TV (the most preferred media choices) should be used to spread awareness and communicate information. Awareness walks and campaigns should be regularly held. Furthermore, imposing heavy fines on indiscriminate waste disposal and open burning is paramount.

Composting and MRF, environmentally friendly waste treatment options, should be mandated for every municipality, considering the level of environmental threat Pakistan is facing due to the mismanagement of solid waste.

REFERENCES

Ali, M., Marvuglia, A., Geng, Y., Chaudhry, N., & Khokhar, S. (2018). Energy based carbon footprinting of household SWM scenarios in Pakistan. *Resources, Conservation and Recycling*, *131*(April), 283–296. https://doi.org/10.1016/j.resconrec.2017.10.011.

Almasi, A., Mohammadi, M., Azizi, A., Berizi, Z., Shamsi, K., Shahbazi, A., & Mosavi, S. A. (2019). Assessing the knowledge, attitude and practice of the kermanshahi women towards reducing, recycling and reusing of municipal solid waste. *Resources, Conservation and Recycling*, *141*(October 2018), 329–338. https://doi.org/10.1016/j.resconrec.2018.10.017.

Amir, S., Asghar, G. F., Batool, R., Nawaz, S., Zahid, A., and Kanwal, A. (2023). A comprehensive waste audit analysis for assessing recycling opportunities in the University Simra Nawaz. *Journal of Xi'an Shiyou University, 66*(09), *09*, 33–47. https://doi.org/10.5281/zenodo.8343484.

Aryal, M., & Adhikary, S. (2024). SWM practices and challenges in Besisahar Municipality, Nepal. *PLoS ONE*, *19*(3 March), 1–23. https://doi.org/10.1371/journal.pone.0292758.

ASTM (American Society for Testing and Materials). (2016, June 06). *Standard test method for determination of the composition of unprocessed municipal solid waste*. https://www.astm.org/d5231-92r16.html

Atta, U., Hussain, M., & Malik, R. N. (2020). Environmental impact assessment of municipal SWM value chain: A case study from Pakistan. *Waste Management and Research*, *38*(12), 1379–1388. https://doi.org/10.1177/0734242X20942595.

Ayub, F., Naqvi, S. L. H., Naqvi, S. H. Z., Yasar, A., Akram, R., & Niamat, J. (2024). Assessment of municipal SWM practices in urban centers of Pakistan: A comprehensive review. *Environmental Protection Research*, *4*(1), 87–103. https://doi.org/10.37256/epr.4120244086.

Baawain, M. S., Al-Mamun, A., Omidvarborna, H., Al-Mujaini, F., & Choudri, B. S. (2019). Residents' concerns and attitudes towards municipal SWM: Opportunities for improved management. *International Journal of Environment and Waste Management*, *24*(1), 93–106. https://doi.org/10.1504/IJEWM.2019.100663

Baba-Nalikant, M., Abdullah, N. A., Husin, M. H., Syed-Mohamad, S. M., Mohamad Saleh, M. S., & Rahim, A. A. (2023). The relationship between knowledge, attitudes, values, and technology in promoting zero-waste pro-environmental behaviour in a zero-waste campus framework. *Recycling*, *8*(2). https://doi.org/10.3390/recycling8020040

Batool, S. A., & Ch, M. N. (2009). Municipal SWM in Lahore City District, Pakistan. *Waste Management*, *29*(6), 1971–1981. https://doi.org/10.1016/j.wasman.2008.12.016

Batool, S. A., & Chuadhry, M. N. (2009). The impact of municipal solid waste treatment methods on greenhouse gas emissions in Lahore, Pakistan. *Waste Management*, *29*(1), 63–69. https://doi.org/10.1016/j.wasman.2008.01.013

Bilal, S., Qasim, S., Rana, A., & Haseeb, Z. (2022). Waste amount characterization survey of municipal solid waste generated in Sahiwal, Punjab-Pakistan. *International Journal of Agriculture & Environmental Science*, *9*(4), 12–20. https://doi.org/10.14445/23942568/ijaes-v9i4p103

Debrah, J. K., Vidal, D. G., & Dinis, M. A. P. (2021). Raising awareness on SWM through formal education for sustainability: A developing countries evidence review. *Recycling*, *6*(1), 1–21. https://doi.org/10.3390/recycling6010006

Desa, A., Ba'yah Abd Kadir, N., & Yusooff, F. (2011). A study on the knowledge, attitudes, awareness status and behaviour concerning SWM. *Procedia - Social and Behavioral Sciences*, *18*, 643–648. https://doi.org/10.1016/j.sbspro.2011.05.095

Desa, A., Kadir, N. B. A., & Yusooff, F. (2012). Waste education and awareness strategy: Towards SWM (SWM) program at UKM. *Procedia - Social and Behavioral Sciences*, *59*, 47–50. https://doi.org/10.1016/j.sbspro.2012.09.244

Devadoss, P. S., Pariatamby, A., Bhatti, M. S., Chenayah, S., & Shahul Hamid, F. (2021). Strategies for reducing greenhouse gas emissions from municipal SWM in Pakistan. *Waste Management and Research*, *39*(7), 914–927. https://doi.org/10.1177/0734242X20983927

Ejaz, N., & Janjua, N. S. (2012). SWM issues in small towns of developing world: A case study of Taxila City. *International Journal of Environmental Science and Development*, *3*(2), 167–171. https://doi.org/10.7763/ijesd.2012.v3.209

Eshete, H., Desalegn, A., & Tigu, F. (2023). Knowledge, attitudes and practices on household SWM and associated factors in Gelemso town, Ethiopia. *PLoS ONE*, *18*(2 February), 1–13. https://doi.org/10.1371/journal.pone.0278181

Ferronato, N., Guisbert Lizarazu, E. G., Valencia Vargas, D. J., Pasinetti, R., & Torretta, V. (2022). Investigation on the solid waste recyclers' perspective in La Paz, Bolivia. *Habitat International*, *123*(May 2021), 102542. https://doi.org/10.1016/j.habitatint.2022.102542

Gall, M., Wiener, M., Chagas de Oliveira, C., Lang, R. W., & Hansen, E. G. (2020). Building a circular plastics economy with informal waste pickers: Recyclate quality, business model, and societal impacts. *Resources, Conservation and Recycling*, *156*(January), 104685. https://doi.org/10.1016/j.resconrec.2020.104685

Gunsilius, E., Spies, S., García-Cortes, S., Medina, M., Dias, S., Scheinberg, A., ... & Ruiz, S. (2011). Recovering resources, creating opportunities. *Integrating the informal sector into solid waste management.* The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

Haider, A., Amber, A., Ammara, S., Saleem Mahrukh, K., & Aisha, B. (2015). Knowledge, perception and attitude of common people towards SWM: A case study of Lahore, Pakistan. *International Research Journal of Environment Sciences*, *4*(3), 2319–1414.

Hamzah, N., Marzuki, N. S., Baharudin, F., Rahim, N. L., Mohd Kamil, N. A. F., Akbar, N. A., & Mohd Zin, N. S. (2022, January). Knowledge, attitudes, awareness and practices on household hazardous waste disposal among undergraduate students in Selangor, Malaysia. In *Proceedings of the 3rd International Conference on Green Environmental Engineering and Technology: IConGEET 2021, Penang, Malaysia* (pp. 103-113). Singapore: Springer Nature Singapore.

Iqbal, A., Abdullah, Y., Nizami, A. S., Sultan, I. A., & Sharif, F. (2022). Assessment of SWM system in Pakistan and sustainable model from environmental and economic perspective. *Sustainability (Switzerland)*, *14*(19). https://doi.org/10.3390/su141912680

Iqbal, J. (2021). Best practices of solid waste management at Institute of Business Management, Karachi, Pakistan. *Journal of Sustainability Perspectives*, *1*, 193-199.

Kamran, A., Chaudhry, M. N., & Batool, S. A. (2016). Role of the IS in recycling waste in Eastern Lahore. *Polish Journal of Environmental Studies*, *24*(2), 537–543.

Kiran, K. G., Kini, S., K., R., P., S. N., & Kiran, N. U. (2015). KAP study of solid waste disposal of households in Kuttar & Manjanadi Panchayath covered under gramaskhema programme of K.S. Hegde Medical Academy. *Journal of Health and Allied Sciences NU*, *05*(03), 029–035. https://doi.org/10.1055/s-0040-1703908

Laor, P., Suma, Y., Keawdounglek, V., Hongtong, A., Apidechkul, T., & Pasukphun, N. (2018). Knowledge, attitude and practice of municipal SWM among highland residents in Northern Thailand. *Journal of Health Research*, *32*(2), 123–131. https://doi.org/10.1108/JHR-01-2018-013

Lema, G., Mesfun, M. G., Eshete, A., & Abdeta, G. (2019). Assessment of status of SWM in Asella Town, Ethiopia. *BMC Public Health*, *19*(1), 1–7. https://doi.org/10.1186/s12889-019-7551-1

Limon, M. R., & Villarino, C. B. J. (2020). Knowledge, attitudes and practices on household food waste: Bases for formulation of a recycling system. *Global Journal of Environmental Science and Management*, *6*(3), 323–340. https://doi.org/10.22034/gjesm.2020.03.04

Loizia, P., Voukkali, I., Zorpas, A. A., Navarro Pedreño, J., Chatziparaskeva, G., Inglezakis, V. J., Vardopoulos, I., & Doula, M. (2021). Measuring the level of environmental performance in insular areas, through key performed indicators, in the framework of waste strategy development. *Science of the Total Environment*, *753*, 141974. https://doi.org/10.1016/j.scitotenv.2020.141974

Majeed, A., Batool, S. A., & Chaudhry, M. N. (2017). Informal waste management in the developing world: economic contribution through integration with the formal sector. *Waste and Biomass Valorization*, *8*(3), 679–694. https://doi.org/10.1007/s12649-016-9648-4

Majeed, A., Batool, S. A., & Chaudhry, M. N. (2018). Environmental quantification of the existing waste management system in a developing world municipality using EaseTech: The case of Bahawalpur, Pakistan. *Sustainability (Switzerland)*, *10*(7). https://doi.org/10.3390/su10072424

Marshall, R. E., & Farahbakhsh, K. (2013). Systems approaches to integrated SWM in developing countries. *Waste Management*, *33*(4), 988–1003. https://doi.org/10.1016/j.wasman.2012.12.023

Merker, R., Schwarz, W., Schreiber, H., & Zlateva, T. (2015). Thinking in systems. *AEU-International Journal of Electronics and Communications*, *69*(1), 151-152.

Misganaw, A. (2023). Assessment of potential environmental impacts and sustainable management of municipal solid waste using the DPSIRO framework: A case study of Bahir Dar, Ethiopia. *Environmental Monitoring and Assessment*, *195*(2). https://doi.org/10.1007/s10661-023-10929-z

Molina, R. A., & Catan, I. (2021). SWM awareness and practices among senior high school students in a state college in Zamboanga City, Philippines. *Aquademia*, *5*(1), ep21001. https://doi.org/10.21601/aquademia/9579

Muhammad, S., Kauser, F., Raza, A., Hassan, I., Janjua, S., Peshawar, T., Kauser, F., Raza, A., Hassan, I., Janjua, S., & Author, C. (2023). Application of system dynamics for the sustainable management of solid. *International Journal of Environmental Issues*, *22*.

Mulya, K. S., Zhou, J., Phuang, Z. X., Laner, D., & Woon, K. S. (2022). A systematic review of life cycle assessment of SWM: Methodological trends and prospects. *Science of the Total Environment*, *831*(March), 154903. https://doi.org/10.1016/j.scitotenv.2022.154903

Nadeem, K., Shahzad, S., Hassan, A., Usman Younus, M., Asad Ali Gillani, S., & Farhan, K. (2023). Municipal solid waste generation and its compositional assessment for efficient and sustainable infrastructure planning in an intermediate city of Pakistan. *Environmental Technology (United Kingdom)*, *44*(21), 3196–3214. https://doi.org/10.1080/09593330.2022.2054370

Nguyen, T. T. T., & Wilson, B. G. (2010). Fuel consumption estimation for kerbside municipal solid waste (MSW) collection activities. *Waste Management and Research*, *28*(4), 289–297. https://doi.org/10.1177/0734242X09337656

Olukoju, A. (2018). "Filthy rich" and "dirt poor:" social and cultural dimensions of SWM (SWM) in Lagos. *Social Dynamics*, *44*(1), 88–106. https://doi.org/10.1080/02533952.2018.1430475

Seadon, J. K. (2010). Sustainable waste management systems. *Journal of Cleaner Production*, *18*(16–17), 1639–1651. https://doi.org/10.1016/j.jclepro.2010.07.009

Sigcha, E., Sucozhañay, D., Cabrera, F., Pacheco, G., & Vanegas, P. (2024). Applying social life cycle assessment in the informal recycling sector: Understanding challenges and limitations. *Waste Management*, *181*(September 2023), 20–33. https://doi.org/10.1016/j.wasman.2024.03.029

UNEP (United Nations Environment Programme). (2024a). *Beyond an age of waste Turning rubbish into a resource*. UNEP, Nairobi.

UNEP (United Nations Environment Programme). (2024b). *Beyond an age of waste Turning rubbish into a resource*. UNEP, Nairobi.

Velis, C. A., Wilson, D. C., Rocca, O., Smith, S. R., Mavropoulos, A., & Cheeseman, C. R. (2012). An analytical framework and tool ('InteRa') for integrating the informal recycling sector in waste and resource management systems in developing countries. *Waste Management and Research*, *30*(9 SUPPL.1), 43–66. https://doi.org/10.1177/0734242X12454934

W., Carabias, V., Winistoerfer, H., & Stuecheli, A. (1999). Social aspects of public waste management in Switzerland. *Waste Management*, *19*(6), 417–425. https://doi.org/10.1016/S0963-9969(99)00087-3

Wang, H., Liu, X., Wang, N., Zhang, K., Wang, F., Zhang, S., Wang, R., Zheng, P., & Matsushita, M. (2020). Key factors influencing public awareness of household solid waste recycling in urban areas of China: A case study. *Resources, Conservation and Recycling*, *158*(October 2019), 104813. https://doi.org/10.1016/j.resconrec.2020.104813

Yıldız-Geyhan, E., Altun-Çiftçioğlu, G. A., & Kadırgan, M. A. N. (2017). Social life cycle assessment of different packaging waste collection system. *Resources, Conservation and Recycling*, *124*(April), 1–12. https://doi.org/10.1016/j.resconrec.2017.04.003

Zarate, M. A., Slotnick, J., & Ramos, M. (2008). Capacity building in rural Guatemala by implementing a SWM program. *Waste Management*, *28*(12), 2542–2551. https://doi.org/10.1016/j.wasman.2007.10.016

Zia, A., Batool, S. A., Chauhdry, M. N., & Munir, S. (2017). Influence of income level and seasons on quantity and composition of municipal solid waste: A case study of the capital city of Pakistan. *Sustainability (Switzerland)*, *9*(9), 1–13. https://doi.org/10.3390/su9091568

Zia, U. U. R., Rashid, T. U., Ali, M., & Awan, W. N. (2020). Techno-economic assessment of energy generation through municipal solid waste: a case study for small/medium size districts in Pakistan. *Waste Disposal & Sustainable Energy*, *2*(4), 337-350.

APPENDICES

Technical Component

WACS data

Appendix Tab. 1 Descriptive Statistics of Total Waste. S.D. = Standard Deviation

Category	Label	Total Waste (kg)	Average Daily Waste (ADW, kg)	S.D. of ADW	% of Total Average Daily Waste
Kitchen Waste	KW	2973.05	42.47214	12.83256	55.30%
Hazardous Waste	HW	88.3	1.261429	1.942249	1.64%
Textile Waste	TW	244.75	3.496429	1.625082	4.55%
Ferrous Waste	FW	23.35	0.467	0.616906	0.61%
Paper Waste	PW	175.15	2.502143	2.197849	3.26%
Aluminum	Al	13.1	0.187143	0.192182	0.24%
Ceramics and Stones	CS	222.3	3.175714	3.341914	4.13%
Yard Waste	YW	51.48	0.735429	0.551406	0.96%
Plastic Waste (Recyclable)	PLW-R	205.9	2.941429	1.25262	3.83%
Plastic Waste (Non-Recyclable: LDPE & PS)	PLW-NR	305.15	4.359286	2.058797	5.68%
Miscellaneous	Misc	904.25	12.91786	7.024393	16.82%
Wood Waste	WW	24.625	0.351786	0.365305	0.46%
Glass and Bottle	GB	65.025	0.928929	0.695035	1.21%
Leather & Rubber	LR	70.85	1.012143	0.937018	1.32%

Formal-IS integration interfaces

Appendix Tab. 2 Interface A- Between the IS and the Formal SWM Sector, modified after (Velis et al., 2012)

A	Group of Interventions	Intervention Points	Specific Actions	Explanation
Formal SWM Interface	Access to waste	Access to waste	Legal recognition of the right of pickers to collect waste, sell the materials separately and keep the income	A legal right to access waste and obtain ownership while accepting related obligations.
			Waste Pickers to have controlled access to waste at collection points	Granting controlled access to waste pickers at collection points under agreed conditions
			Waste pickers to have controlled access to waste at transfer stations, disposal sites or other waste facilities	Granting controlled access to the waste pickers at transfer stations and disposal sites under agreed conditions
		Role in Formal SWM system	Inclusion into/ integration with formal SWM sector collection	Mechanisms such as memoranda of association or formal contracts for primary collection between the municipalities/cantonments/formal authorities and the IS
			Inclusion into/integration with SWM sector transport	Memoranda of association or formal contracts to provide services

A	Group of Interventions	Intervention Points	Specific Actions	Explanation
			Official role in providing recycling within formal SWM system	Itinerant buyers, street hawkers, and specifically junkyards- all involved in sorting and collecting recyclables- become the official recyclers. They are facilitated by engaging and involving them through a simple contracting process and provision of low-cost loans, as stated by (Gunsilius et al., 2011)
	Recognizing role of IS in SWM	Socio-political context towards IS	• Change in attitudes • Institutionalizing policies so that the IS is not affected by political changes	Transitioning from repression, neglect, and collusion to active cooperation, formally supported by policies, between the formal and ISs.
			Acknowledging the role and contribution of the IS by advertising the benefits provided by the Informal System	Measuring the recycling rates and publishing the cost savings because of avoided collection and disposal
		Promote inclusivity	Involve all stakeholders in SWM planning	Recognition of the IS as an essential stakeholder
			Institutionalize inclusivity of the IS	Establishing committees responsible for conducting regular surveys and feedback mechanisms
	Protecting public health and environment	Protecting public health and environment	Control sorting in the street and ensure that residues after sorting are disposed of poorly	Rights bring responsibility; therefore, waste pickers should agree to simple control measures strictly enforced by the authorities. Also, the authorities regularly dispose off the remains.
			Regulate handling of hazardous wastes (Hospital waste in particular)	Hazardous waste in general and hospital waste in particular is disposed of regularly, and the activity of the IS is forbidden
			Regular collection and disposal of waste from the marginalized areas where the IS resides	Promotion of regular collection and disposal of solid waste from low-income/marginalized areas, especially where the scavengers, street hawkers reside
	Strengthening Interfaces	Improving formal SWM/Informal Interface	Smoothing takeover of solid waste from households to the IS	The street hawkers can collect the solid waste from the street hawkers smoothly
			Smooth transition from IS to city authorities for secondary transport and disposal	The IS collects waste from door to door and then hands it over to city authorities at an agreed place. Allowing recyclers time and space to collect the recyclables at the transfer or disposal sites without interfering with the safe operation
		National policies improving formal/informal	National policies/legislation/strategies to promote recycling	Priced disposal/introduction of gate fee so that the authorities are encouraged to promote and facilitate recycling incentives and measures

Appendix Tab. 3 Interface B- Between the IS and the materials and value chain, modified after (Velis et al., 2012)

B	Group of Interventions	Intervention Points	Specific Actions	Explanation
Material & Value Chain	Improving the quality of materials	Improving the quality of the source materials	Segregation at the household level	Measures like separation of wet waste (organic) from dry waste or segregation of waste into separate containers such as glass, plastics, and others
			Agreements between the waste generators and the IS	Individual agreements of the waste generators, i.e., households with the IS stakeholders such as scavengers, itinerant buyers/street hawkers for the collection of waste/recyclables

B	Group of Interventions	Intervention Points	Specific Actions	Explanation
	Adding value to secondary raw materials/products sold	Increasing quantity available for sale	Use of larger containers by waste collectors	Provision of larger and more durable sacks to the waste collectors as larger quantities generally attract higher prices
			Use of wheeled containers by waste collectors	Use of hand trolleys, tri-cycle carts, and other modified forms of bicycles & motorcycles
			Provision of spacious storage spaces	Provision of larger spaces with protection from rain to the individual recyclers for the storage of recyclables
		Reprocessing	Segregating collected materials into distinct categories	Segregation of plastics based on various types such as PET, HDPE, etc., paper & cardboard into low-quality and high-quality and disassembling computers
			Washing/removing contaminants	Cleaning the recyclables to rid them of contaminants
			Densification to lower transportation costs	Shredding of the plastics to densify the product, thus reducing the transportation fares
			Processing to intermediate products	Melting, extruding, and pelletizing the plastic
			Making final products	Final products such as paper, plastics, and glass
	Improving linkages along value chain	Improving linkages along value chain	Enhancing relation between the IS and recycling industries	The junkyards have direct links/contacts with the recycling industries or large consumer companies
			Agreements with middlemen	The arrangements where the junkyards rely on the middlemen who collect various recyclables from the junkyards and then sell them to the larger recycling industries or consumer companies
			Bypassing intermediaries	The waste pickers sell various recyclables directly to the recycling industries

Appendix Tab. 4 Interface C- Between the IS and the Society, modified after (Velis et al., 2012)

C	Group of Interventions	Intervention Points	Specific Actions	Explanation
Societal Interface	Aiding recognition and acceptance of the IS	Supporting legal identification	Provision of National identity Cards & other legal documents such as birth certificates	Providing the scavengers, street hawkers, and junkyard owners with the relevant legal documents to facilitate their integration into the formal economy
			Right to vote, right to property, and duty to pay taxes	The IS stakeholders have the right to cast votes and purchase properties. The right to vote is essential, and considering the significant population of the IS stakeholders, their votes can make a difference and allocation of this right can prove to be a significant step in their empowerment. Paying taxes is an essential matter for the integration of the IS into the formal economy. The government can facilitate the registration process by providing an umbrella registration option to junkyards through which they can register on behalf of the street hawkers and scavengers who are in contact with them so that individual registration is not required
			Acknowledging waste picking as a profession	National-level recognition of the occupation in the National Register of Occupations or Professions
		Encouraging acknowledgement and	Issuance of Identity Cards	The provision of cards and uniforms which can help relevant people identify them during their work hours

C	Group of Interventions	Intervention Points	Specific Actions	Explanation
			Issuance of uniforms	
		Involving the public in the intervention	Awareness campaigns	Public awareness campaigns to facilitate the acceptance of the IS. The IS sector members especially the scavengers and street hawkers, face social discrimination at the hands of the public, so the awareness sessions can aid in bettering the situation
			Inclusion of public representatives in the planning phases	The involvement of public representatives in the planning and implementation of the interventions can aid in the societal acceptance of the interventions
			Encouraging source separation	Educating the public on the importance of sorting at the household level and encouraging them to segregate the waste into distinct categories such as dry waste and wet waste or paper, plastic, and organic
	Measures involving children, education, and gender equality & inclusion	Promoting child education	Child labour elimination	Not allowing children below the age of 18 according to national and international guidelines (International Labour Organization)
			Rewards for attending school	Children who are involved in scavenging are encouraged to attend school and offered rewards such as allowing controlled access at the disposal sites on the condition that they will enroll in schools
			Allocation of separate schools for IS members' children or some quota in schools	The IS sector members' children are offered quota in schools, or specific schools are set up for them where they have access to basic education
		Encouraging gender equality and inclusivity	Special initiatives targeting women's inclusion in IS	Facilitating the inclusion of women in the IS related activities which can aid in their empowerment
			Provision of loans	Provision of easily accessible loans to women
	Occupational and health safety	Ensuring a safe working environment	Use of PPEs	Use of gloves and masks to ensure safe working environment
			Access to healthcare facilities	The provision of easily accessible and insured health facilities to IS members
			Provisions for separate sorting of hazardous waste	Adequately trained individuals are allowed access and permission to sort hazardous waste

Appendix Tab. 5 Interface O- Empowerment/Enabling actions, modified after (Velis et al., 2012)

O	Group of Interventions	Intervention Points	Specific Actions	Explanation
Enabling Actions	ISs' Structure	ISs organization	Unions or Associations	Organization of people in the form of unions and associations empowers them with more bargaining capacity
		Participation of NGOs'	NGO's engagement in organizing IS	NGOs facilitate the formation of IS unions & associations or represent their interests
		Role of National Forums	Initiating dialogues/discussions on IS rights	Presence of national forums or networks that advocate for the rights of the IS
	Financial Viability	Economic Sustainability	Provision of accessible loans/Microcredit	Since the IS needs to purchase items before selling them at a profit, easily accessible loans are crucial for meeting its needs and helping to establish small businesses

			Limiting the market dependability through various measures such as fixed prices	The IS collects and sells recyclables to companies or industries, with sale prices dependent on market demand. To reduce the sector's vulnerability to fluctuating market conditions and prevent exploitation, measures such as implementing fixed prices are necessary
	Capacity Building	Capacity Enhancement and Development	Training courses	Educating the IS about bookkeeping, data collection, rules and regulations, buyer requirements, OHS aspects, and technical awareness such as sorting importance & how to improve product quality. Since the IS involves a business potential and many junkyards follow business models, improving their entrepreneurial skills will aid in their personal development
		Documentation	Maintaining a database of personnel, costs, and earnings	Data keeping aids in better regulation of IS and implementation of SOPs. Lack of record-keeping has been identified as a major cause of failure in many case studies

Appendix Tab. 6 Current & Required Assessments of the IS Interface with the Formal SWM Sector

A - SWM (SWM) sector interface (Total Score: Current = 0.24, Required = 0.89)

Group of interventions	Intervention points	Specific actions	Level of consideration		Average count per intervention		Average count per group		Justification
			Current	Required	Current	Required	Current	Required	
Access to waste	Access to waste	Legal recognition of the right of pickers to collect waste, sell the materials separately, and keep the income	I=0	K=1	0.17	0.67	0.09	0.67	During the interactions with the stakeholders such as scavengers, street hawkers, and representatives of the formal authorities, it was found that no such mechanism exists, and the formal authorities, i.e., POF, specifically didn't desire ISs' involvement. This intervention should be treated as a key action to facilitate the integration of the IS with the formal sector, as it will help the formal authorities fulfill their duties with lesser resources and help the IS fulfill their financial needs.
		Waste pickers to have controlled access to waste at collection points	I=0	I=0					Currently, the IS has no controlled access to waste collection points, and considering the socio-demographic factors of the informal stakeholders and the number of resources required to ensure controlled access, the required level of consideration is recommended as I=0.
		Waste pickers to have controlled access to waste at transfer stations, disposal sites or other waste facilities	C=0.5	K=1					There is a medium level of consideration for this intervention point as the waste pickers are allowed controlled access by the PPP, but the Cantonment Board Wah is providing no access. The required level of intervention should be treated as key action as it is comparatively easier to provide controlled access at the transfer

A - SWM (SWM) sector interface (Total Score: Current = 0.24, Required = 0.89)

Group of interventions	Intervention points	Specific actions	Level of consideration		Average count per intervention		Average count per group		Justification
			Current	Required	Current	Required	Current	Required	
									stations and disposal points. Moreover, it will also facilitate the recycling sector.
	Role in formal SWM system	Inclusion into/ integration with formal SWM sector collection	I=0	K=1	0	0.67			Currently, the IS has no formal role in providing waste collection services; however, this should be treated as a key action to facilitate integration and ensure sustainable usage of resources.
		Inclusion into/integration with formal SWM sector transport	I=0	I=0					Currently, there is no formal role of the IS in the provision of waste transportation services, and because the infrastructure for transport is already available with the formal sector, involving the IS can result in undue inconvenience; therefore, the status quo is recommended for the future.
		Official role in providing recycling within formal SWM system	I=0	K=1					Currently, the IS has no official role in the recycling process, and junkyard owners have complained about the undue fines and penalties imposed by the Cantonment Board Wah. This intervention point is recommended to be treated as key action to promote the recycling culture.
Recognising role of IS in SWM	Socio-political context towards IS	Change in attitudes Institutionalizing policies so that the IS is not affected by the political changes	I=0	K=1	0	1	0	0.88	Currently, the IS is repressed, neglected, and colluded. Also, there are no policies regarding their role and participation. There should be active participation between both well supported by formal policies, so the required consideration level is K=1.
		Acknowledging the role and contribution of IS by advertising the benefits provided by the Informal System	I=0	K=1					Currently, the role and contribution of the IS are not encouraged; however, to facilitate the integration process, this intervention should be treated as a key action.
	Promote inclusivity	Involve all stakeholders in SWM planning	I=0	C=0.5	0	0.75			Currently, the IS is not treated as a key stakeholder and is thus not consulted at all. It is recommended that considering the socio-demographic aspects of the IS, at least a medium level of consideration is allocated to this specific action where the junkyard owners (who collect the waste from itinerant buyers and scavengers) are involved

A - SWM (SWM) sector interface (Total Score: Current = 0.24, Required = 0.89)

Group of interventions	Intervention points	Specific actions	Level of consideration		Average count per intervention		Average count per group		Justification
			Current	Required	Current	Required	Current	Required	
									or the involvement in decisions which directly impacts them such as fines, taxes, and penalties.
		Institutionalise inclusivity of IS	I=0	K=1					Currently, there is no mechanism of feedback that is important for integrating the informal system with the formal system, so this specific action is recommended to be allocated key consideration.
Protecting public health and environment	Protecting public health and environment	Control sorting in the street and ensure that residues after sorting are disposed of properly	C=0.5	K=1	0.5	1	0.5	1	Currently, control sorting is not being practiced in the streets and open burning is being done; however, in most areas, the authorities are properly disposing of the remains. For better integration, strict fines should be imposed against open burning; therefore, this specific action is recommended to be allocated key consideration.
		Regulate handling of hazardous wastes (Hospital waste in particular)	C=0.5	K=1					Currently, it was observed that only the hospital waste was being collected separately, and the activity of informal was minimal around the collection points where the hospital waste was being dumped; however, at the dumpsite, it was observed that the IS had access to the hazardous waste after the authorities had dumped it. Considering its sensitivity, this specific action must be treated as a key action.
		Regular collection and disposal of the waste from the marginalized areas where IS resides	C=0.5	K=1					The solid waste from marginalized areas such as Jamilabad and Shadman Town, where the scavengers and street hawkers were residing due to low rents, was collected and disposed of less frequently than in other areas. This specific action is recommended to be treated as a key action by regular and frequent solid waste collection.
Strengthening interfaces	Improving formal SWM/informal interface	Smoothing takes over of solid waste from households to the IS	K=1	K=1	0.75	1	0.38	1	The street hawkers were collecting waste from the households, and the status quo is recommended for better integration of informal and formal sectors.
		Smooth transition from IS to city authorities for secondary	C=0.5	K=1					During the field visits, it was observed that the PPP was allowing recyclers to collect and purchase it at a reasonable cost; however, the CBW was not providing any controlled

A - SWM (SWM) sector interface (Total Score: Current = 0.24, Required = 0.89)								
Group of interventions	**Intervention points**	**Specific actions**	**Level of consideration**		**Average count per intervention**		**Average count per group**		**Justification**
			Current	**Required**	**Current**	**Required**	**Current**	**Required**	
		transport and disposal							access, as previously mentioned. Moreover, the IS collected the waste in some areas, such as Gulshan Colony. After recovering the recyclables, it was disposed of in the specified bins, but other than this, no such mechanism was found where the IS was handing over the waste to the city authorities at agreed/specified place. This specific action should be treated as a key action and allocated K=1.
	National policies improving formal state/informal interface	National policies/legislation/strategies to promote recycling	I=0	K=1	0	1			Currently, there are no specific policies or strategies to promote recycling. No measures that will encourage recycling are being taken. Measures such as priced disposal or gate fees can be introduced where the trucks are weighed and priced so that authorities are forced to take measures promoting recycling. During the field visits, it was observed that the truck is regularly weighed when it arrives at the disposal site, but there is no restriction over the quantity of waste. This specific action must be treated as a key action.

Appendix Tab. 7 Current and Required Assessments of the IS Interface with the Material and Value Chain

B - Materials and value chain interface (Total Score: Current = 0.52, Required = 0.73)									
Group of interventions	**Intervention points**	**Specific actions**	**Level of consideration**		**Average count per intervention**		**Average count per group**		**Justification**
			Current	**Required**	**Current**	**Required**	**Current**	**Required**	
Improving quality of materials for recycling at their source	Improving quality of the source materials / reducing contamination	Segregation at the household level	C=0.5	K=1	0.75	1	0.75	1	During the field visits and interactions with the city authorities, it was found that the POF had provided three different dustbins for the collection of glass, plastics, and others; however, after inspection, it was found that it contained mixed waste. As per the PPP representative interview, providing two dustbins, i.e., wet waste and dry waste, is more practical and will be more convenient in convincing the residents to sort the waste into only two categories. The CBW did not provide any sorting/segregation option; therefore, a medium-level

									consideration was currently being allocated. For future reference, key considerations must be allocated to facilitate better integration.
		Agreements of the waste generators with the IS	K=1	K=1					During the survey, it was found that there were individual agreements between households and itinerant buyers and scavengers regarding waste collection. However, PPP, which had set up a material recovery facility and was collecting waste door to door, desired that households hand over all the waste to them to meet their operational expenditures. The status quo is recommended to be followed for better integration of both sectors.
Adding value to the secondary raw materials/ products sold	Increasing quantity available for sale	Use of larger containers by waste collectors	C=0.5	K=1	0.67	1	0.49	0.85	The street hawkers used sacs with a capacity to hold recyclables of up to 100kg, but the authorities provided no assistance or facilitation. If the recycling culture has to be promoted and the waste arriving at the dumpsite has to be minimized, then facilitation needs to be provided.
		Use of wheeled containers by waste collectors	C=0.5	K=1					The street hawkers and itinerant buyers used bicycles and motorcycles with sacs to collect the recyclables. In some cases, these bicycles were provided to street hawkers by the junkyard owners free of cost on a day-to-day basis, but again, there was no facilitation provided by the city authorities to the IS, which must be provided to promote recycling.
		Provision of spacious storage spaces	K=1	K=1					The junkyard owners had spacious spaces for the storage of materials. These spaces were registered with the city authorities. The status quo is recommended for future reference as well.
	Reprocessing	Segregating collected materials into distinct categories	K=1	K=1	0.3	0.7			Currently, the IS and PPP segregate waste into distinct categories. PPP has set up a material recovery facility that sells recyclables to recyclers. The status quo is recommended for the future as well.
		Washing/ removing contaminants	I=0	K=1					Currently, as per the interaction with the scavengers, street hawkers, and junkyard owners, no washing is done; however, doing so can aid in improving the quality of the recyclables.
		Densification to lower the	C=0.5	C=0.5					Currently, the junkyard owners do not shred the plastics themselves; however, they sell them to nearby

		transportation costs							facilities with shredding options; the junkyard owners refer to them as godowns. The junkyard owners mentioned that they faced the issue of high transportation fares since the motorways enforced load limits. So if the junkyards could shred the waste themselves, they could lower the prices. However, since it would require high capital, the existing status is also recommended for the future
		Processing to intermediate product	I=0	C=0.5					Mechanisms involving the processing of recyclables to intermediate categories weren't found in the study area; however, at least a medium-level consideration is required for this specific action. Encouraging and facilitating the private sector to set up such facilities is necessary so that these recyclables aren't transported to Lahore for recycling.
		Making final products	I=0	C=0.5					Currently, the recyclables are transported to far located areas such as Lahore, and no local manufacturing of products from the waste is done, which results in high transportation costs for the IS stakeholders; therefore, at least a medium level of consideration in this regard is required to facilitate the private sector to set up such facilities.
Improving linkages along value chain	Improving linkages along value chain	Enhancing relation between the IS and recycling industries	C=0.5	C=0.5	0.33	0.33	0.33	0.33	Currently, the junkyards that are located in central locations, such as near Grand Trunk road, have direct links with the recycling industries and larger consumer industries; however, the junkyards, which were comparatively smaller and located away from Grand Trunk road, did not have direct contacts. Since all the stakeholders seemed fine with the present arrangement, the status quo is also recommended for the future.
		Agreements with middlemen	C=0.5	C=0.5					During the field visits, it was observed that such arrangements did exist where the smaller junkyards relied on these middlemen since these junkyards, owing to the relatively smaller size of their setups, didn't fulfill the needs of larger companies. Hence, the middlemen collected the recyclables from various junkyards and then sold it to the larger recycling industries or consumer companies.

		Bypassing intermediaries	I=0	I=0					The waste pickers were collecting mixed waste and selling it mixed to the junkyards at the rate of PKR 60 per kg or sorting it before selling it according to each recyclable type. The collection was very limited in scale, considering the industry needs, as they were collecting a maximum load of 100kg, and selling it to junkyards was convenient. The same arrangements, considering the waste pickers' existing capacity, are recommended for the future.

Appendix Tab. 8 Current and Required Assessments of the IS Interface with the Society

C - Social aspects and interfaces with society (Total Score: Current = 0.13, Required = 0.65)

Group of interventions	Intervention points	Specific actions	Level of consideration		Average count per intervention		Average count per group		Justification
			Current	Reqd	Current	Reqd	Current	Reqd	
Aiding recognition and acceptance of the IS	Supporting legal identification	Provision of National identity Cards & other legal documents such as birth certificates	C=0.5	K=1	0.33	1	0.22	0.94	The survey determined that a significant proportion of scavengers, street hawkers, and junkyard owners were Afghan refugees, and many respondents did not have any legal documents. The IS stakeholders from Pakistan had access to legal documents. The issue of Afghan refugees is complex as it involves aspects of national security. However, to better integrate IS stakeholders into the formal economy, legal documents are essential. Therefore, better regulation of Afghan refugees is required.
		Right to vote, right to property, and duty to pay taxes	C=0.5	K=1					Currently, the IS members who hail from Pakistan have the right to vote and property, but the Afghani refugees are not entitled to these rights. None of the IS members interviewed during the study were paying taxes; thus, their contribution to the formal economy was non-existent. Considering the socio-demographic aspects of the IS, facilitating them in the registration process is recommended to integrate them into the formal economy.
		Acknowledging waste picking as a profession	I=0	K=1					Waste picking currently is not enlisted in the national list of occupations, and for facilitating the integration of both sectors, it is recommended that waste picking is recognized as an occupation on the national level.
	Encouraging acknowle	Issuance of Identity Cards	I=0	K=1	0	1			During the survey, it was found that none of the IS members had ID cards or uniforms. The residential societies

	dgement and acceptance	Provision of uniforms	I=0	K=1					provided the waste pickers with uniforms and ID cards, a concept that can be easily implemented and will help the authorities, such as the POF, to ensure security issues if the IS members are issued ID cards and uniforms.
	Involving the public in the intervention	Awareness campaigns	C=0.5	K=1	0.33	0.83			During the interactions with the POF, CBW representatives, and residents, it was found that some cleanliness drives were planned and arranged by the POF, but the campaigns to promote the acceptance of sanitary workers or IS weren't arranged. It is recommended that the public should be educated on the importance of this sector so that they don't face discrimination.
		Inclusion of public representatives in the planning phases	I=0	C=0.5					Currently, the residents are not aware of any initiatives that have been planned or are being conducted by the authorities, let alone being part of the process. It is recommended that a medium level of consideration is allocated to this action by involving the councilors or getting the public's feedback before implementing any initiative. For instance, three distinct bins (for paper, glass, organics & others) were installed as a pilot project, but those bins contained mixed waste, so instead of three bins, a two-bin concept having dry waste and wet waste, which is more convenient to the public could have been a better option.
		Encouraging source separation	C=0.5	K=1					Currently, POF has installed three bins to collect paper, glass, organics, and others, but the CBW hasn't taken such measures. It is recommended that all relevant authorities, including CBW and POF, treat this specific action as a key action.
Measures involving children, education, and gender equality & inclusion	Promoting child education	Child labour elimination	I=0	C=0.5	0	0.33	0	0.17	Child labor is prevalent currently, with many children of age even less than 10. It is recommended that at least a medium level of consideration be given, such as students under ten years old not being allowed and authorities taking strict action against their parents. It is pertinent to mention here that according to IS representatives, they engage their children in labor because they don't have any other option to make ends meet.
		Rewards for attending school	I=0	I=0					Currently, no incentives are being offered, but it is pertinent to mention that the IS representatives interviewed were not interested in education at all, no matter what the incentive. They were

									only interested in religious education. The existing state of affairs is recommended as major attitudinal shifts are currently required to convince people to send their children to school.
		Allocation of separate schools for IS member's children or some quota in schools	I=0	C=0.5					Currently, neither separate schools nor special quotas are available for the children of IS members. However, as mentioned above, the children are not interested in school education. The IS members are more interested in religious education, so mechanisms where these children are enrolled for religious education but are also taught some basic school education, satisfy the requirements of all stakeholders.
	Encouraging gender equality and inclusivity	Special initiatives targeting women's inclusion in IS	I=0	I=0	0	0			No special initiatives have been found to promote the involvement of women. During the interaction, IS members were asked whether they would be willing to engage their women if such initiatives were offered, but due to socio-cultural aspects, they were not willing. Therefore, considering the current scenarios, it is recommended that the existing situation be considered.
		Provision of loans	I=0	I=0					Currently, no such loans are available to women, but even if they were available, the IS members responded negatively to the involvement of their women owing to socio-cultural reasons.
Occupational health and safety	Ensuring safe working environment	Use of PPEs	I=0	C=0.5	0.17	0.83	0.17	0.83	During the field visits as well as WACS, it was observed that the IS members do not use PPEs when explicitly instructed to use them; they requested lenience as, according to them, they could work more efficiently without PPEs and also that they had never faced any health issues due to this work. This issue is specific to the local context, so a medium level of intervention with strict instructions on using masks is recommended.
		Access to healthcare facilities	C=0.5	K=1					Currently, the IS members who had CNICs could utilize the DHQ facilities where they had access to affordable healthcare facilities; however, the IS members opined that the availability of insured health facilities under which they can opt for private hospitals to avail better healthcare would be more suitable. The IS members who did not have CNICs were relying on locally available substandard and unqualified healthcare options. The specific action must be treated as a key action.

		Provisions for separate sorting of hazardous waste	I=0	K=1					Currently, the hazardous waste is directly transferred to the dumpsite with no sorting, and during the visit to the dumpsite it was observed that waste collectors had uncontrolled and illegal access to such waste and were selling it at high rates after sorting it. The specific action must be treated as a specific action owing to its importance about economic and environmental aspects.

Appendix Tab. 9 Current and Required Assessments of the Enabling Actions

O - Enabling actions - organisation & empowerment (Total Score: Current = 0.08, Required = 0.69)

Group of interventions	Intervention points	Specific actions	Level of consideration		Average count per intervention		Average count per group		Justification
			Current	Required	Current	Required	Current	Required	
ISs' Structure	ISs' organization	Unions or Associations	I=0	K=1	0	0.83	0	0.83	Currently, the IS sector in the study area does not have any unions; however, it is recommended for better integration that the IS sector has structured unions or associations so that they can protect their rights and avoid exploitation.
	Participation of NGOs'	NGO's engagement in organizing IS	I=0	K=1					Currently, the IS sector did not report any such NGO; moreover, as per the literature review, some NGOs, such as Green Earth Recycling, are based in Lahore, but their aims were related to promoting recycling. The presence of NGOs can aid in protecting the IS rights.
	Role of National Forums	Initiating dialogues/discussion on IS rights	I=0	C=0.5					Currently, no such forums are available on the national level. There is an international forum, " International Alliance of Waste Pickers," with representation from Pakistan, too, but no significant data was found on Pakistan on their website. An active role and representation of such forums are recommended to facilitate better integration with at least moderate consideration.
Financial viability	Economic Sustainability	Provision of accessible loans/Micro credit	I=0	C=0.5	0	0.5	0	0.5	Street hawkers rely on personal contacts to collect waste and repay households once the items are sold to junkyards. On the other hand, Junkyards operate solely on a cash basis and purchase only when they have available funds. It is recommended to provide loans on easy terms to junkyards regulated by city authorities and adhere to city regulations. Street hawkers and scavengers can also be included in this

									system, but only if registered with city authorities, which is currently not the case.
		Limiting the market dependability through various measures such as fixed prices	I=0	C=0.5					During field visits and interactions with the IS community, it was found that they have recently been facing tough situations due to a sudden decrease in the prices of recyclables, which is often dictated by market demands. Therefore, it is recommended that if fixed prices cannot be implemented, there should be regulations on the price setting of recyclables that are acceptable to both the IS community and industry representatives. This is why a medium-level consideration is recommended in this regard.
Capacity Building	Capacity Enhancement and Development	Training courses	I=0	C=0.5	0.25	0.75	0.25	0.75	Currently, no training is being provided. The lack of knowledge about various regulations is often used to impose heavy fines on them. For example, there are regulations on stagnant water in the surroundings of junkyards, which poses a malaria threat. Therefore, it is recommended that training sessions for junkyards be initially conducted. Later, similar training should be provided to scavengers and street hawkers once they are registered with the authorities.
	Documentation	Maintaining a database of personnel, costs, and earnings	C=0.5	K=1					During the survey, it was determined that the CBW maintains a database of junkyards. However, there is no record of the number of street hawkers and scavengers. Junkyards maintain records of their sales and purchases, but street hawkers and scavengers do not keep any records. It is recommended that street hawkers and scavengers be registered with the city authorities. This can be facilitated by offering incentives or instructing junkyards to purchase only from registered scavengers and street hawkers. Junkyards have personal contact with scavengers and street hawkers, who even provide bicycles for collection. Therefore, junkyards can be utilized to register scavengers and street hawkers.

Social Component

Questionnaire Pretesting with Experts' Opinion

1. **Reviewer 1 (Technical & Social Specialist in Global Waste & Resource Management affiliated with the UN Environmental Programme)**

- Section 1: You could ask how many of those household members are dependents, and how many earn a living.
- Section 2:
  Q1 Door-to-door and kerbside mean the same to me. Maybe this could be a door-to-door or communal collection point. You could also include "not applicable" for people who don't have access to a waste collection service.
- You could also include a question about whether any materials are collected separately, e.g. for recycling or composting.
- Section 3
  Q9 again this is confusing - could it be door-to-door or communal collection points?
  Section 2: Q5 is the same as Section 4 Q1 (are you satisfied?)
  Section 4 Q4 - you could add a question after to ask what media they consume most often? Is it radio, Facebook, newspapers, etc.?
- Section 4 Q7 - would people know why it's good to segregate waste, i.e. so it can be recycled and turned into something of value?
- Section 5 Q1 I found the wording a little confusing
  Section 5 - it might be good to ask if anyone collects recyclables separately?
  Q5 I would swap the question around to say "I use cotton bags instead of plastic"
- Finally, you might like to ask if they have any other comments at the end.

2. **Reviewer 2 (Independent Consultant and Expert on SWM)**

The questionnaire has a very good coverage of different topics.

- I would recommend to arrange the questions better, so they flow as a 'conversation'. This means, simpler and easier questions to come early and more discussion type and difficult to come later. In practice, all surveys are done as a conversation.
- In each of the questions, try to make things simpler for a user. Think about their understanding of the subject. If translation will be done, this can be handled.
- You may like to give a good re-think about the nature of KAP questions, at the moment these are mixed together. Knowledge is about what they know and understand. Attitude is about what they feel, perceive or think about these issues and practice how they use knowledge and attitudes in practice. Good KAP surveys have a clear thread among these, appearing in questions.
- Generally, I discouraged the use of questionnaire surveys, unless there is an expectation from the client. A combination of short KAP, with semi-structured interviews, key informants and focus group discussions will bring more information and analysis.

3. **Reviewer 3 (Assistant Professor at Department of Environmental Engineering, Institute of Environmental Sciences & Engineering, NUST)**

- The objectives of the survey firstly need to be defined in a very clear-cut manner, i.e., what exactly are you trying to figure out? Because if it would be open-ended, then even after data collection, I am afraid the findings might not be very useful.
- Because SWM includes many aspects, the system boundary (regarding SWM) needs to be clearly defined, e.g., is your focus only on collection aspect? transport included? etc.
- The questions need to be made very plain, easily understandable for the layman public.
- Currently, the term "treatment" is frequently used at places, but common public might not know various options of treatment etc. Also, I feel this term is incorrectly being used, while

the correct term could be management, or even more specifically, collection. In short, the usage of terms should be correct as well as specific.

- Some questions seem misplaced. For example, Question# 01 in Section 03 seems to be more related to KNOWLEDGE section, instead of section on ATTITUDE. Questions need to be accurately placed within the most befitting sections.
- In section 1, it is unclear whether income of an individual is being asked, or of whole family? Need to be made clearer. Also, this could be made simpler, e.g., categorizing into lower income, mid income, high income, etc.
- Questions are not adequately there to assess the existing situation. For example, what is currently the collection method in their area? (Door-to-door collection, kerbside, alley collection, etc.? Collection frequency (how many times waste is collected per week?), Is it off on sat and sun or on which days? do you use garbage (plastic) bags for your waste? average expenditure on that?
- A more comprehensive question should be there to determine the composition, e.g., the given options should cover how much plastic? how much metals? how much paper? how much organic/kitchen waste? how many pampers? etc. But a balance needs to be struck. Not too many or complicated categories should be there.
- In Practices section, there should be more questions, e.g., are you willing to pay for solid waste collection? how much can you pay? what frequency is desired? what mode of collection is desired? willing to attend community awareness session(s)? willing to separate dry and wet fractions of waste? willing to do 5-bin sorting (plastics, metals, paper, organic, others)? etc.
- It should be ensured that almost each question covers both aspects, e.g., current situation, and the willingness for future upgradation/intervention.
- Such aspects could be asked, e.g., do you face odor problems due to improper collection, mosquitoes/flies/roaches issue? cats issue? aesthetics issue?
- Q# 05 in Section is incomprehensible/ hard to understand / vague.
- Opinion on open burning should be asked.
- Question(s) should be asked to determine their knowledge about the interrelationship of mismanaged solid waste and health and environment. For example, do are they aware that open burning of their solid waste could lead to respiratory health issues? etc.
- In question 4 of Section 3, the term "media training" is vague.
- The options of many questions seem random and sometimes difficult to understand.
- Some questions have MCQ options, while some are in yes/no, etc. Wouldn't it be difficult to apply a consistent analysis method at the end to interpret results? The analysis method should be conceived beforehand so that format of questions could be finalized accordingly.

4. Reviewer 4 (Assistant Professor at School of Social Sciences & Humanities, NUST)

The questionnaire you developed is good one and is asking question about knowledge, attitude and practise about the SWM but I have few suggestions and comments regarding the development, structure of questionnaire and sample of study, which are as follows:

- You need to identify the sampling frame (e.g. area, age group, educational background etc.) for your study because it affects response. For instance, if you are collecting data from rural areas or uneducated people or less educated people then English would not be a good choice. Similarly, within Wah Cantt, I think there is some segregation of posh area /privileged or underprivileged area, therefore, you must be cautious about asking questions regarding practices etc. May be, a quick observation visit of that area is helpful in finalizing your KAP survey.
- In demographics, you can ask questions regarding their municipal area and also whether they are living in flats or houses because waste management in both cases is different.

- In current situation assessment Q2, you asked about specific solid waste item but in response of that question you combine three or more response together which is bit confusing.
- In Knowledge section Q5&6 is more of practise question, please check it, Q7 is bit confusing because i dont think so people are aware about the segregation of waste materials or maybe you can change the response rate for this question from SA-SD to know it or do not have any knowledge (check articles).
- In the attitude section, Q2 and 3 is confusing, maybe you miss any word in the sentence, Q4 can included in knowledge instead of attitude section.
- In practise section Q3 needs to be revised because I dont think that it is practised in Pakistan, Q5 is negative question which need to be revised.
- According to my knowledge and understanding you must use one type of response rate in one section e.g., in the knowledge section if you are using yes/no then all questions must by on similar pattern. Please check it.
- The response rate for attitude can be strongly agree to disagree but for practise I think you can use other e.g., aware and not aware etc.
- Before administering this questionnaire, I would suggest you develop a norm of its scoring e.g., what does high score and low score mean, which score in each section you consider high and which one as low. This exercise clarifies a lot of things regarding your questionnaire, e.g., research questions, hypotheses, and analysis.
- Lastly, Wah Cantt is very small city and of you are collecting data only from Wah Cantt then it would be difficult for you draw conclusion which can be generalizable to Pakistan. I would suggest adding any other city which is more populated, otherwise it would be difficult to get it published in a good journal.

5. **Reviewer 5 (Associate Professor in the Chemical Engineering Department at University of Wah)**
   - **Overall, the public survey is comprehensive and very useful. However, Section 3 (Public Awareness) may need to be reviewed because common people may not be familiar with the concepts of chemical waste, electronic waste, and plastic waste.**
   - **Additionally, it would be beneficial to maintain the same number of questions in each section or follow a chronological order.**
   - **Consider adding a question about the impact of cleanliness campaigns, such as banners and wall chalking, on behavior.**
6. Reviewer 6 (Lecturer in the Psychology Department at University of Wah)
   - **It is suggested that the scale be translated into Urdu language using appropriate translation protocols to enhance cultural relevance. Additionally, within the education category of your demographics, the inclusion of an option for individuals who have never attended school raises concerns regarding data collection from participants who may not possess literacy skills, particularly in English.**
   - **Within the subdomain of existing situation assessment, there is inconsistency in the response set of items/questions. Some utilize dichotomous options while others offer 3 to 4 choices. It is recommended to standardize the response set to a uniform number of options based on the intended measurement criteria and purpose. Failure to do so may hinder the ability to conduct comprehensive statistical analysis.**
7. Reviewer 7 (Associate Professor at the National Institute of Urban Infrastructure Planning, UET Peshawar)

It is a well drafted questionnaire. My observations are as follows:

- In Section 1 the respondents might not be comfortable in sharing the household income so you may add an option i.e., decline to answer. Moreover, you have already included proxy questions such as residence year of construction, whether they live in rented house or own house, and residence area which can be used to determine the approximate economic conditions. Another question about their house's constructed area can be added to further determine their economic conditions.
- In Section 2 question # 6 regarding the kind of problem they face due to improper solid waste collection, rodents may be added as an option as that is also a consequence of the poor solid waste collection.
- In Section 2 question # 7 that is regarding the amount they are paying for the SWM services, "per month" must be added to clarify the question.
- In Section 2 question # 8 which is regarding their willingness to pay for improved services is a question that is more suited in the attitudes section.
- In Section 3 question # 3 chemical waste needs to be bit clarified to facilitate the general public although the section is about determining the knowledge but still some clarification should be provided.
- In Section 4 question #1 i.e., I am satisfied with the current status of the SWM services, may be better suitable in the current situation assessment.
- In Section 4 a question i.e., whether the segregation is the job of sweepers or households can be useful to judge their attitudes.
- In Section 4, a question i.e., whether the public will be willing to pay for biodegradable bags ; an amount lets say 1PKR, may be added to judge their attitude.
- In Section 4, a question i.e., whether they will be willing to pay an extra amount for the purchase of beverages; the extra amount will be reimbursed on returning the bottle or disposing that bottle in a specified bin; a concept known as container deposit scheme to promote recycling, may be added.
- In Section 4, a question i.e., whether they will be willing to keep a cloth bag for groceries and if the residents are told that is environmentally friendly, may be added.
- Question #2 of Section 4 is not clear so that needs clarification.
- Phrasing of the questions in Section 5 may be revisited (if the statistical concerns are not an issue) in a way that e.g., I dump solid waste at designated spots and the options can be always, usually, never etc.,

8. Reviewer 8 (Consultant at UN Environment Programme; an expert in Circular Economy, Industrial Ecology, Life Cycle Assessment, and Plastic Waste Management)

- Section 1 Question #10: Not sure why residence year of construction is being asked.
- Section 2: Question about who collects waste is also important i.e., municipality, informal, private, may be added.
- Section 2: Question about whether they sort or/and sell any item or if their domestic workers do so, may be added.
- Section 3: Question#2: Explanation of the chemical waste may be added.
- Section 3: Question#4: This as stand-alone question may not be best when interpreting the answers, you may add a follow up questions and avoid the mistaking of assuming on participant's behalf. One assumption is educated are mindful and generate less or sort etc. Other assumption is educated and may earn more or have status as such that they generate more, which one are you using and if open to interpret how would you know what participant has in mind.
- Section 3: Question#9: This seems like a guiding question. Suggest for half surveys flip i.e., roadside collection is best mode compared to …….. We use this to remove bias from the surveys.

- Section 4: Question#1: How is this different from Q#5 in situational assessment. Seems a repetition.
- Section 4: Question#3: This as stand-alone question may not be best when interpreting the answers, you may want to add a follow up questions and avoid the mistake of assuming on participant's behalf. Follow up question could be based on income level, or flat vs individual house, or in a private housing society vs other.
- Section 4: Question#7: This suggest that you are assuming residents are willing to segregate, I wouldn't assume that or would ask question on efforts needed to self-sort and then ask if they are willing to sort.
- Section 5: Question#3: Dispose? This term may not be the best term to use, confusing at the moment.

9. Reviewer 9 (Lecturer in Civil Engineering Department at the University of Wah; A resident of Wah Cantt City)

- Section 1: A question about whether they live in own house or rented house may be added as the people tend to care more when they live in own house as compared to rented house.
- Section 1: Options may be given in section 1 to facilitate the respondents and subsequent analysis.
- Section 1: Suggestion to add Diploma as an option in the education options.
- Section 2: Question about who collects the waste i.e., Municipality, Cantonments, Informal or Others, may be added.

10. Reviewer 10 (Assistant Professor in Civil Engineering Department at the University of Wah)

- In the practices section instead of using Likert scale, multiple answers or yes/no option may be more useful.
- Question about Open Burning practice may be asked as I have seen people burning the solid waste lying near their houses.

Questionnaire Draft (English Version)

Knowledge Attitude Practices (KAP) Survey

Dear Participants:

This research study is part of a funded project to determine the knowledge, attitudes, and practices, with regard to the SWM, of the residents of Wah Cantt. Your honest responses will significantly enrich the caliber of our research. Be assured that these responses will be kept confidential and exclusively utilized for research purposes. Your involvement has no personal ramifications and total anonymity will be ensured. **Filling out the questionnaire survey will take 4-5 minutes and** your inputs will assist the policymakers, municipality, and cantonments' stakeholders to make informed decisions, thus ensuring the successful planning and implementation of SWM programs.

Section 1: Demographic Information:

1. **Gender:**
   A. Male
   B. Female
2. **Age:**
   A. 18-30
   B. 31-45
   C. 46-60
   D. >60
3. **Education:**
   A. No Education
   B. Primary Education
   C. Secondary Education
   D. Diploma
   E. Bachelor's degree & above
4. **Occupation:**
   A. Self Employed
   B. Government Employed
   C. Private Institute
   D. Others
5. **Total Household Income (Total Salary of all the members in your house)**: _____
6. **Household members/ Family size:**
   A. 1-3
   B. 4-6
   C. 7-9
   D. >10
7. **Household members who are employed/earning: _____**
8. **Residence Area:_____**
9. **Duration of residency in Wah Cantt:**
   A. <2 years
   B. 2-5 years
   C. 6-10 years
   D. >10 years
10. **Do you live in your own house or rented house:?**
    A. Own House
    B. Rented House

Section 2: Existing Situation Assessment:

1. **What is the current waste collection method in your area?**
   A. Door to Door collection
   B. Roadside/Kerbside collection from skips and tubs
   C. No access to waste collection services
2. **Who collects the solid waste of your house?**

A. Cantonment Board Wah/POF
B. IS (Scavengers)
C. Private Sector

3. **What is the waste collection frequency (how many times waste is collected per week)?**
   A. Daily
   B. Alternate days
   C. Once a week
   D. No Collection
4. **Is waste collected on Weekends i.e., Saturday and Sunday?**
   A. Yes
   B. No
5. **Is there any waste dumping point (dustbin, skips, tubs) near your home?**
   A. Yes
   B. No

6. **Are you satisfied with the waste management services being provided currently?**
   A. Yes B. No
7. **Do you use garbage (Plastic) bags for your waste?**
   A. Yes B. No
8. **What kind of problem do you face due to improper solid waste collection?**
   A. Odor/Smell C. Rodents
   B. Mosquitoes/flies D. Only aesthetics issue
9. **How much are you currently paying per month for the SWM services?**
   A. Rs _____ B. Not paying
10. **Are you willing to pay for the improved SWM services such as timely door-to-door collection, cleaning of streets, etc.?**
   A. Yes C. No, I can't afford it.
   B. No, It's the duty of the city authority/government.
11. **What media type do you use the most?**
   A. Social Media (Facebook, Instagram) C. Radio
   B. TV D. Newspaper

Section 3: Public Knowledge:

1. **Is solid waste a source of pollution for the environment?**
   i. Yes ii. No
2. **Have you ever heard about 3R's (Reduce, Reuse, and Recycle)?**
   A. Yes B. No
3. **Burning solid waste can lead to respiratory health issues.**
   A. Yes B. No
4. **Open dumping of waste can cause health-related problems such as diarrhea, typhoid, and cholera.**
   A. Yes B. No
5. **Paper waste, plastic bottles, and metal are recyclable.**
   A. Yes B. No
6. **Compost or organic fertilizers can be prepared from solid waste.**
   A. Yes B. No
7. **The amount of solid waste can be reduced by reusing it at the household level.**
   A. Yes B. No
8. **Sorting of solid waste at home can help the SWM Authorities by turning waste into something of value.**
   A. Yes B. No
9. **Plastic bags (shoppers) are a threat to the environment**.
   A. Yes B. No
10. **Electronic waste and Chemical waste (batteries, paints etc.,) are considered hazardous waste.**
   A. Yes B. No

Section 4: Public Attitude:

1. **Solid waste is anything without value.**
   A. Strongly disagree D. Agree
   B. Disagree E. Strongly agree
   C. Neutral
2. **Considering the health and environmental effects of household solid waste is important in the disposal of waste.**
   A. Strongly disagree B. Disagree

C. Neutral
D. Agree
E. Strongly agree

3. Solid waste is one of the environmental problems that needs immediate attention.

A. Strongly disagree
B. Disagree
C. Neutral
D. Agree
E. Strongly agree

4. Waste segregation/sorting is the job of sweepers only and not the households.

A. Strongly disagree
B. Disagree
C. Neutral
D. Agree
E. Strongly agree

5. The role of media (Broadcast i.e., TV Channels & FM, Social Media) is important in understanding the management of household solid waste & its importance.

A. Strongly disagree
B. Disagree
C. Neutral
D. Agree
E. Strongly agree.

6. Cleanliness drives and campaigns on the importance of SWM arranged by the city authorities can prove beneficial for spreading awareness among the residents.

A. Strongly disagree
B. Disagree
C. Neutral
D. Agree
E. Strongly agree

7. Will you be willing to pay for biodegradable bags; an amount of 10-15 Rs, for carrying groceries?

A. Strongly disagree
B. Disagree
C. Neutral
D. Agree
E. Strongly agree

8. Do you approve of punishments (such as fines) for indiscriminate/random household solid waste disposal?

A. Strongly disagree
B. Disagree
C. Neutral
D. Agree
E. Strongly agree

9. Do you approve of the people paying for the services provided for the management of solid waste?

A. Strongly disagree
B. Disagree
C. Neutral
D. Agree
E. Strongly agree

10. Do you approve of measures such as the container deposit scheme i.e., an extra amount is paid by the customers on the purchase of beverages which is returned/reimbursed on the return of the bottle?

A. Strongly disagree
B. Disagree
C. Neutral
D. Agree
E. Strongly agree

11. Will you be willing to keep a cloth bag for carrying groceries instead of plastic bags, considering that cloth bags are environmentally friendly?

A. Strongly disagree
B. Disagree
C. Neutral
D. Agree
E. Strongly agree

12. The city government should conduct regular supervision and control on illegal dumping of solid waste in the town.

A. Strongly disagree
B. Disagree
C. Neutral
D. Agree

E. Strongly agree

Section 5: Public Practices/Behavior:

1. **Approximately how much kg of Solid Waste does your house generate per week?** _____kg.
2. **Do you separate/sort solid wastes before disposal?**
   A. Yes B. No
3. **How do you get rid of solid wastes from home?**
   A. Dumped in the backyard with sacs
   B. Dumped along roadsides/in gully
   C. Dumped in the collection points designated by the authorities
4. **How often do you dispose waste from your home?**
   A. Everyday
   B. Every alternate day
   C. Once a week
5. **What specific solid waste item is present in the greatest amount in your household generated solid waste?**
   A. Kitchen waste
   B. Paper waste
   C. Plastic waste
   D. Others (Pampers, Dirt, Debris)
6. **Do you make any deliberate effort to keep your house surroundings clean?**
   A. Yes B. No
7. **What do you prefer for carrying purchased items during grocery shopping?**
   A. Cloth bag
   B. Plastic Bag
   C. Whichever is available, No preference.
8. **Do you separately collect and sell recyclable items of solid waste to junkyards or street hawkers?**
   A. Yes B. No
9. **Do you reuse plastic bottles and glass bottles in your house?**
   A. Yes B. No
10. **Do you burn solid waste?**
    A. Yes
    B. No

Any Comment or Suggestion:

_____

_____

سوالنامہ

Knowledge Attitude Practices (KAP) Survey

علم رویوں طریقوں کا سروے

عزیز شرکاء:

یہ تحقیقی مطالعہ واہ کینٹ کے رہائشیوں کے سالڈ ویسٹ مینجمنٹ(کوڑا کرکٹ کی مینجمنٹ)کے حوالے سے علم ، رویوں اور طریقوں کا تعین کرنے کے لیے ایک فنڈڈ شدہ تحقیق کا حصہ ہے ۔ آپ کے ایماندارانہ جوابات ہماری تحقیق کی صلاحیت کو نمایاں طور پر تقویت دیں گے ۔ یقین رکھیں کہ ان جوابات کو خفیہ رکھا جائے گا اور خصوصی طور پر تحقیقی مقاصد کے لیے استعمال کیا جائے گا ۔ آپ کی شمولیت کا کوئی ذاتی اثر نہیں ہے اور نام ظاہر نہ کرنے کو یقینی بنایا جائے گا ۔ سوالنامہ سروے کو پر کرنے میں 4-5 منٹ لگیں گے اور آپ کے جوابات پالیسی سازوں ، میونسپلٹی ، اور چھاؤنی کے اسٹیک ہولڈرز کو باخبر فیصلے کرنے میں مدد فراہم کریں گے ، اس طرح سالڈ ویسٹ مینجمنٹ پروگراموں کی کامیاب منصوبہ بندی اور نفاذ کو یقینی بنایا جائے گا ۔

سیکشن 1: آبادیاتی معلومات:

1. جنس
- **عورت**
- **مرد**

2. عمر
- **46-60**
- **18-30**
- **60 سے زائد**
- **31-45**

3. تعلیم
- **ڈپلومہ**
- **کوئی تعلیم نہیں**
- **بیچلر ڈگری یا اس سے اعلی تعلیم**
- **ابتدائی تعلیم**
- **ثانوی تعلیم**

4. پیشہ
- **پرایویٹ کمپنی میں ملازم**
- **اپنا کام/کاروبار**
- **دیگر**
- **سرکاری ملازم**

5. کل گھریلو آمدنی (آپ کے گھر کے تمام اراکین کی کل تنخواہ): _____

6. گھر کے کل (ٹوٹل) ممبران:
- **7-9**
- **1-3**
- **10 سے زائد**
- **4-6**

7. کھر کے وہ افراد جو کما رہے ہیں: _____

8. واہ کینٹ میں رہائش کس جگہ ہے؟ _____

9. واہ کینٹ میں کتنے عرصے سے رہائش پذیر ہے؟
- **6-10 سال**
- **2 سال سے کم عرصہ**
- **10 سال سے زائد**
- **2-5 سال**

10. کیا آپ اپنے گھر یا کرائے کے مکان میں رہتے ہیں؟
- **اپنا گھر**
- **کرائے کا مکان**

سیکشن 2: موجودہ صورتحال کا جائزہ:

1. آپ کے علاقے میں کوڑا کرکٹ جمع کرنے کا موجودہ طریقہ کیا ہے؟
- **کوڑا کرکٹ جمع کرنے کی خدمات تک رسائی نہیں**
- **گھر گھر سے**
- **سڑک کی سائڈ پر پڑے ہوے کنٹینر سے**

2. آپ کے گھر سے کوڑا کرکٹ کون جمع کرتا ہے ؟
- **پرایویٹ کمپنی**
- **کنٹونمنٹ والے/** POF
- **کوڑے والے/ پھیری والے**

3. آپ کے کھر سے ہفتے میں کتنی دفعہ کوڑا کڑکٹ اٹھایا جاتا ہے؟
- **ہفتہ میں ایک بار**
- **روزانہ**
- **کبھی نہیں**
- **ہر دوسرے دن**

4. کیا ہفتہ اتوار کوڑا اٹھایا جاتا ہے؟
- **نہیں**
- **ہاں**

5. کیا آپ کے گھر کے قریب کوئی کچرا ڈمپنگ پوائنٹ (ڈسٹبن ، ٹب) ہے ؟

- **نہیں** • **ہاں**

6. کیا آپ فی الحال فراہم کی جانے والی کوڑا کرکٹ ک صفائی کے نظام سے مطمئن ہیں ؟
- **نہیں** • **ہاں**

7. کیا آپ کوڑا ڈالنے کے لیے پلاسٹک کے لفافے استعمال کرتے ہیں؟
- **نہیں** • **ہاں**

8. کوڑا کرکٹ کی وجہ سے آپ کو کس قسم کی پریشانی کا سامنا کرنا پڑتا ہے ؟
- **چوہے** • **بد بو**
- **صرف علاقے کی خوبصورتی متاثر ہوتی** • **مچھر**

9. آپ فی الحال سالڈ ویسٹ مینجمنٹ/کوڑا کرکٹ کی صفائی کی سرویسز کے لیے ماہانہ کتنی رقم ادا کر رہے ہیں ؟
- **پیسے نہیں ادا کر رہا/ مفت ہے** • **_____روپے**

10. کیا آپ صفائی کے بہتر نظام جیسے کہ وقت پر گھر گھرسے کوڑا اٹھانا ، گلیوں کی صفائی وغیرہ کے لیے ماہانہ پیسے ادا کرنے کے لیے تیار ہیں ؟
- **نہیں، میری گنجائش نہیں** • **ہاں**
- **نہیں، یہ حکومت کی ذمہ داری ہے**

11. آپ میڈیا کی کونسی قسم زیادہ استعمال کرتے ہیں؟
- **ٹی وی** • **فیسبک، انسٹاگرام**
- **اخبار** • **ریڈیو**

سیکشن 3: معلومات عامہ

1. کیا کوڑا کرکٹ ماحول کے لیے آلودگی کا ذریعہ ہے ؟
- **نہیں** • **ہاں**

2. کیا آپ نے کبھی **3R (Reduce, Reuse, and Recycle)** کے بارے میں سنا ہے ؟
- **نہیں** • **ہاں**

3. کوڑے کو جلانے سے سانس کے مسائل پیدا ہو سکتے ہیں۔
- **نہیں** • **ہاں**

4. کھلے میں کچرا پھینکنے سے اسہال ، ٹائیفائیڈ اور ہیضے جیسے صحت سے متعلق مسائل پیدا ہو سکتے ہیں۔
- **نہیں** • **ہاں**

5. کوڑے میں شامل کاغذ اور پلاسٹک کی بوتلوں کونئ شکل دے کر دوبارہ کارآمد بنایا جا سکتا ہے۔
- **نہیں** • **ہاں**

6. کوڑے سے کمپوسٹ یا نامیاتی کھاد تیار کی جا سکتی ہے ۔
- **نہیں** • **ہاں**

7. کچرے کی مقدار کو گھریلو سطح پر دوبارہ استعمال کرکے کم کیا جا سکتا ہے ۔
- **نہیں** • **ہاں**

8. گھر میں کچرے کو الگ کرنے سے (مثال کے طور پر کچن کے گند کو علیحدہ اور کاغذ کو علیحدہ وغیرہ وغیرہ) حکام کو کچرے کو قابل قدر چیز میں تبدیل کرنے میں مدد کر سکتی ہے ۔
- **نہیں** • **ہاں**

9. پلاسٹک کے تھیلے ماحول کے لیے خطرہ ہیں۔
- **نہیں** • **ہاں**

10. الیکٹرانک کچرا اور کیمیائی کچرا (بیٹریاں ، پینٹ وغیرہ) خطرناک کچرا کہلاتی ہے ۔
- **نہیں** • ہاں

سیکشن 4: عوامی رویے

1. کوڑا ہر وہ چیز ہے جس کی کوئی اہمیت نہیں ہے۔
- **متفق ہوں** • **شدید اختلاف رائے ہے**
- **مکمل طور پر متفق ہوں** • **اختلاف رائے ہے**
- **غیر جانبدار**

2. گھریلو کچرے کے صحت اور ماحولیاتی اثرات پر غور کرنا کچرے کو ٹھکانے لگانے میں اہم ہے۔
- **متفق ہوں** • **شدید اختلاف رائے ہے**
- **مکمل طور پر متفق ہوں** • **اختلاف رائے ہے**
- **غیر جانبدار**

3. کوڑا کرکٹ/کچرا ماحولیاتی مسائل میں سے ایک ہے جس پر فوری توجہ دینے کی ضرورت ہے۔

- **متفق ہوں**
- **مکمل طور پر متفق ہوں**
- **شدید اختلاف رائے ہے**
- **اختلاف رائے ہے**
- **غیر جانبدار**

4. کچرے کو الگ کرنا/چھانٹنا صرف صفائی کرنے والوں کا کام ہے نہ کہ گھر والوں کا نہیں۔
- **متفق ہوں**
- **مکمل طور پر متفق ہوں**
- **شدید اختلاف رائے ہے**
- **اختلاف رائے ہے**
- **غیر جانبدار**

5. کوڑا کرکٹ/کچرے کی صفائی کے انتظام اور اس کی اہمیت کو سمجھنے میں میڈیا (ٹی وی چینلز، ایف ایم اور سوشل میڈیا) کا کردار اہم ہے ۔
- **متفق ہوں**
- **مکمل طور پر متفق ہوں**
- **شدید اختلاف رائے ہے**
- **اختلاف رائے ہے**
- **غیر جانبدار**

6. شہر کے حکام کی طرف سے کوڑا کرکٹ/کچرے کی صفائی کے انتظام اور اس کی اہمیت پر صفائی مہمات رہائشیوں میں آگاہی پھیلانے کے لیے فائدہ مند ثابت ہو سکتی ہیں ۔
- **متفق ہوں**
- **مکمل طور پر متفق ہوں**
- **شدید اختلاف رائے ہے**
- **اختلاف رائے ہے**
- **غیر جانبدار**

7. کیا آپ خریداری کرتے وقت چیزوں کو رکھنے کیلیے ایسے پلاسٹک کے تھیلے جن کا ماحول پر کوئی بھی منفی اثر نہیں ہو خریدنے کے لیے آمادہ ہونگے اگر ان کی قیمت 10-15روپے ہو۔
- **متفق ہوں**
- **مکمل طور پر متفق ہوں**
- **شدید اختلاف رائے ہے**
- **اختلاف رائے ہے**
- **غیر جانبدار**

8. کیا آپ کھلا کچرا پھینکنے والوں کو سزاؤں (جیسے جرمانے) کے حق میں ہیں ؟
- **متفق ہوں**
- **مکمل طور پر متفق ہوں**
- **شدید اختلاف رائے ہے**
- **اختلاف رائے ہے**
- **غیر جانبدار**

9. کیا آپ کے خیال میں عام عوام کو کچرا اٹھانے کے نظام اور اسے ٹھکانے لگانے کیلیے حکام کو پیسے/فیس دینی چاہیے؟
- **متفق ہوں**
- **مکمل طور پر متفق ہوں**
- **شدید اختلاف رائے ہے**
- **اختلاف رائے ہے**
- **غیر جانبدار**

10. کیا آپ کنٹینر ڈپازٹ اسکیم جیسے اقدامات کی منظوری دیتے ہیں جس میں مشروبات کی خریداری پر صارفین کی طرف سے اضافی رقم ادا کی جاتی ہے جو بوتل کی واپسی پر واپس/واپسی کی جاتی ہے ؟
- **متفق ہوں**
- **مکمل طور پر متفق ہوں**
- **شدید اختلاف رائے ہے**
- **اختلاف رائے ہے**
- **غیر جانبدار**

11. یا آپ پلاسٹک کے تھیلوں کے بجائے خریداری کرنے کے لیے کپڑے کا بیگ رکھنے کے لیے تیار ہوں گے ، اس بات کو مد نظر رکھتے ہوئے کہ کپڑے کے تھیلے ماحول دوست ہیں ؟
- **متفق ہوں**
- **مکمل طور پر متفق ہوں**
- **شدید اختلاف رائے ہے**
- **اختلاف رائے ہے**
- **غیر جانبدار**

12. حکومت کو چاہیے کہ وہ شہر میں کچرے کو غیر قانونی طریقے سے پھینکنے کی باقاعدہ نگرانی اور کنٹرول کرے ۔
- **متفق ہوں**
- **مکمل طور پر متفق ہوں**
- **شدید اختلاف رائے ہے**
- **اختلاف رائے ہے**
- **غیر جانبدار**

<u>سیکشن 5: عوامی طرز عمل</u>

1. آپ کے گھر ہر ہفتے تقریباً کتنا کلو کچرا جمع ہوتا ہے ؟ _____کلو۔
2. کیا آپ کچرا پھینکنے سے پہلے اسے الگ کرتے ہیں ؟

- **نہیں**
- **ہاں**

3. آپ گھرکا کچرا کس طریقے سے پھینکتے ہیں؟

- **ڈسٹبن یا حکام کی طرف سے مقرر شدہ جگہوں پر پھینکتے ہیں**
- **گھر کے پیچھے تھیلے میں پھینکتے ہیں**
- **روڈ کی سائیڈ یا گلی میں پھینکتے ہیں**

4. آپ اپنے گھر سے کچرا کتنی بار نکالتے ہیں ؟

- **ہفتے میں ایک بار**
- **روزانہ**
- **ہر دوسرے دن**

5. آپ کے گھر میں جمع ہونے والے کچرے میں سب سے زیادہ مقدار میں کون سی چیز موجود ہوتی ہے ؟

- **پلاسٹک کچرا**
- **کچن کا کچرا**
- **دیگر(پیمپر وغیرہ)**
- **کاغذ**

6. کیا آپ اپنے گھر کے آس پاس کے ماحول کو صاف رکھنے کے لیے کوئی کوشش کرتے ہیں ؟

- **نہیں**
- **ہاں**

7. خریداری کے دوران خریدی ہوئی اشیاء رکھنے کے لیے آپ کس چیز کو ترجیح دیتے ہیں ؟

- **جو بھی دستیاب ہو**
- **کپڑے کا تھیلا**
- **پلاسٹک کا لفافہ**

8. کیا آپ کچرے میں سے دوبارہ استعمال کی جانے والی اشیاء کو الگ سے اکٹھا کرتے ہیں اورکباڑیوں یا پھیری والوں کو فروخت کرتے ہیں؟

- **نہیں**
- **ہاں**

9. کیا آپ اپنے گھر میں پلاسٹک کی بوتلیں اور شیشے کی بوتلیں دوبارہ استعمال کرتے ہیں ؟

- **نہیں**
- **ہاں**

10. کیا آپ کوڑا جلاتے ہیں؟

- **نہیں**
- ہاں

کوئی تبصرہ یا تجویز: