Assessment of effects of peri-urban development on solid waste management institutes: A case study of Rawalpindi

By

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Dedication

To
My parents
My brothers and sisters
My Uncle and Cousins
Dr. Abdul Waheed
&
To all those who encouraged me to acheive the end of this research.

Acknowledgement

First of all, I am very thankful to Almighty Allah, who gave me the strength, motivation, guidance, power of mind and skills to complete my research work and my Maters Degree. It would not have been possible to be at this stage of writing Acknowledgement without Allah's help.

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List of Abbreviations

SWM	Solid Waste Management
SWMS	Solid Waste Management System
Mt	Million-tons
WM	Waste Management
SDG	Sustainable Development Goals
TPD	Tons Per Day
CDA	Capital Development Authority
RDA	Rawalpindi Development Authority
MCI	Metropolitan Corporation Islamabad
RWMC	Rawalpindi Waste Management Company
SW	Solid Waste
SPSS	Statistical Package for Social Sciences
FA	Factor Analysis
PCA	Principal Component Analysis
MSWM	Municipal Solid Waste Management
SW-EMS	Solid Waste Environmental Management System
LCA	Life Cycle Assessment
HH	Household
SD	Stnadard Deviation
KMO	Kaiser-Meyer-Olkin Measure of Sampling Adequacy
RCM	Rotated Component Matrix
WCS	Waste Collection Services
WS	Waste Separation

ABSTRACT

Urbanization is known as the social process leading to the creation of cities. Presently, the world population living in urban areas is 55%, and by 2050, it is projected that it will increase to 68%. Africa and Asia will have 90% of this surge. In South Asia, the highest rate of urbanization is in Pakistan, and by 2025, nearly 50% of the its population will be living in urban areas. Due to rapid urbanization, Pakistan has witnessed an increase in waste generation. The per year generation of solid waste in Pakistan is 48.5 Mt and is growing annually at 2% or more in Pakistan. All major cities of Pakistan faces the enormous challenge of managing solid waste. This study aims at assessing the effect of peri-urban development on SWM institutes in Rawalpindi. The SWM practices, barriers, perception of household and effect of peri-urban development on SWM institutes are assessed in this research.

The data was collected by means of household questionnaire, expert opinions, field observation and interviews with institutions. The data was analysed in SPSS and MS-Excel. The analysis concluded that there are five areas of a SWMS in peri-urban areas that need improvements, which includes technical and operational limitations, implementation of regulations, finance and human resource, household behavior and operational capacity and equipment.

SWM authorities need to introduce awareness campaigns through print, electronic and social media, seminars, and events regarding waste reduction, disposal and separation. The outcome of this research will serve as a base point for the SWM institutes and local governing bodies because it will provide a base for policy initiatives related to integrated SWM system. Furthermore, this research will increase the existing body of knowledge in environmental studies related to SWMS.

1. CHAPTER: INTRODUCTION

Urbanization is known as the social process leading to the creation of cities. Due to urbanization, physical development of urban areas takes place, which is mostly associated to industrialization (Hussain & Imitiyaz, 2018). Presently, the world population living in urban areas is 55%, and by 2050, it is projected that it will increase to 68%. Africa and Asia will have 90% of this surge. (United Nations, 2018). In South Asia, the highest rate of urbanization is in Pakistan, and by 2025, nearly 50% of the its population will be living in urban areas. (UNDP Pakistan, 2018).

Unplanned and unmanaged urbanization is leading to the irregular expansion of cities (Jarah & Zhou, 2019) and deteriorated urban governance (Haider & Badami, 2010), resulting in an inappropriate SWMS (Tahir et al., 2015). The irregular expansion of cities often develops geographical areas, known as peri-urban areas (Nicodemus & Ness, 2010). (Adell, 1999) defines it as meaningfully pre-urban area, which has problems of housing, transport, and environment. Municipal services are provided very infrequently in peripheral areas due to which solid waste is disposed of by households in an inappropriate manners. The volume of solid waste has increased due to the swift increase of inhabitants in peri-urban areas. In contrast, an institutional capability to control them is highly lacking (Saxena & Sharma, 2015).

SWM is a very complex issue in peri-urban areas. Communities living in peri-urban areas often perform informal SWM practices. Inadequate SWM is attributed to numerous factors, including lack of logistics and financial management, infrastructure, unplanned areas, and the role of community, i.e., knowledge, willingness, attitude, and satisfaction (Mamady, 2016).

SWM is an important part of activities required for achieving at least 7 SDGs. Improved SWM will meaningfully add to the improved health and living condition of 3 billion people worldwide (Wilson & Velis, 2013). In developing countries, governments attempt to create and implement regulations about sustainable WM system. Many inadequate frameworks are created to counter the problem of solid waste, resulting in an inadequate SWM in peri-urban areas (Schnitzer & Hans, 2009; Shekdar & Ashok, 2009).

Planning of WM includes the reuse, reduce, recycle and appropriate disposal (Morris & Holthausen, 1994). SWM planning can be successful by combined efforts of government, local community, and other concerned organizations. Furthermore, to ensure sustainable SWM practices, all-inclusive policies, and legal support structure are highly recommended (Ezeah & Roberts, 2012).

1.1. Problem statement

Urbanization in Pakistan is growing at 3% annually, which is highest in South Asia (Jabeen & Farwa, 2017). The rapid population growth has hampered the development of infrastructure and efficient delivery of utility services, including SWM in cities (Dino & Mustafa, 2015). Furthermore, peri-urban areas are not spared from getting affected by rapid urbanization and population growth. Due to rapid urbanization, Pakistan has witnessed an increase in waste generation. The per year generation of solid waste in Pakistan is 48.5 Mt and is growing annually at 2% or more in Pakistan. (Administration, 2019). All major cities of Pakistan faces the enormous challenge of managing solid waste. The non-existence of planning, governance issues, inadequate SWMS, and less awareness in community are the basic factors for worsening the solid waste problems in Pakistan (Administration,

2019). (Jabeen et al., 2017) stated that the major hurdle in urbanization research is the inadequacy of the latest, consistent, and reliable statistical data in Pakistan. In developing countries, most studies are conducted on SWM, focusing on urban areas or city centres, and peri-urban areas are highly ignored (Kariuki, 2015). To fill this research gap and moderate the likelihood of conflict produced by the inadequate WM system. It is essential to assess the effects of peri-urban development on SWM institutions in peri-urban areas of Rawalpindi".

1.2. Research objectives

The major objective/ goal of the study is to assess the effects of peri-urban development on solid waste management institutes. Following are the research objectives of the study.

i. To examine the solid waste management practices in peri-urban areas.
ii. To investigate the effects on solid waste management institutes by peri-urban development.
iii. To assess household perception about the solid waste management system.
iv. To suggest a framework to integrate solid waste management of peri-urban areas into solid waste management of the city

1.3. Research questions

The following are the research questions.

i. What are the practices of SWM in peri-urban areas?
ii. What are the SWMS barriers in peri-urban areas?
iii. What is the effect of peri-urban development on SWM institutes?
iv. What is the household's perception of the SWMS in peri-urban areas?

1.4. Justification of the study

Rawalpindi generates solid waste of 4,400 TPD, which is the fourth-highest quantity of waste produced in Pakistan (Administration, 2019). The practices of WM in Rawalpindi are not performed effectively and properly (Dino & Mustafa, 2015). There is no integrated approach for SWM in Rawalpindi. The waste is thrown in open drains, and vacant spaces, creating environmental pollution and an aesthetically bad look. Waste collection is fairly inadequate and is limited to important areas, and deprived communities are passed over (Nisar & Naushad, 2008). Despite the severity and magnitude of the problem, insufficient work has been carried out on the aspects related with the SWM from the perspective of peri-urban areas. This study will work as a base point for the SWM institutes and local governing bodies because it will provide a base for policy initiatives related to integrated SWMS. Furthermore, this research will assist the existing body of knowledge in environmental studies related to SWMS. Lastly, it will be of application in the cities of developing world for better SWMS. Other researchers can also work on different factors of SWM in peri-urban areas in the context of Pakistan.

1.5. Scope and limitations of the study

This study will focus on the SWMS in peri-urban areas of Rawalpindi. The SWM practices, barriers, perception of household and effect of peri-urban development on SWM institutes will be assessed in this study. This study will provide information that can be used to formulate policy base lines, which will help in addressing SWM issues in peri-urban areas. The limited time and financial constraints results in limiting the scope of this work to the peri-urban areas of Rawalpindi. Therefore, the outcome of this study cannot be practical for any other geographical area.

Furthermore, this study is focused on SW generated by domestic premises. Therefore, the output of this study does not provide confidence to generalize them to other types of waste.

2. CHAPTER: LITERATURE REVIEW

2.1. Urbanization

Urbanization is the social process that leads to cities' formation. Consequently, the rapport between urbanization and cities is like cause and effect (Hussain & Imitiyaz, 2018). The process of urbanization is defined as a migration of people from rural areas where leading economic activity is agriculture towards heavily inhabited urban areas characterized by service and industrial activities (United Nations, 2015).

In third world countries, the rapid rate of urbanization has led to the development debate over this accelerated pace, its causes, and consequences. The debate concluded it as “over-urbanization” because of the growing influx of rural migrants into the cities due to the pull factor of the city and push factor of the rural areas. Thus, cities have become a centre of urban misery and poverty in developing and underdeveloped countries (Hussain & Imitiyaz, 2018).

All-encompassing public policies can only accrue the urbanization benefits. Unmanaged and unplanned urbanization can lead to irregular expansion of cities (Jarah & Zhou, 2019), environmental problems, i.e., inadequate water supply, traffic obstruction, inappropriate SWMS, etc.(Tahir et al., 2015), social problems, i.e., health problems, erratic education system and urban poverty (Bapari & Haque, 2016) and deteriorated urban governance (Haider & Badami, 2010).

2.2. Peri-Urban Development

More attention has been given to peri-urban development due to the competition or conflict different type of land uses due to peri-urban expansion. For defining the same geographical area, many alternative terms have been used, i.e., the periphery, inner rural, the urban fringe, city outskirts, suburban, the rural commuting zone, and

peri-urban area (Nicodemus & Ness, 2010). There are different disciplinary views, conceptual frameworks, and approaches to define peri-urban areas in literature. (Adell, 1999) defines it as meaningfully pre-urban area, which has problems of housing, transport, and environment.. (Maconachie & Binns, 2006) defines it as "blurring" between rural area and urban area.

2.3. Problems and issues in peripheral areas

Lack of institutional structure for development and governance of peripheral areas results in weak infrastructure. Additionally, the increase in population has strained the environmental carrying capacity of peripheral areas due to which they have substandard level of infrastructure and services. Municipal services are rarely provided due to which solid waste is dumped in low-lying land or thrown along roadsides. The volume of SW has increased due to the swift increase of inhabitants in peri-urban areas. In contrast, an institutional capability to control them is highly lacking (Saxena & Sharma, 2015).

2.4. Solid waste management system (SWMS)

Environmental impact of SWM is ignored in most developing countries. Furthermore, these countries have developed a disturbing attitude towards the effects of improper handling of solid waste (Batool & Chuadhry, 2009). SWM is termed as management of the discarded material by various techniques, tools, methods, and programs. The SWMS includes all activities i.e., disposal, collection and treatment of SW material (Tchobanoglous, 1993). Improper disposal of SW results in unhygienic conditions, i.e., greenhouse gas emissions and polluted water resources in surrounding areas. SWM shall comprise activities that helps in minimizing the solid waste's health, aesthetic, and environmental effects (Rouse, 2008). SWM has

been practiced since the beginning of civilizations. The scenario was altogether different in the past because the land was available in large quantities, and the population was very less. At present, the population is very rapidly increasing, and less land is available, due to which extreme measures are required for developing viable strategies and practices of managing solid waste (Azam, 2004).

2.5. Components of SWM

The main functional elements of MSWM are shown in the figure below.(Khan & Samadder, 2014).

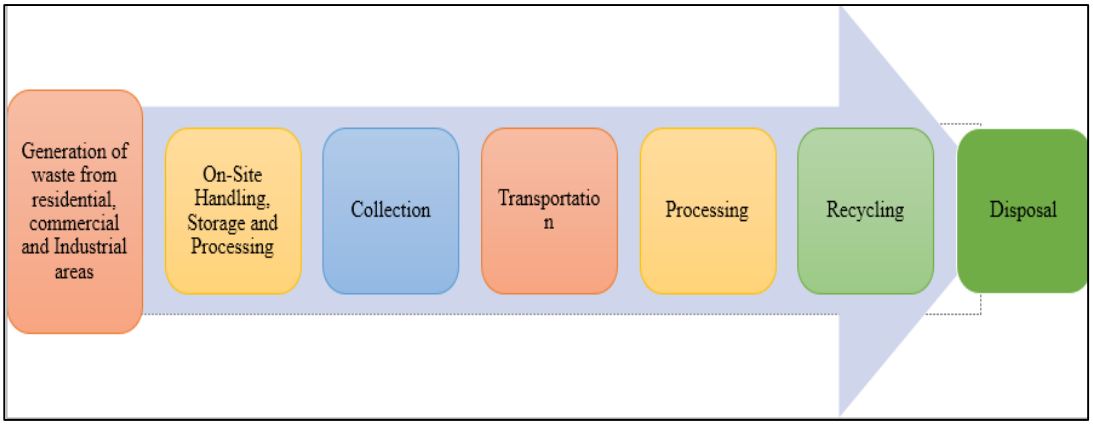


Figure 1: Functional components of the MSWM (Khan & Samadder, 2014)

2.6. Solid waste Classification

There are numerous ways to classify SW based on its characteristics, sources, and potential risk. Based on characteristics, solid waste can be bifurcated into biodegradable, i.e., food, paper and garden waste, etc., and non-biodegradable, i.e., glass, plastic, and metal waste. Based on sources, SW can be characterised into construction, industrial, residential, municipal, and commercial waste (Tchobanoglous, 1993). SW can be divided into hazardous and non-hazardous waste based on potential risk. Furthermore, solid waste can be bifurcated into organic, i.e., easily compostable such as food, paper, and wood waste, etc., and inorganic, i.e.,

non-compostable such as leather, metal, glass, rubber, and plastic waste, etc. (UNEP, 2017).

2.7. SWM practices in peri-urban areas

SWM in the peri-urban zone is a complex and conflict-ridden problem because these zones' economic, social, and ecological functions impact the city and rural areas. Planning of SWM in peripheral areas is learnt by 3 different fields, i.e., urban planning, rural planning, and the customs that describe the development of these fields (Tacoli, 2012).

In peri-urban areas, many communities practice an informal SWMS, i.e., throwing and burying solid waste in open spaces and burning solid waste. However, this practice is not sustainable because it does not consider any special treatment for non-biodegradable and toxic components, which can cause severe health and environmental problems. In urban and peri-urban areas, the municipality collects solid waste. Still, peri-urban areas are often hampered by solid waste because they are used as disposal sites for the waste collected by the municipality (Githua & Kisumu, 2018). In Kenya, the private sector and small enterprises collect and dispose of SW in peripheral areas. The private sector usually carries out SWM in an uncoordinated way, i.e., the community is not involved in SWM. SW is mostly disposed of by waste collectors in vacant plots, resulting in masses of uncollected garbage that is hazardous for human health and the environment (Mulatya, 2014; Njoroge & Kimani, 2014). In developing countries, most governments have created and implemented environmental protection and sustainable WM regulations. Many of these policy frameworks are inadequate in addressing the problem of SW in

peripheral areas, resulting in inadequate SWM in peripheral areas (Schnitzer & Hans, 2009; Shekdar & Ashok, 2009).

2.8. Household perception regarding SWMS

Inadequate SWM is attributed to numerous factors, i.e., lack of logistics and financial management, infrastructure, unplanned areas, and the role of the community, i.e., their knowledge, willingness, attitude, and satisfaction (Mamady, 2016). Inappropriate and inadequate knowledge about handling domestic waste leads to serious environmental and health consequences. Households having better knowledge about domestic waste disposal can keep the environment clean (Jatau, 2013). The positive attitude of the household is highly affected by the household level of knowledge. People with inadequate awareness about disposal of SW have a negative approach towards disposing SW. WM authorities can achieve many environmental and health benefits if households dispose of their solid waste properly (Shahzadi & Hussain, 2018).

2.9. Relationship between SWM and SDGs

The 17 SDGs and 169 targets were stated in Agenda 2030, which was adopted by 193 member states of UN in 2015. The SDGs and its targets are an urgent call of action for all countries worldwide, i.e., developed countries and developing countries (UN, 2020).

SWM is an essential part of activities required for accomplishing at least eight SDGs. At least eight SDGs and their targets are directly linked to SWM. Providing waste collection facilities to all citizens, eradicating burning and open dumping of solid wastes, and upgrading the existing dumping sites are certainly the pre-steps for achieving SDGs in developing countries. Improved SWM will significantly add to

the health and living condition of three billion people worldwide (Rodić & Wilson, 2017).

2.9.1. Relationship between SWM and SDG's from an environment perspective

The relationship between SWMS and SDGs from an environmental perspective is discussed below at both global and local levels.

2.9.1.1. Global Level

At the global Level, SDG 7: Affordable and clean energy and its target 7.2: Global energy mix, surge portion of renewable energy derived from SWM technologies through organic waste. The SDG 13: Climate action, which can be achieved by good practices of SWM to reduce greenhouse gases. The SDG 14 and its target 14.1: Protect aquatic life from the litter of all kinds, including land-based activities. This target can be achieved by spreading SW collection services and prevent SW from entering the oceans. Consequently, solving these SW problems by providing satisfactory, affordable, and safe SWM services to everyone by eradicating open burning and uncontrolled dumping would be a valuable addition to sustainable development as defined by the SDGs of the UN (Rodić & Wilson, 2017).

2.9.1.2. Local level

At the local level, the SDG 11 and its target 11.6: Decrease the hostile environmental effects on cities by giving importance to WM. The SDG 12 and its target 12.4: Wastes and chemicals shall be effectively managed to minimize the adverse impacts of chemicals and all wastes on the environment and human health. The SDG 6 and its target 6.3. The SDG 15: Life on land and its target 15.1. In order to achieve SDG

6 and SDG 15, all types of waste shall be properly managed to avoid environmental degradation (Rodić & Wilson, 2017).

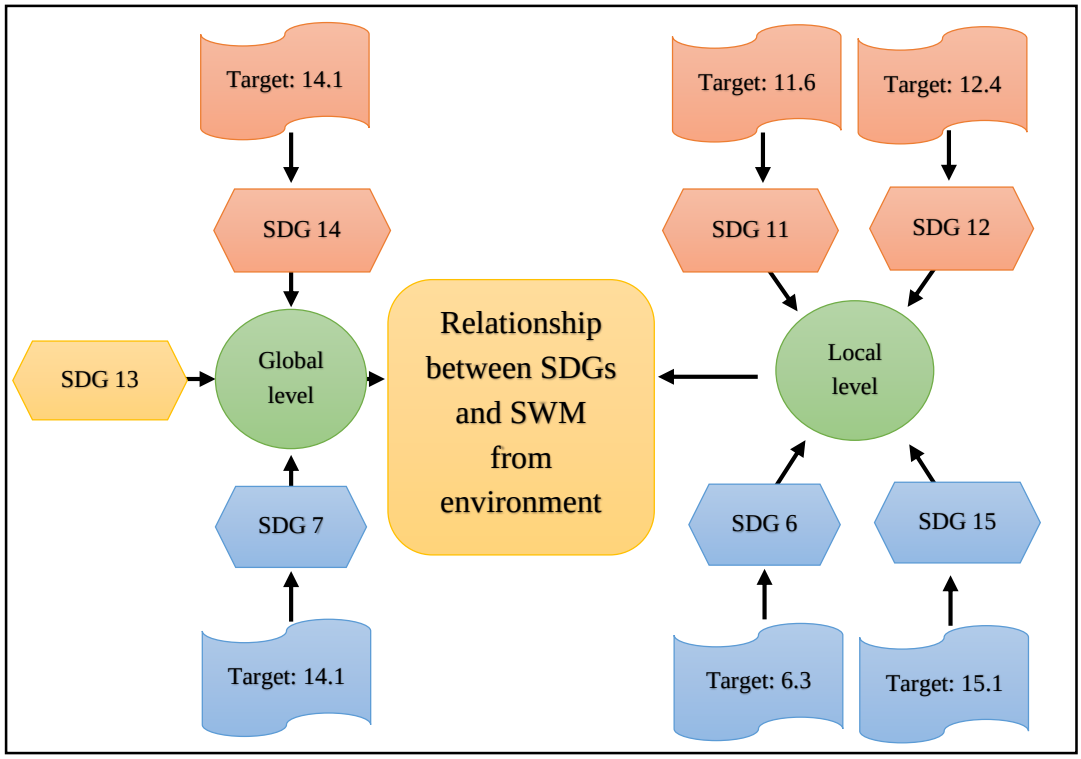


Figure 2: Relationship between SWM and SDGs from an environment perspective

2.9.2. Relationship between SWM and SDG's from a public health perspective

In SDGs, protection of public health is discussed in SDG 3 and its target 3.9: Prevent sicknesses from the soil, air, and water pollution. In SDG 11: and its target 11.6: Make sure all people have access to basic services. These targets can be achieved by having safe and adequate SWM services (Rodić & Wilson, 2017).

Figure 3: Relationship between SWM and SDG from a public health perspective.

2.10.SWM strategies

It is observed that WM planning can only become successful by the combined effort of all stakeholders, i.e., government, local community, and other concerned organizations. Furthermore, to ensure the best SWM practices, all-inclusive policies and legal support structures are highly recommended (Ezeah & Roberts, 2012). Planning of WM includes the reuse, reduce, and recycling of SW for reducing the biophysical and socioeconomic impacts (Morris & Holthausen, 1994). The following are the strategies adopted by different countries worldwide for managing solid wastes.

2.10.1. SWM in peripheral areas of African mega cities

SWM is the most important challenge in all communities. However, the problem is very severe in Africa due to social and economic reasons and lack of proper urbanization in peri-urban areas of cities. The solid waste problem is more serious in mega cities of Africa, i.e., Luanda (Capital of Angola), where the population has increased immensely due to civil war spread around the country resulting in migration of people to Angola's capital and settled in suburban areas of the capital. There was no SWMS in peripheral areas of Luanda city. Most of the waste was thrown in open dumps, residential areas, and near watercourses, provoking public health problems.

The Government of Angola has approved the strategic plan for managing solid waste with quantitative and temporal targets to eradicate the problem of solid waste. In this process, a low-cost solution was proposed for solving the problem of solid waste in Luanda. It was not identical to use the same method for collecting the solid waste used in urban areas of Luanda. In this solution, the public company, i.e., ELISAL has built three transfer stations, each having 2000m^2 and nine container barges. The

workers were responsible for cleaning the streets and roads of the neighbourhood and collecting the solid waste with the mini-truck, wheelbarrows, agriculture truck, and mini dumper. After collection, the waste was transferred to the station, from where it was advanced to the landfill in Mulenvos, Luanda. The waste deposited was weighed at the entrance of the landfill, and the company was paid according to the quantity of waste transported to the landfill (Russo, 2012)

2.10.2. Low-cost institutional SW-EMS in Canada

Canada has developed a SW-EMS to upgrade its municipal WM. In 1994, low-cost institutional SW-EMS was started with the catchphrase "go green at the workplace" aiming to minimize solid waste generation. The system's effectiveness was checked by waste auditing (Dowie & McCartney, 1998).

The audit examines:

i. Source and composition of waste.
ii. Weights of waste produced.
iii. Possibilities of improvement in the action plan of WM.

The solid waste audits can help identify the opportunities for reducing waste, recycling, and reusing (Frame et al., 1994)

Furthermore, another valuable tool is called LCA to evaluate the WM system. LCA determines the shortcomings and opportunities for improvement of the system (Arena & Mastellone, 2003). (Craighill & Powell, 1996) applied LCA to two cases i.e.

i. Comparing two methods of collection and identification of recyclable waste
ii. Comparing six waste disposal alternatives using social, environmental, and economic criteria.

3. CHAPTER: RESEARCH METHODOLOGY

3.1. Introduction

An organized way to solve a problem is known as research methodology. It aims to appoint the right procedures to work out solutions or provide the research plan. It includes learning different techniques used during research, i.e., conducting surveys, interviews, tests, and critical studies. It includes the procedures of describing, explaining, and envisaging the research phenomenon and how the research process is to be carried out (Goundar, 2012). In this section, the methodology to conduct research, indicators, types of data collection and techniques to analyse data for achieving the research objectives are briefly explained.

3.2. Research Design

The hybrid research design was used in this study, i.e., exploratory and descriptive methods were used to collect, analyse, and study the data.

3.3. Case study area (Profile)

Rawalpindi is situated in the Punjab province of Pakistan. As per census 2017, it is the fourth largest city by means of the population in Pakistan. The total population of Rawalpindi is 20.9 million (Statistics, 2017). The SWM in Rawalpindi is performed by Rawalpindi Waste Management Company (RWMC) in the jurisdiction of Metropolitan Corporation Rawalpindi (MCR), which was established in 2013 (RWMC, 2013), Cantonment Board in Cantonment area, and private contractors in private housing schemes, e.g., Bahria Town Rawalpindi and PWD Housing Society, etc. The data is collected from peri-urban areas of Rawalpindi, i.e., UC-82: Morgha and UC-86: Dhamial, where the SWM is done by RWMC, which is a public sector

institute, Bahria Town Rawalpindi and PWD Housing Society, where the SWM is done by private sector institute, i.e., private contractors.

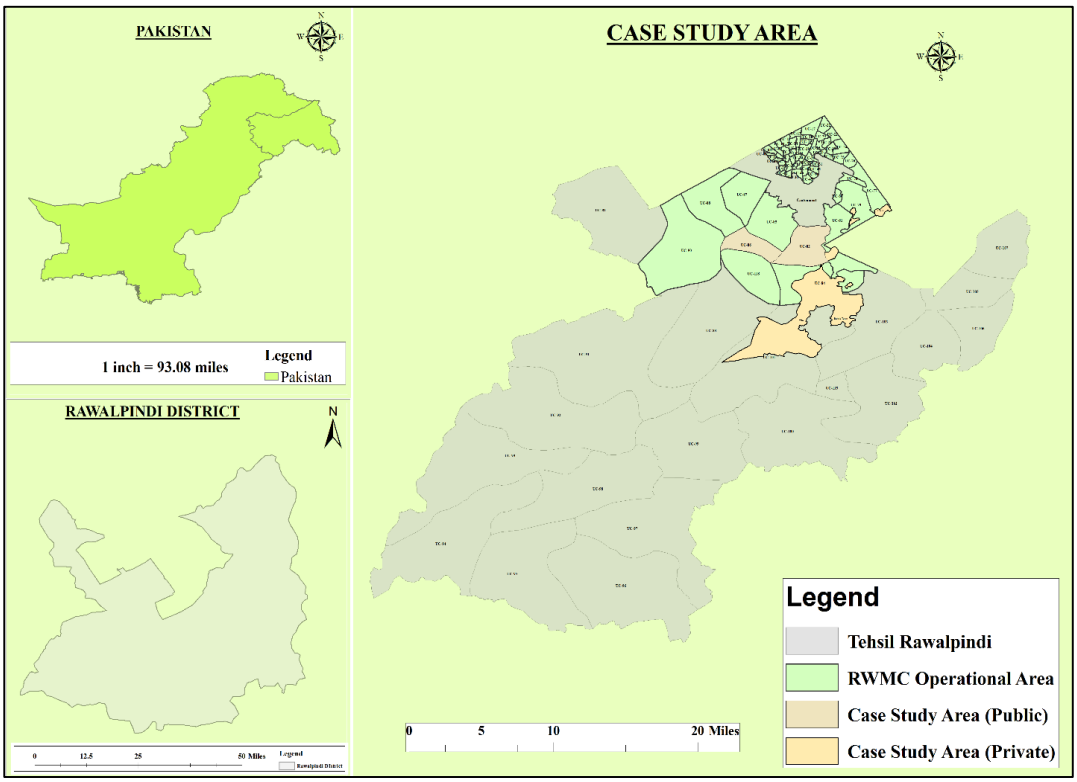


Figure 4: Case study area map

3.4. Research methodology

The research methodology used in this study is shown in the form of flow chart below.

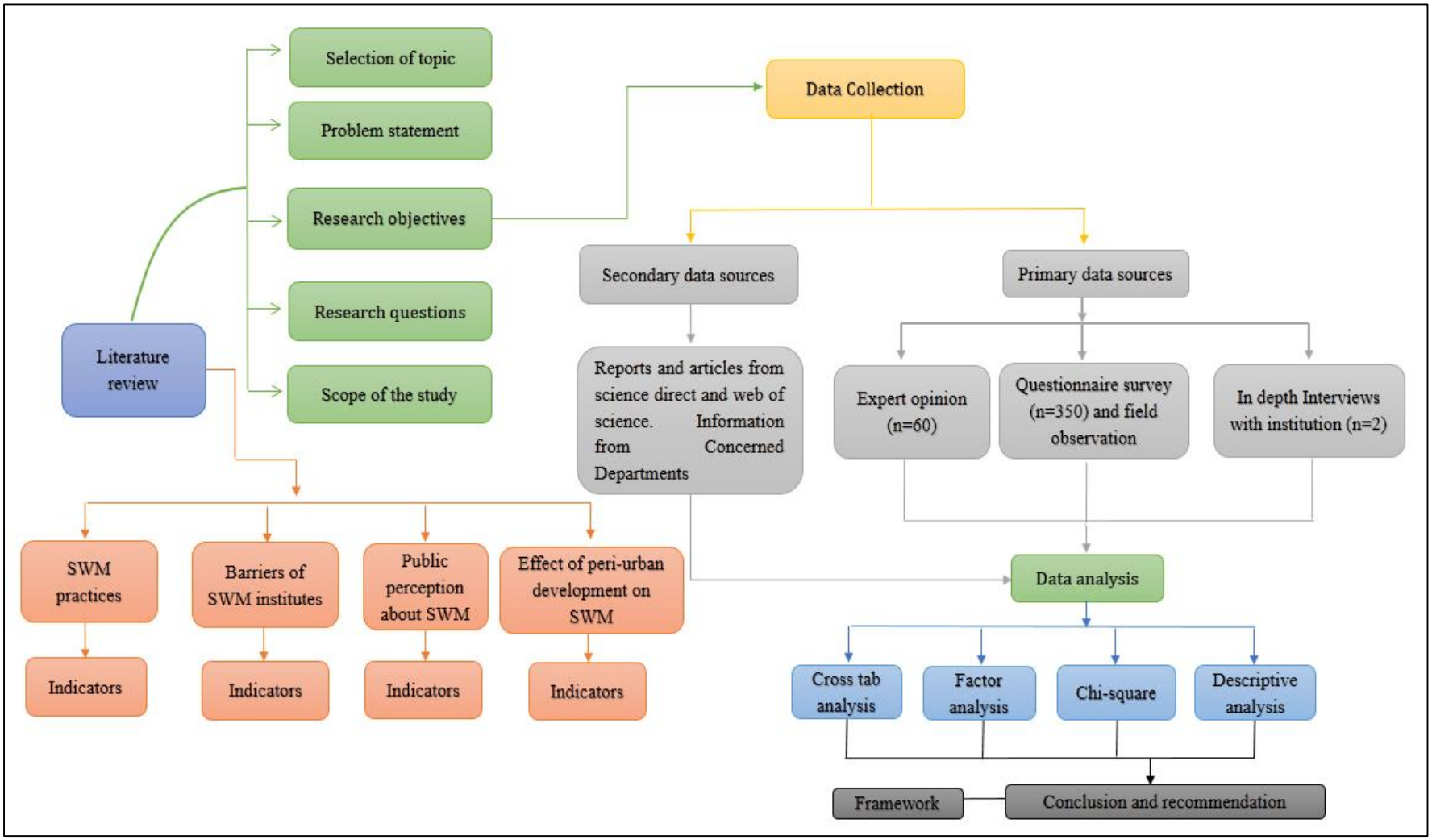


Figure 5: Research methodology flow chart

3.5. Data collection

The main part of this research was collecting data to achieve the study's main objective, which is "assessing the effect of peri-urban development on SWM institutes." This objective requires primary data and secondary data, and for this purpose, both data were collected.

3.5.1. Secondary data

It was the backbone of this research. Previously existing literature on solid waste practices, household perception about the SWMS, and SWMS barriers were identified from research papers, official reports, published reports, and policy papers. Articles were downloaded from different scientific websites, i.e., Google scholar, science direct, and web of science published from 1991 to 2021, to collect the indicators to achieve the study's main objective.

3.5.2. Primary Data

It was collected to fill the gap in secondary data and to assess the effect of peri-urban development on SWM institutes. Three different questionnaires were prepared to collect primary data. Primary data was collected through three major sources.

i. The close-ended questionnaire was prepared from the indicators related to socio-demographic characteristics of households, SWM practices, and perception of households about SWMS. The questions of practices were provided with options from which the household has to select an option, while the questions of perception were valued on the Likert Scale. Furthermore, field observation was also done by taking pictures.

ii. An open-ended questionnaire was prepared to conduct interviews with the official of institutions performing SWM in peri-urban areas to understand the effect of peri-urban development on SWM institutes.

iii. The close-ended questionnaire was prepared from the barriers identified through literature, including questions related to socio-demographics of experts. The questionnaire was valued on the Likert Scale. The public sector organizations from where the expert opinion was retrieved include RWMC, CDA, RDA, MCI. The experts working in private sector organizations were included from the PWD Society office and Maintenance & Services Department, Bahria Town (Pvt. Ltd), etc. Furthermore, the experts from academia were also part of the expert opinion survey. The experts were very professional with their work, attitude and they perform their duties with full dedication.

3.5.3. Sample size

Three different questionnaires prepared to collect the data with sample size are discussed below.

i. Household questionnaire

Many financial and human resources, logistics, and time were required to conduct a 100% study of the area. Considering these limitations, the study was based on sampling. The technique used to select the sample population was simple random sampling for examining SWM practices and recording the household perception about the SWMS. 350 questionnaires were collected from the study area. 46.85% of questionnaires were collected from the private

sector, and 53.14% of questionnaires were collected from the public sector in peri-urban areas.

Table 1: Questionnaires collected from different areas

Questionnaires collected from different areas		Frequency	Percent
Name of Town/ Area	PWD Housing Society	80	22.9
	Bahria Town Rawalpindi	84	24.0
	UC-82 Morgha	100	28.6
	UC-86 Dhamial	86	24.6
	Total	350	100.0
Type of Institute	Public	186	53.14
	Private	164	46.85
	Total	350	100

ii. Institutional questionnaire

To obtain the institutional perspective about the effect of peri-urban development on SWM institutes. The officials of institutions were interviewed, i.e., one each from public and private sector institutes (n=2).

iii. Expert opinion questionnaire

To retrieve the expert opinion for identifying the barriers of SWMS in peri-urban areas. 70 questionnaires were disseminated among the experts from the public and private sector organizations, and 60 questionnaires were received with a response rate of 85.7%.

3.6. Indicators

The indicators to assess the effect of peri-urban development on SWM institutes are identified through three main stages.

i. Indicators systemization and selection.

ii. Survey and systemization of indicators.

iii. Implementation of indicators.

3.6.1. Indicators systemization and selection

The data collection indicators were identified through research articles, published reports, official reports, policy papers, and publications. The data was searched online from different official and scientific websites. Google scholar, web of science, and science direct were used to download articles related to SWMS from 1991 to 2021.

3.6.2. Survey and systemization of indicators

Journals and online databases were searched for finding research papers and institutionally published reports related to SWM practices, perception of household about SWM, barriers of the SWMS, and effect of peri-urban development on SWM institutes by using keywords, i.e., SWM, SWMS, SWM practices, SWM generation, disposal, collection, separation, household satisfaction, household attitude, household willingness, household knowledge and barriers of SWM during the period from 1991 to 2021. This technique helped in identifying 75 indicators.

3.6.3. Indicators selections

The content analysis method was used, which include three stages;

i. Removing the repetition of indicators by self-evaluation.

ii. The indicators were compared with the basic meaning of the SWMS.

iii. Availability of data.

By using these criteria, the indicators were reduced to 64 from 75.

3.6.4. Implementation of selected indicator

The remaining 64 indicators were used to make the questionnaire for data collection.

The indicators used for making the questionnaire for assessing the SWM practices in study area are shown below. It includes 18 indicators about demographic information, SW generation, storage, disposal, and collection.

Table 2: Indicators for the questionnaire of SWM practices

S. No.	Indicators	References
1	Education of the household head.	(Benítez and Ojeda, 2008; Noufal & Adipah, 2020; Zaman, 2014)
2	Household size.	(Benítez and Ojeda, 2008; Noufal & Adipah, 2020; Zaman, 2014)
3	Household monthly income.	(Benítez and Ojeda, 2008; Noufal & Adipah, 2020; Zaman, 2014)
4	Estimated waste generated daily.	(Benítez and Ojeda, 2008; Karak & Bhagat, 2012; Monavari & Omrani, 2012)
5	Type of waste generated daily.	(Benítez and Ojeda, 2008; Karak & Bhagat, 2012; Monavari & Omrani, 2012)
6	Type of container for storage of waste in the house.	(AlHumid & Hatem, 2019; Zaman, 2014)
7	Where is the household disposing of solid waste?	(AlHumid & Hatem, 2019; Yoada & Chirawurah, 2014; Zaman, 2014)
8	How often emptying the solid waste container inside the house?	(AlHumid & Hatem, 2019; Zaman, 2014)
9	Practicing waste separation inside house.	(AlHumid & Hatem, 2019; Yoada & Chirawurah, 2014; Zaman, 2014)
10	Availability of public bin near the house.	(AlHumid & Hatem, 2019; Zaman, 2014)
11	Condition of public bin near house.	(AlHumid & Hatem, 2019; Zaman, 2014)
12	Dumping waste alongside garbage bin.	(AlHumid & Hatem, 2019; Zaman, 2014)
13	How often emptying the public bin near the house?	(AlHumid & Hatem, 2019; Zaman, 2014)
14	Availability of garbage collection services from home.	(Feo & Ferrara, 2019; Yoada & Chirawurah, 2014)
15	Waste collection charges.	(Feo & Ferrara, 2019; Yoada & Chirawurah, 2014)
16	How often does the waste collector collect waste from the house?	(Feo & Ferrara, 2019; Yoada & Chirawurah, 2014)
17	Priority concern for solid waste in your area.	(Yoada & Chirawurah, 2014; Zaman, 2014)
18	Type of institute responsible for SWM in your area.	(Yoada & Chirawurah, 2014; Zaman, 2014)

The indicators used for making the questionnaire for assessing the household perception about SWM in study area are shown below. It includes 19 indicators about household perception regarding SWM in peri-urban areas.

Table 3: Perception of household about the SWM.

S. No.	Variables	References
1	Satisfied with the overall performance of SWM authority.	(Choon & Tan, 2017)
2	Satisfied with the solid waste bin location near our house	(Choon & Tan, 2017)
3	Satisfied with the solid waste bin size near our house.	(Choon & Tan, 2017)
4	Satisfied about SW collection fee system.	(Jones & Evangelinos, 2010)
5	Understanding the concept of sustainable SWM.	(Akil, 2014)
6	Effective SWM has a positive effect on sustainable development.	(Akil, 2014)
7	Many environmental issues will be minimized if SW is managed properly.	(Afroz & Tudin, 2011)
8	The main environmental issue is SW.	(Srivastava & Ismail, 2015)
9	The new development process has a negative impact on SWM in our area.	(Srivastava & Ismail, 2015)
10	Attended seminars/ events related to SWM.	(Afroz & Tudin, 2011)
11	Understanding the importance of recycling SW.	(Afroz & Tudin, 2011)
12	Individual responsibility to contribute to the SWMS.	(Babaei et al., 2015)
13	Waste collection authority treats all households equally.	(Choon & Tan, 2017)
14	Waste collection staff collects waste from our neighbourhood in the right/ needed time.	(Choon & Tan, 2017)
15	Concerned about the SW impact on health.	(Alam & Ahmade, 2013)
16	Submit complain to SWM authority.	(Afroz & Tudin, 2011)
17	Willing to participate in WM seminar/event.	(Afroz & Tudin, 2011)
18	Willing to do waste separation inside my house.	(Afroz & Tudin, 2011)
19	Willingness to pay extra for better WCS.	(Babaei et al., 2015)

The indicators used for making the questionnaire about SWM barriers are shown below. It includes 27 indicators about SWMS.

Table 4: Barriers of the SWMS

Code	Barriers	References
V1	Household has less awareness regarding SWM.	(Marshall & Khosrow, 2013; Yukalang & Ross, 2017)
V2	Implementation of regulations related to solid waste is poor.	(Esmaeilian et al., 2018)
V3	SWM institutes lack the capacity to operate.	(Fernando, 2019)
V4	Insufficient funds to carry out SWM operations.	(Marshall & Khosrow, 2013)
V5	Human resource has a low capability to operate SWM.	(Yukalang & Ross, 2017)
V6	Insufficient funds for conducting research on SWM.	(Yuan, 2013)
V7	The waste collection fee system is uncertain.	(Aid et. al, 2017)
V8	Low financial viability of WM system.	(Aid et. al, 2017)
V9	Increase in area of operation for solid waste.	(Moghadam & Mokhtarani, 2009)
V10	Increase in the total quantity of solid waste.	(Moghadam & Mokhtarani, 2009)
V11	Inappropriate facilities for waste separation.	(Yukalang & Ross, 2017)
V12	Uncontrolled disposal sites.	(Moghadam & Mokhtarani, 2009)
V13	Inadequate waste treatment capacity.	(Fernando, 2019)
V14	Inadequate use of necessary instruments and technology for collection of solid waste.	(Fernando, 2019)
V15	Inadequate use of necessary instruments and technology for disposal of solid waste	(Fernando, 2019)
V16	Inadequate use of necessary instruments and technology for recycling of solid waste	(Fernando, 2019)
V17	Improper training of waste workers.	(Fernando, 2019)
V18	Operational equipment is insufficient for the collection of solid waste.	(Yukalang & Ross, 2017)
V19	Operational equipment is insufficient for the transfer of solid waste.	(Yukalang & Ross, 2017)
V20	Formal waste recycling facilities are not existing.	(Yuan, 2013)
V21	Haphazard growth makes waste collection difficult.	(Fernando, 2019; Yukalang & Ross, 2017)
V22	Poor community engagement by organizations in WM activities.	(Fernando, 2019; Yukalang & Ross, 2017)
V23	Lack of coordination and communication between SWM organizations.	(Aid et. al, 2017)
V24	Irrational behaviour of households regarding disposal of solid waste.	(Marshall & Khosrow, 2013; Yukalang & Ross, 2017)
V25	Incomplete regulations of SWM.	(Yukalang & Ross, 2017)
V26	Poor data management by SWM institutes.	(Esmaeilian et al., 2018)
V27	Inadequate knowledge about potential benefits regarding SWMS	(Aid et. al, 2017; Yukalang & Ross, 2017)

3.7. Data analysis methods

In this research, qualitative and quantitative data were evaluated. The qualitative data was valued on the Likert Scale. The Likert Scale is taken on five-scale parameters, i.e., one represented strongly disagree means the poorest condition, two represented disagree means a poor condition, three represented uncertain means moderate condition or respondent do not know the answer, four represented agree means the good condition and five represented strongly agree means very good condition.

Table 5: Interpretation of Likert Scale

Value	Response	Interpretation
1	Strongly Disagree (SD)	Poorest condition
2	Disagree (D)	Poor condition
3	Uncertain (Un)	Moderate condition or unclear about the question
4	Agree (A)	Good condition
5	Strongly Agree (SA)	Very good condition

The descriptive data was also collected by making close-ended questionnaires. Both qualitative and quantitative data were analysed by using SPSS and Microsoft Excel. SPSS was used for descriptive analysis to obtain chi-square value (*p*-value), cross-tabulation, mean ($\bar{X}$), standard deviation, and frequencies of the respondents. Microsoft Excel was used for graphical representation of the data. Factor Analysis (FA) was carried out in SPSS. The data analysis techniques are explained below.

3.7.1. Chi-square test of independence

The p-value has been used to measure the significance level (where $\alpha = 0.05$). If the p-value is less than α, the respondents have different opinions about the question. In case, p-value is larger than α, the respondents have the same opinion about the question (McHugh, 2013).

3.7.2. Cross tabulation

Cross tabulation is a technique to analyse the association between indicaotrs quantitatively. The variables are grouped to know the correlation between different variables and change in correlation from one grouping variable to another grouping variable (Kamakura, 1997).

3.7.3. Mean value ($\bar{X}$) sub-division for Social Sustainability Index (SSI)

To calculate the Social Sustainability Index (SSI), mean value ($\bar{X}$) of each variable was combined to calculate the mean value ($\bar{X}$) of each sub-index. The mean value ($\bar{X}$) of each sub index was valued on following scale.

Table 6: Mean value ($\bar{X}$) sub-division for SSI

Serial No.	Mean ($\bar{X}$) value range	Interpretation
1	0 – 1	Not sustainable
2	1.01 -2.5	Low sustainability
3	2.51 – 4	Moderate sustainability
4	4.01 – 5	High sustainability

3.7.4. Mean ($\bar{X}$)

The mean value ($\bar{X}$) was also calculated by using the formula stated below (Chakrabarty, 2018).

It is expressed as.

Mean = Sum of total observations ÷ Total numbers of observations

3.7.5. Standard deviation

A standard deviation (or σ) shows the spreading of data by considering the ($\bar{X}$) of the data. A small value indicates that data is gathered around the ($\bar{X}$), and a large value indicates that data is spread around the ($\bar{X}$) (Wan & Wang, 2014).

3.7.6. Factor Analysis (FA)

The barriers collected from the expert opinion survey were analysed through FA. It benefits in determining and grouping the large set of variables into relatively small and meaningful factors to explain certain perspectives (Tucker, 1958). Furthermore, PCA method was used in the FA because it identifies and calculates the composite scores for variables or factors.

3.8. Covid-19 SOPs

Covid-19 SOPs were strictly followed during data collection as advised by the National Command and Operation Centre (NCOC), Government of Pakistan. The main preventive measures taken during the survey are written below.

i. Avoided physical contact with respondents during data collection.

ii. Made sure that both respondent and surveyor was wearing the mask

iii. Used hand sanitizer before giving and after receiving the questionnaire from the respondent.

iv. Six feet distance was maintained during the household survey and expert opinion survey.

4. CHAPTER: SWM PRACTICES IN PERI-URBAN AREAS

4.1. Introduction

This section identifies the practices of SWM in study area. 350 household questionnaires were collected to examine the SWM practices in peri-urban areas. The data collected from the households was analysed by using SPSS. SPSS was used for descriptive analysis to obtain chi-square value (*p*-value), cross-tabulation, mean ($\bar{X}$), Standard deviation and frequencies of the respondents.

4.2. Data analysis

The detailed analysis is discussed below.

4.2.1. Socio-demographic characteristics of households

Education-wise, 31.7% of respondents have the matric education or less while 8.0% of respondents have the education of M.Phil. or MS. Furthermore, 23.7% of respondents have done B.A. or B.Sc., 22.0% of respondents have studied Master or BS (Hons.), and 14.6% of respondents have done intermediate. The average ($\bar{X}$) education of the household was 12, i.e., intermediate with a SD of 3.73.

The average ($\bar{X}$) household size of the respondents was 6.35 with a standard deviation of 1.86. The average ($\bar{X}$) household size in the private sector was 6.30 with a standard deviation of 1.76 while the average ($\bar{X}$) household size in the public sector was 6.40 with a standard deviation of 1.93. It indicates that areas, where public sector institutions carry out SWM have a relatively high average ($\bar{X}$) household size. 34.0% of respondents have a household size of 7-8, while 14.9% of respondents have 9 or more members. Furthermore, respondents

having household size 4 or less is 20.6%, and 30.6% of respondents have a household size ranging between 5-6.

Table 7: Socio-demographic Characteristics of Household

Socio-Demographics		Frequency	Percent	Mean ($\bar{X}$)	Std. Deviation
Education of Respondent	Matric or less	111	31.7	12	3.73
	Intermediate	51	14.6		
	B.A or B.Sc.	83	23.7		
	Masters	77	22.0		
	M.Phil. or MS	28	8.0		
	Total	350	100.0		
Household Size	4 or less	72	20.6	6.35	1.86
	5 – 6	107	30.6		
	7 – 8	119	34.0		
	9 or more	52	14.9		
	Total	350	100.0		
Household Income (In PKR)	50,000 or less	45	12.9	98928	60118
	50,001 – 75,000	120	34.3		
	75,001 – 100,000	92	26.3		
	100,001 – 125,000	27	7.7		
	More than 125,000	66	18.9		
	Total	350	100.0		

Household income-wise, 34.3% of respondents have an income ranging between 50,001 to 75,000 while 7.7% of households have income stretching between 100,001 to 125,000. Furthermore, 26.3% of respondents have a household income ranging from 75,001 to 100,000, 18.9% of households have income higher than 125,000, and 12.9% of households have an income of 50,000 or less. The average ($\bar{X}$) household income was 98,928 with a standard deviation of 60,118. The average ($\bar{X}$) household income in areas where SWM is carried out by public sector is 77,184 with a standard deviation of 28,445, while the average ($\bar{X}$) household income in areas where the private sector carry out SWM is 123,751 with a standard deviation

of 74,042. It indicates that households living in areas where the private sector carry out SWM have a higher income as compared to areas where the public sector carries out the SWM.

4.2.2. Estimated daily waste generated by households

The information was retrieved from the respondents about the estimated daily waste generated by the household. 36.9% of respondents have answered that they generate 0.6kg – 1kg of solid waste daily, of which 36.0% belongs to the public sector while 37.8% belongs to the private sector. 14.3% of respondents replied that they generate 0.5kg or less solid waste daily, of which 12.4% belongs to the public sector and 16.5% belongs to the private sector. Furthermore, 16.9% of respondents replied that they generate 1.1kg to 1.5kg solid waste daily, of which 16.7% belongs to the public sector, and 17.1% of respondents belongs to the private sector. 16.9% of respondents generate solid waste of 1.6kg to 2.0kg, of which 17.7% belongs to the public sector, and 15.9% belongs to the private sector. 15.1% of respondents replied that they generate more than 2kg SW daily, of which 17.2% belongs to the public sector and 12.8% of households belongs to the private sector. The average ($\bar{X}$) amount of daily SW generated by households is 1.32kg with a SD of 0.64. Furthermore, the average ($\bar{X}$) amount of SW generated by households in the study area where the public sector carries out SWM is 1.36kg, with a SD of 0.66. In comparison, the average ($\bar{X}$) amount of SW generated by households where the private sector carries out the SWM is 1.26kg with a SD of 0.64.

Table 8: Estimated daily solid waste generated

Indicator		Type of Institute		Total	*chi-square test*
		Public	**Private**		
Estimated daily solid waste generated	0.5Kg or less	12.4%	16.5%	14.30%	X^2= 2.407 *p*-value= 0.661
	0.6Kg - 1Kg	36.0%	37.8%	36.90%	
	1.1Kg - 1.5Kg	16.7%	17.1%	16.90%	
	1.6Kg - 2Kg	17.7%	15.9%	16.90%	
	More than 2 Kg	17.2%	12.8%	15.10%	
	Total	**100.00%**	**100.00%**	**100.00%**	

The results indicate that respondents living in the peri-urban area where the public sector carries out the SWM have a higher average ($\bar{X}$) household size, i.e. 6.40 and generate a higher average ($\bar{X}$) amount of solid waste, i.e. 1.36kg/day as compare to the private sector which has comparatively smaller average ($\bar{X}$) household size, i.e. 6.30 and generate less amount of average daily solid waste 1.26kg/day. It indicates that the larger the household size, the greater the daily SW generation. In Vietnam, a study conducted by (Trang & Dong, 2017) has also established that the larger the HH size, the greater the amount of daily SW generated. The p-value (0.661) indicates no significant variance between the opinion of households in the study area.

4.2.3. Type of SW generated by households

The households were questioned regarding the type of SW generated daily. The organic or vegetable waste generated daily by households has the highest percentage in the public and private sectors, i.e., 37.03% and 40%. The least type of SW generated by resepondents living in public and private sectors is metal, and its daily generation is 0.99% and 1.3%.

Table 9: Composition of solid waste generated

	Categories	Type of Institute			
		Public		Private	
		($\bar{X}$)	SD	($\bar{X}$)	SD
Composition of solid waste generated	Plastic (%)	31.61	7.72	31.34	8.92
	Glass (%)	2.9	3.51	2.71	3.93
	Paper (%)	27.47	7.34	24.17	8.37
	Organic or Vegetable waste (%)	37.03	8.54	40	9.99
	Metal (%)	0.99	2.07	1.3	2.60

The household in areas operated by the public sector generates 31.61% of plastic waste daily, while households in the private sector generate 31.34% of plastic waste daily. The respondents living in the public sector generate 27.47% of paper waste daily, while the private sector household generates 24.17% of paper waste daily. The household living in areas operated by the public sector generates 2.9% of glass waste daily, while households living in the private sector generate 2.71% of glass waste daily. (Sha'Ato et al., 2007) in his study submitted that household generates much less metal and glass waste than paper and plastic waste.

4.2.4. Public bins availability and its usage by households

The information related to the availability of public bins, condition of public bins, people dumping garbage alongside public bins, and behavior of people regarding dumping of solid waste alongside public bins was retrieved from the respondents.

The *p*-value (0.000) indicates a major variance of opinion amongst households living in study area where SW is managed by the public and private SWM institutes.

84.6% of respondents answered that public bin is available near our house while 15.4% of respondents replied that public bins are not available near our house.

Furthermore, 100.0% of respondents in the private sector replied that public bins are available near our house, while 71.0% of respondents answered that public bins are available near our house in the public sector.

Table 10: Public bins availability and its usage

Public bins availability and its usage		Type of Institute		Total	*Chi-square test*
		Public	**Private**		
Availability of Public bins near your house	Yes	71.0%	100%	84.6%	X^2= 56.299 *p*-value= 0.000
	No	29.0%	0.0%	15.4%	
	Total	186	164	350	
		100%	100%	100%	
Condition of Public bins near your house	Good Condition	53.8%	74.4%	65.2%	X^2= 13.682 *p*-value= 0.000
	Bad Condition	46.2%	25.6%	34.8%	
	Total	132	164	296	
		100%	100%	100%	
How often is the public bin emptied?	Everyday	36.4%	65.9%	52.7%	X^2=26.712 *p*-value= 0.000
	Two Times a week	32.6%	20.7%	26.0%	
	Once a week	31.1%	13.4%	21.3%	
	Total	132	164	296	
		100%	100%	100%	
People are dumping SW beside trash bin inlieu of placing it in the trash bin	Yes	47.7%	21.3%	33.1%	X^2=22.991 *p*-value= 0.000
	No	52.3%	78.7%	66.9%	
	Total	132	164	296	
		100%	100%	100%	
Why do people dump solid waste alongside garbage bins?	Difficult to place the SW in the trash bin due to SW nearby the trash bin	34.9%	48.6%	39.8%	X^2=18.151 *p*-value= 0.000
	Bin is always fully occupied	38.1%	0.0%	24.5%	
	Irrational behavior of people	27.0%	51.4%	35.7%	
	Total	63	35	98	
		100%	100%	100%	

52.7% of households replied that the public bin is emptied daily, of which 65.9% of respondents belong to the private sector, and 36.4% of respondents belong to the public sector. 26.0% of respondents answered that public bins are emptied once a

week, of which 32.6% belong to the public sector, and 20.7% belong to the private sector. 21.3% of respondents replied that public bins are emptied two to three times a week, in which 31.1% of respondents belong to the public sector while 13.4% of respondents belong to the private sector.

33.1% of respondents answered that people are dumping solid waste alongside garbage bins instead of putting it inside the garbage bin, of which 47.7% of households belong to the public sector, and 21.3% of respondents belong to the private sector. 66.9% of households replied that people are not dumping solid waste alongside garbage bin, of which 78.7% belongs to the private sector and 52.3% belongs to the public sector.

Figure 6: Garbage placed alongside public bin in the public sector

When respondents were asked about the reason behind dumping garbage alongside garbage bin instead of putting it inside, 39.8% answered that it's difficult to place the SW in the trash bin due to SW nearby the trash bin in which 34.9% belongs to the public sector, and 48.6% belongs to the private sector, 24.5% answered that bin

is always fully occupied where all respondents belong to the public sector, and 35.7% of respondents answered that it is due to irrational behavior of people in which 51.4% belongs to the private sector, and 27.0% belongs to the public sector.

4.2.5. Storage, waste separation, and disposal of SW

The respondents were asked about the storage, separation, and disposal of SW by respondents in study area. The *p*-value of practicing waste separation inside the house is 0.125, indicating similar responses from public and private households. The *p*-value of solid waste storage, place of disposing household waste, and often disposal of household waste is equal to or less than 0.005, which shows a significant difference between respondents' opinions in peri-urban areas managed by the public and private sector institutes.

68.9% of household answered that they dispose of household waste daily, of which 78.0% of respondent belongs to the private sector, and 60.8% of household belongs to the public sector. 21.7% of household answered that they dispose of their household waste two times a week, of which 21.5% belongs to the public sector, and 22.0% belongs to peri-urban area managed by private sector institute for SW. Furthermore, 17.7% of HH answered that they dispose of their household waste once a week. All these respondents belong to peri-urban areas managed by public sector institutes.

Table 11: Storage, waste separation and disposal of household solid waste

Storage, waste separation, and disposal of HH SW		Type of Institute		Total	*Chi-square test*
		Public	Private		
Storage of solid waste inside the house	Rubbish bin/drum	50.0%	60.4%	54.9%	X^2=18.151 *p*-value= 0.000
	Plastic Bag	50.0%	39.6%	45.1%	
	Total	186	164	350	
		100.0%	100.0%	100.0%	
Practising waste separation inside the house	Yes	19.9%	26.8%	23.1%	X^2= 2.358 *p*-value= 0.125
	No	80.1%	73.2%	76.9%	
	Total	186	164	350	
		100.0%	100.0%	100.0%	
Place of disposing household waste	Nearby Container	69.4%	67.7%	68.6%	X^2= 110.403 *p*-value= 0.125
	Open Space/ Vacant Plot	30.6%	0.0%	16.3%	
	Handed over to the waste collector	0.0%	32.3%	15.1%	
	Total	186	164	350	
		100.0%	100.0%	100.0%	
How frequently you dispose of your HH SW?	Everyday	60.8%	78.0%	68.9%	X^2= 32.891 *p*-value= 0.000
	Two times a week	21.5%	22.0%	21.7%	
	Once in a week	17.7%	0.0%	9.4%	
	Total	186	164	350	
		100.0%	100.0%	100.0%	

54.9% of households answered that they store solid waste in a rubbish bin/ drum inside the house, of which 60.4% of respondent belongs to the private sector, and 50.0% of respondents belongs to the public sector. Furthermore, 45.1% of households responded that they store solid waste in a plastic bag, of which 39.6% belong to the private sector, and 50.0% belong to the public sector. The respondents were asked about the disposal of household waste. 68.6% answered that they dispose of their household waste to a nearby container, of which 67.7% belong to the private sector and 69.4% belong to the public sector.

Figure 7: Households dispose of their SW to open space plot in the public sector.

30.6% of respondents answered that they dispose of their household waste to nearby open space/ vacant plots. All these respondents belong to peri-urban areas managed by public sector institutes. Furthermore, 32.3% of respondents answered that they hands over waste to waste collector. All these respondents belong to peri-urban areas managed by private sector institutes.

Figure 8: Household waste is placed inside the box in the private sector.

76.9% of households answered that they are not practicing waste separation inside the house, of which 73.2% of household belongs to the private sector, and 80.1% of household belongs to the public sector. Furthermore, 23.1% of households responded that they are practicing waste separation inside the house, of which 26.8% belong to the private sector, and 19.9% belong to the public sector.

4.2.6. Garbage collection service from houses in peri-urban areas

The *p*-value (0.000) for the availability of garbage collection services from houses suggests a significant difference between respondents' opinions in the stydy area.

Table 12: Garbage collection services

Garbage collection services		**Type of Institute**		**Total**	***Chi-square Test***
		Public	**Private**		
Availability of Garbage collection services from houses	Yes	0.0%	100%	46.9%	X^2=350.000 *p*-value= 0.000
	No	100%	0.0%	53.1%	
	Total	186	164	350	
		100%	100%	100%	
How often do waste collectors collect waste from houses	Everyday	0%	62.2%	62.2%	
	2-3 Times a week	0%	37.8%	37.8%	
	Total	0	164	164	
		0%	100%	100%	
Waste Collection Fees	500	0%	29.3%	29.3%	
	600	0%	32.3%	32.3%	
	650	0%	15.8%	15.8%	
	800	0%	9.80%	9.80%	
	1250	0%	6.10%	6.10%	
	1400	0%	6.70%	6.70%	
	Total	0	164	164	
		0%	100%	100%	

The garbage collection services from houses are available only in the peri-urban area managed by the private sector institutes. 62.2% of households in the private sector answered that waste collector collects household waste from houses daily. 37.8% of households in the private sector answered that waste had been collected from their

houses two to three times a week. The waste collection fees have been collected in the private sector only where 77.4% of households answered that they pay 500 to 650 Pkr/ Month while 12.8% of households pay 1250 to 1400 Pkr/Month for solid waste collection services. Houses having larger areas have to pay more for waste collection services in peri-urban areas managed by the private sector institutes.

4.2.7. Priority concern for solid waste in peri-urban areas

The *p-value* (0.000) indicates a noteworthy variance among respondents' opinions, which shows that respondents living in the study area have different concerns regarding SW.

The HH were enquired regarding the priority concern of SW in their areas. 56.6% of respondents replied that there is no concern of solid waste in their areas, of which 78.7% belong to the private sector, and 37.1% belong to the public sector. 10% of the respondents answered that solid waste negatively affects the environment in our area, of which 4.9% belongs to the private sector, and 14.5% belongs to the public sector.

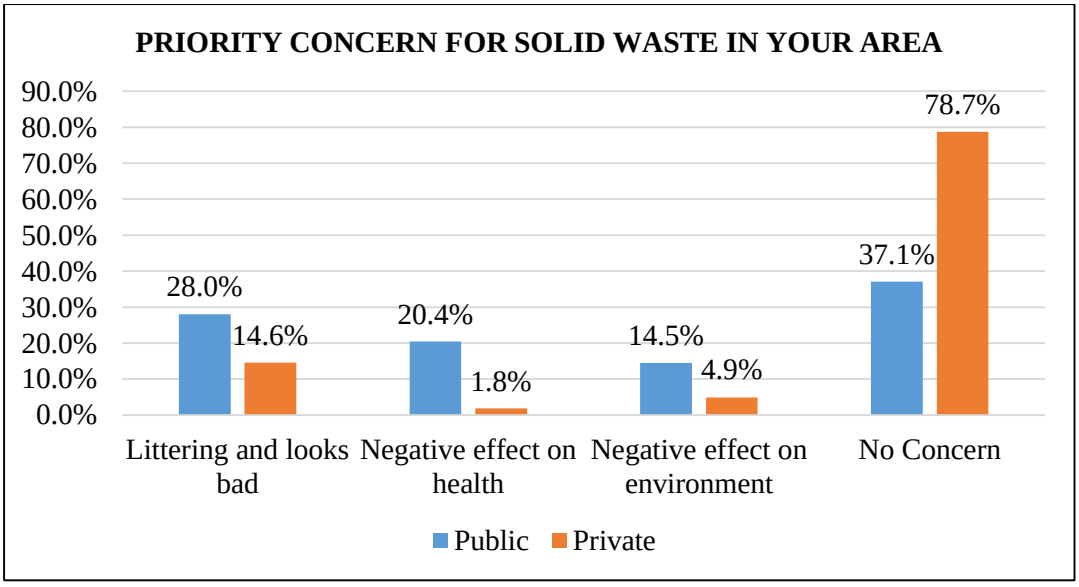


Figure 9: Priority concern for SW.

Furthermore, 21.7% of households consider littering and looking bad as a priority concern for solid waste, in which 28.0% belongs to the public sector, and 14.6% belongs to the private sector. The reason behind the high number of respondents in the public sector is that there is no public bin available in some neighbourhoods due to which households dump their waste in open spaces/ vacant plots. 11.7% of households consider that solid waste has a negative effect on our health, in which 20.4% of households belong to the private sector, and 1.8% of households belong to the public sector.

4.2.8. Evaluating the key performance indicator SWM practices

SWM practices were evaluated using indicators from the questionnaires collected from the peri-urban areas.

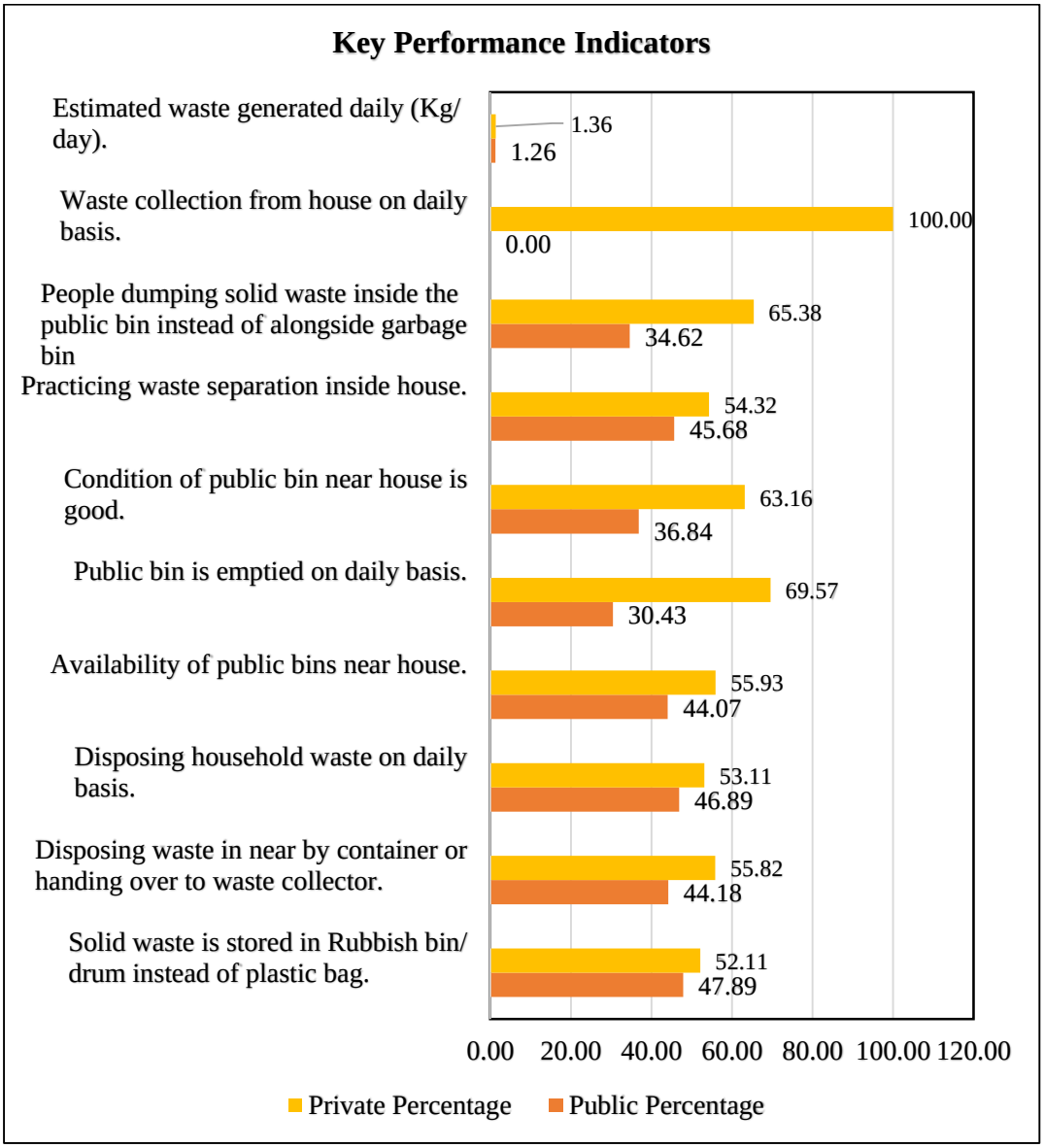


Figure 10: Key performance indicator of SWM practices in study area.

More households dispose of HH waste daily in study area managed by the private sector institutes than public sector institutes for solid waste. A higher number of households use rubbish bins/drums instead of plastic bags in the private sector than the public sector, resulting in less use of plastic in the private sector. Furthermore, more households in the private sector dispose of their household waste to either nearby containers or are handed over to waste collectors than the public sector.

Many respondents in peri-urban areas managed by the private sector institute answered that the public bins are available near our house compared to the public sector. There were some areas in the public sector where bins were not available. People were dumping household waste in open space/ vacant plots, resulting in littering and negatively affecting the environment and health. The condition of the public bin is good in peri-urban areas managed by the private sector, as compared to the public sector. Furthermore, many respondents answered that public bins are emptied daily in the private sector. In contrast, very few respondents answered that public bins are emptied daily in the public sector. Most households do not carry out the practice of waste separation in the public and private sectors. 81 out of 350 respondents answered that they are practicing waste separation inside the house in peri-urban areas managed by the public and private sector institutes for solid waste. Many households living in the private sector are dumping solid waste inside the garbage bin instead of putting it alongside the garbage bin compared to the public sector. One of the main reasons which is evident from this study is that in the private sector, solid waste bins are emptied daily due to which people dump their household waste inside the garbage bin, while in public sector household complains that the bin is always fully occupied due to which they are unable to dump solid waste inside the public bin. Resultantly, households put solid waste alongside garbage bins. Furthermore, there are no waste collection services from houses in peri-urban areas managed by the public sector institutes for solid waste. In contrast, the private sector provides waste collection services from houses on an almost daily basis. The average daily waste generation by household is relatively greater in peri-urban areas managed by the public sector than the private sector.

5. CHAPTER: EFFECTS ON SWM INSTITUTES BY PERI-URBAN DEVELOPMENT

5.1. Introduction

This section explains the effects of peri-urban development on SWM institutes by studying the barriers of SWM in study area through expert opinion surveys and in-depth interviews with officials of SWM institutes in peri-urban areas about the effects of peri-urban development on SWM institutes. The factor analysis done in SPSS to analyse barriers, and in-depth interviews were explained in narration. The detailed analysis is discussed below.

5.2. Socio-Demographic characteristics of experts

Representing the age group of experts, 50% of experts were young, ranging between 19-34 years and 50% of respondents were old, ranging between 35-65 years. The ($\bar{X}$) age of experts was 38 y, and the SD was 10.349.

Table 13: Socio-Demographics Characteristics of experts

Socio-Demographics		**Frequency**	**Percent (%)**	**Mean** ($\bar{x}$)	**Standard Deviation** (**σ**).
Age	Young (19 – 34 years)	30	50.0	38	10.349
	Old (35 – 65 years)	30	50.0		
Experience	Less than 10 years	27	45.0	13	8.849
	10 or more years	33	55.0		
Qualification	Bachelors	26	43.3	1.61	0.584
	MS or M.Phil.	31	51.7		
	Ph.D.	3	5.0		
Office type	Private	29	48.3	1.51	0.503
	Public	31	51.7		

When weighing the respondents based on their experience, 45% of experts have experience less than 10 years while 55% have experienced more than 10 years, average ($\bar{X}$) experience of experts was 13 years. The SD of experience was 8.849.

Demonstrating qualification of the experts, 51.7% of experts have done MS or M.Phil., 5% of experts have done doctorate (Ph.D.), indicating that more than half of the respondents are highly qualified. In comparison, 43.3% of respondents have done bachelors in their respective fields.

When weighing the type of office where experts were working, 51.7% of experts work in public offices while 48.3% of experts work in private offices.

5.3. Statistical Analysis

The data collected for measuring the barriers were analysed using software, i.e., Microsoft Office and SPSS. Microsoft Office was used for calculating means, frequencies, percentages, and average means. The data reduction method, i.e., factor analysis, was executed in SPSS to categorize the barriers to understanding the data better.

5.4. Reliability statistics

Firstly, the data reliability was measured in SPSS by applying Cronbach's Alpha method. This test measures the internal consistency amongst the different factors. In this case, the value is 0.951, greater than the least value of 0.7, indicating that this study's data is reliable at a 5% significance level.

5.5. Factor analysis

The factor analysis was executed for easy understanding and a better interpretation of the barriers. The analysis output has a few factors that explain the large portion of total variability and suitable names are assigned to these variables that highly

correlate with each other. Other tests were also applied, i.e., KMO and Bartlett's test to check the suitability and reliability of the data for FA.

5.5.1. KMO and Bartlett's test

The FA was carried out to convert all variables into well-integrated and suitable factors/ categories using IBM SPSS.

The KMO is a value that presents the extent of variance in the variables due to underlying factors. The value of KMO should be between 0.5-1 for useful FA. In this case, the KMO value is 0.769, indicating that our data is useful for FA.

Table 14: KMO and Bartlett's test

KMO and Bartlett's test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.769
Bartlett's Test of Sphericity	Approx. Chi-Square	1488.105
	Df	351
	Sig.	.000

Additionally, the table shows Bartlett's test of sphericity in which chi-square was recorded to be 1488.105, which is a very large value and has significance at the lowest possible, i.e., 0.000. This shows that our data is useful for FA.

5.5.2. Total variance explained

The PCA Method was applied to the data in SPSS to make categories. There was no specific number of factors specified in SPSS to make the preferred categories. The SPSS extracted five factors in this study, and these five factors together explain 70.855% of the total variance. Reviewing initial factor loading suggests that a proper solution was achievable through Principal Component Analysis.

The results of the table below indicate that the 1st factor explains 47.069%, the 2nd factor explains 8.303%, the 3rd factor describes 5.338%, the 4th factor explains 5.192% and the 5th factor explains 4.953% of the total variance of all variables.

Table 15: Total Variance Explained

Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	12.709	47.069	47.069	7.194	26.643	26.643
2	2.242	8.303	55.373	3.711	13.743	40.386
3	1.441	5.338	60.710	3.240	12.001	52.387
4	1.402	5.192	65.902	2.671	9.891	62.278
5	1.337	4.953	70.855	1.873	6.938	69.217
6	.995	4.094	74.949			
7	.905	3.685	78.634			
8	.792	2.935	81.569			
9	.753	2.789	84.358			
10	.670	2.482	86.840			
11	.582	2.156	88.996			
12	.458	1.696	90.693			
13	.390	1.445	92.138			
14	.352	1.302	93.440			
15	.323	1.196	94.637			
16	.280	1.038	95.674			
17	.242	.898	96.572			
18	.209	.775	97.347			
19	.170	.628	97.975			
20	.129	.478	98.453			
21	.116	.429	98.882			
22	.106	.392	99.274			
23	.072	.266	99.540			
24	.049	.182	99.722			
25	.036	.133	99.855			
26	.023	.085	99.940			
27	.016	.060	100.000			

The scree plot shown below helps in finding the best number of components. The components on the steep slope are extracted. This study will use the first five components as the last big drop is between the fifth and sixth components. Furthermore, the computer printout does not notify that output is non-positive. Hence, one more condition for proceeding with analysis has been attained.

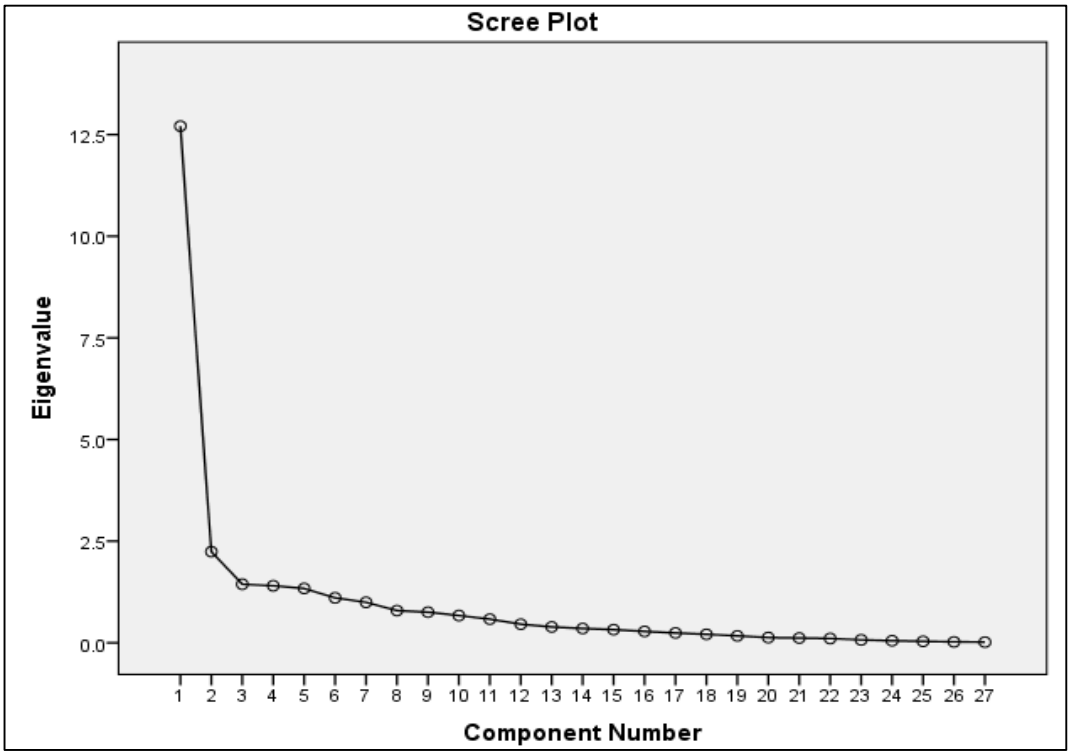


Figure 11: Scree Plot

5.5.3. Barrier Categorization

All barriers were converted by factor analysis into five categories (barriers category). The factor loading value (small coefficient absolute value is suppressed) was fixed at 0.50, eliminating coefficient values less than 0.50. Thus, variables having coefficient values greater than 0.50 remained in the rotated component matrix. The RCM, mean ($\bar{X}$), and the SD is shown below.

Table 16: RCM with a $(\bar{X})$ and SD

Code	Barriers Category	Barriers included in Category	Component					SD	Mean ($\bar{X}$)
			F01	F02	F03	F04	F05		
F01	Technical limitations and operations	V15	.852					1.273	3.80
		V16	.805					1.219	3.73
		V14	.768					1.232	3.80
		V9	.756					1.263	3.72
		V17	.745					1.381	3.58
		V12	.722					1.516	3.80
		V13	.664					1.466	3.57
		V20	.630					1.485	3.38
		V23	.602					1.406	3.58
		V22	.593					1.407	3.55
		V11	.578					1.351	3.85
F02	Implementation of regulations	V2		.777				1.431	3.45
		V26		.768				1.557	3.18
		V27		.662				1.556	3.13
		V21		.652				1.478	3.47
		V25		.542				1.654	3.33
F03	Finance and human resource	V4			.884			1.316	3.28
		V8			.851			1.327	2.63
		V7			.597			1.494	3.15
		V5			.594			1.255	3.02
		V19			.593			1.439	3.38
		V6			.538			1.534	3.45
F04	Household behaviour	V24				.662		1.342	2.83
		V1				.642		1.587	3.30
F05	Operational capacity and equipment	V3					.691	1.552	3.22
		V18					.634	1.439	3.18

A total of 26 barriers were placed in five factors. Furthermore, the ($\bar{X}$) and SD of each barrier has also been calculated with the help of SPSS.

5.5.4. Results and discussion

The 26 barriers placed in five different factors by factor analysis are explained below.

5.5.4.1. F01: Technical limitations and operation

The technical limitations and operation (F01) comprising V9, V11, V12, V13, V14, V15, V16, V17, V20, V22, and V23 appeared as the major factor in our study. The major barriers towards measuring technical limitation and operations in the peri-urban areas were found to be V11: Inappropriate facilities for waste separation ($\bar{X}$ = 3.85), V14: In the peri-urban area, the use of necessary instruments and technology are inadequate for collection of solid waste, V15: Inadequate use of necessary instruments and technology for disposal of solid waste ($\bar{X}$ = 3.80). Particularly, low- and middle-income countries face problems using modern technologies like vehicle routing optimization problem for collection that have various effects on the cost of collecting solid waste, efficiency, and pollutant emissions (Hannan & Mamun, 2015). V12: The disposal sites are uncontrolled in the peri-urban area ($\bar{X}$ = 3.80), V16: The use of necessary instruments and technology are inadequate for recycling of SW in study area ($\bar{X}$ = 3.73). The official from the public sector institute showed his concern during an interview about modern technology by adding that WM authorities in the public sector are using modern technology for the collection of SW in city centres and are not focusing on peri-urban areas. Similarly, V9: The total area of operation of solid waste has increased in the peri-urban area ($\bar{X}$ = 3.80). During an interview, the official from the public sector institute stated an increase in a total area of operation and uncontrolled disposal sites, i.e., RWMC, started its operation in 2013 with 62 Union Councils (UC's). During these nine years, the total number of union councils were increased to 68 due to the rapid increase in population. Recently, two new peri-urban Union Councils (UC 84: Adyala and UC 92: Bajinyal),

previously not operated by RWMC for SWM, were added into the operations due to the rapid increase in population and urbanization.

Other technical limitation and operational barrier includes (F01), V17: Improper training of waste workers working in the peri-urban area ($\bar{X}$ = 3.58), also identified by (Javied et al., 2015), that the shortage of trained and competitive human resources is one of Pakistan's major municipal SWM problems. V23: Lack of coordination and communication between SWM organizations in the study area ($\bar{X}$ = 3.58), V13: Inadequate waste treatment capacity ($\bar{X}$ = 3.57), V22: Poor community engagement by organization in WM activities ($\bar{X}$ = 3.55). Community engagement has positive impact on effective SWM. A higher scale of public engagement in reducing SW at the source is required (Kumar & Nandini, 2013). V20: Formal waste recycling facilities are not existing ($\bar{X}$ = 3.38), corresponding to the study of (Fan & Lili, 2016), it is vital to provide formal SW recycling facilities in developing countries due to the increase in the magnitude of the total waste generated.

5.5.4.2. F02: Implementation of regulations

The implementation of regulations (F02) comprising V2, V26, V27, V21, and V25 appeared as the second factor in our study. The major barriers towards measuring implementation of regulations (F02) were found to be V21: The haphazard growth makes waste collection difficult in the peri-urban areas ($\bar{X}$ =3.47). During an interview, the official from the public sector explained that irregular and unplanned growth is an important factor for inadequate SW collection operations because streets are very narrow where collection trucks cannot go through. Furthermore, during the rainy season, it is impossible to go on foot because the streets are unpaved, due to which they become sludgy. Additionally, non-implementation of master plan

and non-availability of peri-urban structure plan and land-use plan are the root causes of these problems. V2: The implementation of regulations of SWM is poor ($\bar{X}$ =3.45). (Okumu & Nyenje, 2011) in his study also stated that SWM regulations are not implemented effectively due to technical, human resource, and social factors. V25: The regulations related to the SWMS are incomplete ($\bar{X}$ =3.33). (Hope & Elizabeth, 1998) in his book stated that developing countries should not simply import the rules and regulations from developed countries but rather study the context of their own countries to meet the challenges of solid waste.

Other implementations of regulations (F02) barriers include V26: In the peri-urban area, there is poor data management by SWM institutes ($\bar{X}$ =3.18) and V27: SWM institutes have inadequate knowledge about potential benefits regarding SWMS ($\bar{X}$ =3.13). During an interview, public and private sector officials stated that SWM institutes do not have proper data management about the SW generated in different areas, type of SW generated and SW recycling, etc.

5.5.4.3. F03: Finance and human resource

The finance and human resource (F03) comprising V4, V8, V7, V5, V19 and V6 appeared as the third factor in our study. The major barriers towards measuring finance and human resource (F03) were found to be V6: The funds are insufficient for researching on SWM ($\bar{X}$ =3.45), V19: The operational equipment is insufficient, e.g., tractor trolleys, trucks for transfer of solid waste in the study area ($\bar{X}$ =3.38). V4: The funds are insufficient to conduct SWM operations in the study area ($\bar{X}$ =3.28). (Olukanni & Nwafor, 2019) said that SWM institutions in different developing countries are hampered by the technological deficit and lack of funding. V7: In the peri-urban area, the waste collection fee system is uncertain ($\bar{X}$ =3.15).

During an interview, the official from the public sector stated that the public sector does not collect waste collection fees in the study area, due to which the public sector institutes lack funds for operations. Waste collection fee is a dire need of the public sector institutes for financing and improving the SWM operation.

Other finance and human resource (F03) barriers include V5: Human resource operating in the peri-urban area has the low capability to operate SWM ($\bar{X}$ =3.02). (Olukanni & Nwafor, 2019) his study also stated that a main obstacle in effective SWM is human resources having a very low understanding of the SWMS. Therefore, more training is needed for SWM human resources. These problems are mostly found in developing countries due to the low importance given to the WM sector. V8: There is the low financial viability of WM system in the peri-urban area ($\bar{X}$ =2.63). (Olukanni & Nwafor, 2019) in their study said that denial to pay for SW services by households hampers the public sector efforts in providing effective SWM services.

5.5.4.4. F04: Household behavior

The household behavior (F04) comprising V24 and V1 appeared as the fourth factor in our study. The major barriers towards measuring household behavior (F04) were found to be V1: Household has less awareness regarding SWM in the peri-urban area ($\bar{X}$ =3.30). (Olukanni & Nwafor, 2019) in their study said that poor waste disposal habits by households hamper the efforts of SWM institutes in providing effective SWM. V24: The behavior of households is irrational regarding disposal of SW in the study area($\bar{X}$ =2.83). The officials from the public and private sector institutes stated that the majority of the household have irrational behavior regarding disposal of solid waste, i.e., households are disposing of household waste in open space/

vacant plots despite the availability of bins. Furthermore, households also dispose of solid waste near a bin instead of an inside bin, due to which SWM institutes face difficulty during the collection of SW. Which directly affects the operations of SWM institutes.

5.5.4.5. F05: Operational capacity and equipment

The operational capacity and equipment (F05) comprising V24 and V1 appeared as the fifth factor in our study. The major barriers towards measuring operational capacity and equipment (F05) were found to be V3: The SWM institutes lack the capacity to operate in the study area($\bar{X}$ =3.22). V18: In the peri-urban area, operational equipment's are insufficient, e.g., dustbins, dumpsters for collection of solid waste ($\bar{X}$ =3.18). The officials from the public sector institute said that public SWM institutes do not have enough resources to place dustbins and dumpsters in study area, due to which HH are dumping SW in vacant spaces. Furthermore, they do not have enough human resources capable of SWM operations.

6. CHAPTER: HOUSEHOLD PERCEPTION ABOUT THE SWM

6.1. Introduction

This chapter identifies households' perceptions about SWMS in study area. 350 responses were collected to study the perception of HH about SWMS in study area. SPSS was used for the descriptive analysis to obtain frequencies, cross-tabulation, Chi-square value (p-value), Mean ($\bar{X}$) and standard deviation. Indicators of perception were distributed into four sub-indexes and individual names were assigned to all sub-indexes. All four sub-indexes were labelled as Social Sustainability Sub Index (SSSI) and combined to measure the Social Sustainability Index (SSI) of SWMS in study area.

6.2. Data analysis

The socio-demographic characteristics of households are already explained in the fourth chapter. The index point is presented in the below table.

Table 17: Perception variables with indexes

Sub-index no.	Sub-index name	Variables
1	Satisfaction of households about SWM facilities	Satisfied with the overall performance of SWM authority in my area. Satisfied with the SW bin location near our house Satisfied with the SW bin size near our house Satisfied with the waste collection fee system.
2	Knowledge and understanding of households about the SWM	I understand the concept of sustainable SWM. Effective SWM has a positive effect on SD Many environmental issues will be minimized if SW is managed properly. Solid waste is a major environmental issue in our area. The new development process has a negative effect on SWM in our area. I have attended seminars/ events related to SWM. I understand the importance of recycling SW.
3	Attitude and behavior of household about the SWMS	Every individual is responsible for contributing to our area's SWMS. The waste collection authority treats all households equally. Waste collection staff collects waste from our neighbourhood in the right/ needed time. Effect of SW on my health is concerning. I always complain to the SWM authority regarding the SW problem in my area.
4	Willingness of households about the SWMS	Willing to join a WM seminar/event. Willing to do waste separation inside my house. Willing to pay extra for better WC services.

6.2.1. Sub-index no. 1: Satisfaction of households about SWM facilities

The *p*-value for all variables, i.e., S1, S2, S3, and S4 is 0.000, indicating a significant difference between respondents' opinions.

The mean value ($\bar{X}$) for S1: Satisfaction regarding the overall performance of SWM authority in the private sector is 3.8, and public sector is 2.25. Furthermore, the mean value ($\bar{X}$) for S2: The private sector's solid waste bin location is 3.04, and the public

sector is 2.87. The mean value ($\bar{X}$) for S3: The private sector's solid waste bin size is 3.01, and the public sector is 2.12. Similarly, the mean value ($\bar{X}$) for S4: The waste collection fee system in the private sector is 3.64, and the public sector is 3.00.

28.6% of households strongly agreed that they are satisfied with the overall performance of SWM authority, of which 52.4% belongs to the private sector, and 7.5% belongs to the public sector. In comparison, 21.7% of households strongly disagreed that they are satisfied with the overall performance of SWM authority in which 31.2% belongs to the public sector, and 11.0% belongs to the private sector. 17.7% of households agreed that they are satisfied with the overall performance of SWM authority in which 17.2% belongs to the public sector, and 18.3% belongs to the private sector. In comparison, 31.4% of households disagreed that they are satisfied with the overall performance of SWM authority in which 44.1% belongs to the public sector, and 17.1% belongs to the private sector.

24.0% of households strongly disagreed that they are satisfied with solid waste bin location near a house in which 28.0% belongs to the public sector, and 19.5% belongs to the private sector. In comparison, 18.9% of households strongly agreed that they are satisfied with a solid waste bin location near a house in which 20.7% belongs to the private sector, and 17.2% belongs to the public sector. 17.1% of households disagreed that they are satisfied with bin location near a house in which 26.8% belongs to the private sector, and 8.6% belongs to the public sector. In comparison, 22.9% of households agreed that they are satisfied with solid waste bin location near a house in which 29.3% belongs to the private sector, and 17.2% belongs to the public sector. 17.1% of households remained uncertain about solid

waste bin location, of which 29.0% belong to the public sector and 3.7% to the private sector.

Table 18: Satisfaction of households about SWM facilities.

Code	Variables		Type of Institute			Mean		*Chi-square test*
			Public	**Private**	**Total**	**Public**	**Private**	
S1	Satisfied with the overall performance of SWM authority in my area.	SD	31.2%	11.0%	21.7%	2.25	3.84	X^2= 100.480 *p*-value= 0.000
		D	44.1%	17.1%	31.4%			
		Un	0.0%	1.2%	.6%			
		A	17.2%	18.3%	17.7%			
		SA	7.5%	52.4%	28.6%			
S2	Satisfied with the solid waste bin location near our house	SD	28.0%	19.5%	24.0%	2.87	3.04	X^2= 58.337 *p*-value= 0.000
		D	8.6%	26.8%	17.1%			
		Un	29.0%	3.7%	17.1%			
		A	17.2%	29.3%	22.9%			
		SA	17.2%	20.7%	18.9%			
S3	Satisfied with the solid waste bin size near our house	SD	34.9%	14.6%	25.4%	2.12	3.01	X^2= 102.625 *p*-value= 0.000
		D	28.5%	35.4%	31.7%			
		Un	29.0%	3.0%	16.9%			
		A	3.8%	27.4%	14.9%			
		SA	3.8%	19.5%	11.1%			
S4	Satisfied with the waste collection fee system.	SD	0.0%	7.9%	3.7%	3.0	3.64	X^2= 322.909 *p*-value= 0.000
		D	0.0%	22.0%	10.3%			
		Un	100%	4.3%	55.1%			
		A	0.0%	29.9%	14.0%			
		SA	0.0%	36.0%	16.9%			
Total			**100.0%**	**100.0%**	**100.0%**			

11.1% of households strongly agreed that they are satisfied with solid waste bin size near the house in which 19.5% belongs to the private sector, and 3.8% belongs to the public sector. In comparison, 25.4% of households strongly disagreed that they are satisfied with solid waste bin size near the house in which 34.9% belongs to the public sector, and 14.6% belongs to the private sector. 14.9% of households agreed that they are satisfied with solid waste bin size near the house, of which 27.4% belong to the private sector, and 3.8% belong to the public sector. 31.7% of households

disagreed that they are satisfied with solid waste bin size near the house, of which 35.4% belong to the private sector, and 28.5% belong to the public sector. 16.9% of households remained uncertain about solid waste bin size, of which 29.0% belong to the public sector, and 3.0% belong to the private sector.

In the private sector, 30.9% of households strongly agreed and agreed that they are satisfied with the waste collection fee system, while 14% strongly disagreed and disagreed that they are satisfied with the waste collection fee system. 100% of households remained uncertain about the satisfaction of the waste collection fee system. All these households belong to the public sector because there was no waste collection fee system in the public sector.

6.2.2. Sub-index no. 2: Knowledge and understanding of households about the SWM

The mean value ($\bar{X}$) for variable, i.e., K1: Understand the concept of sustainable SWM in the private sector is 3.65 and in the public sector is 2.59, K2: Effective SWM has a positive impact on SD in the private sector is 3.70 and in the public sector is 3.30, K3: Many environmental issues will be minimized if SW is managed properly in the private sector is 3.46 and in the public sector is 3.16, K4: Solid waste is the major environmental issue in our area in the public sector is 3.56 and in the private sector is 2.60, K5: New development process has a negative impact on SWM in our area in the public sector is 3.59 and in the private sector is 2.49, K6: Attended seminar/ events related to SWM in the private sector is 2.38 and in the public sector is 2.15 and K7: Understand the importance of recycling of SW in the private sector is 2.61 and in the public sector is 2.43.

The *p*-value for K1, K2, K3, K4, K5, K6, and K7, is lesser than 0.05. It shows that there is a substantial variance between the opinion of households.

30.3% of households strongly agreed that they understand the concept of sustainable SWM in which 39.6% belongs to the private sector and 22.0% belong to the public sector while 26.6% of households strongly disagreed that they understand the concept of sustainable SWM in which 36.6% belongs to the public sector, and 15.2% belongs to the private sector. 20.6% of households agreed that they understand the concept of sustainable SWM in which 28.7% belongs to the private sector, and 13.4% belongs to the public sector while 18.6% of households disagreed that they understand the concept of sustainable SWM in which 24.7% belongs to the public sector, and 11.6% belongs to the private sector.

27.4% of households strongly agreed that effective SWM has a positive impact on SD in which 32.2% belongs to the private sector, and 23.1% belongs to the public sector while 8.3% of households strongly disagreed that effective SWM has a positive impact on SD in which 8.7% belongs to the public sector, and 7.9% belongs to the private sector. 21.1% of households agreed that effective SWM has a positive impact on SD in which 29.2% belongs to the private sector, and 13.9% belongs to the public sector, while 10.3% of households disagreed that effective SWM has a positive impact on SD in which 12.4% belongs to the public sector, and 7.9% belongs to the private sector. 32.9% of households were uncertain, of which 42.0% belonged to the public sector and 22.6% belonged to the private sector.

35.7% of households strongly agreed that many environmental issues would be minimized if solid waste is managed properly in which 31.8% belongs to the public sector, and 40.3% belongs to the private sector, while 21.1% of households strongly

disagreed that many environmental issues will be minimized if solid waste is managed properly in which 20.5% belongs to the public sector, and 22.0% belongs to the private sector. 21.1% of households agreed that many environmental issues would be minimized if solid waste is managed properly in which 23.3% belongs to the private sector, and 19.4% belongs to the public sector, while 19.7% of households disagreed that many environmental issues will be minimized if solid waste is managed properly in which 25.8% belongs to the public sector, and 12.8% belongs to the private sector. 2.3% of households were uncertain, of which 2.6% belonged to the public sector, and 1.9% belonged to the private sector.

34.3% of households strongly agreed that solid waste is the major environmental issue in our area in which 45.7% belongs to the public sector, and 21.3% belongs to the private sector while 24.0% of households strongly disagreed that solid waste is the major environmental issue in our area in which 18.8% belongs to the public sector, and 29.9% belongs to the private sector. 11.7% of households agreed that solid waste is the major environmental issue in our area in which 13.9% belongs to the public sector, and 9.2% belongs to the private sector while 20.9% of households disagreed that solid waste is the major environmental issue in our area in which 31.8% belongs to the private sector, and 11.3% belongs to the public sector. 9.1% of households were uncertain, of which 10.2% belonged to the public sector, and 7.9% belonged to the private sector.

30.6% of households strongly agreed that new development process has a negative impact on SWM in our area in which 40.3% belongs to the public sector, and 19.5% belongs to the private sector. In comparison, 25.7% of households strongly disagreed

that new development process has a negative impact on SWM in our area in which 42.1% belongs to the private sector, and 11.3% belongs to the public sector.

Table 19: Knowledge and understanding of households about SWM.

Code	Variable		Type of Institute			Mean		*Chi-square test*
			Public	**Private**	**Total**	**Public**	**Private**	
K1	I understand the concept of sustainable SWM.	SD	36.6%	15.2%	26.6%	2.59	3.65	X^2= 42.323 *p*-value= 0.000
		D	24.7%	11.6%	18.6%			
		Un	3.2%	4.9%	4.0%			
		A	13.4%	28.7%	20.6%			
		SA	22.0%	39.6%	30.3%			
K2	Effective SWM has a positive impact on SD.	SD	8.7%	7.9%	8.3%	3.30	3.70	X^2= 24.000 *p*-value = 0.000
		D	12.4%	7.9%	10.3%			
		Un	42.0%	22.6%	32.9%			
		A	13.9%	29.2%	21.1%			
		SA	23.1%	32.2%	27.4%			
K3	Many environmental issues will be minimized if SW is managed properly.	SD	20.5%	22.0%	21.1%	3.16	3.46	X^2= 10.223 *p*-value = 0.037
		D	25.8%	12.8%	19.7%			
		Un	2.6%	1.9%	2.3%			
		A	19.4%	23.3%	21.1%			
		SA	31.8%	40.3%	35.7%			
K4	SW is the major environmental issue in our area.	SD	18.8%	29.9%	24.0%	3.56	2.60	X^2= 39.179 *p*-value = 0.000
		D	11.3%	31.8%	20.9%			
		Un	10.2%	7.9%	9.1%			
		A	13.9%	9.2%	11.7%			
		SA	45.7%	21.3%	34.3%			
K5	New development process has negative impact on SWM in our area.	SD	11.3%	42.1%	25.7%	3.55	2.49	X^2= 66.491 *p*-value = 0.000
		D	14.0%	19.5%	16.6%			
		Un	23.1%	4.9%	14.6%			
		A	11.3%	14.0%	12.6%			
		SA	40.3%	19.5%	30.6%			
K6	I have attended seminar/ events related to SWM	SD	51.6%	40.8%	46.6%	2.15	2.38	X^2= 30.886 *p*-value = 0.000
		D	14.0%	26.8%	20.0%			
		Un	11.3%	0.0%	6.0%			
		A	14.0%	17.7%	15.7%			
		SA	9.1%	14.6%	11.7%			
K7	I understand the importance of recycling solid waste.	SD	42.0%	29.3%	36.0%	2.43	2.61	X^2= 16.830 *p*-value = 0.000
		D	23.7%	29.9%	26.6%			
		Un	2.6%	2.4%	2.6%			
		A	13.0%	26.8%	19.4%			
		SA	18.8%	11.6%	15.4%			
Total			**100.0%**	**100.0%**	**100.0%**			

12.6% of households agreed that the new development process has a negative impact on SWM in our area in which 14.0% belongs to the private sector, and 11.3% belongs to the public sector, while 16.6% of households disagreed that the new development process has a negative impact on SWM in our area in which 19.5% belongs to the private sector, and 14.0% belongs to the public sector. 14.6% of households were uncertain, of which 23.1% belonged to the public sector, and 4.9% belonged to the private sector.

11.71% of households strongly agreed that they had attended seminar/ events related to SWM in which 14.6% belonged to the private sector, and 9.1% belonged to the public sector, while 46.6% of households strongly disagreed that they have attended seminar/ events related to SWM in which 51.6% belongs to the public sector, and 40.8% belongs to the private sector. 15.7% of households agreed that they had attended seminar/ events related to SWM in which 17.7% belonged to the private sector, and 14.0% belonged to the public sector, while 20.0% of households disagreed that they have attended seminar/ events related to SWM in which 26.8% belongs to the private sector, and 14.0% belongs to the public sector. 6.0% of households were uncertain which belongs to the public sector.

15.4% of households strongly agreed that they understand the importance of recycling the solid waste in which 18.8% belongs to the public sector, and 11.6% belongs to the private sector while 36.0% of households strongly disagreed that they understand the importance of recycling the solid waste in which 42.0% belongs to the public sector, and 29.3% belongs to the private sector. 19.4% of households agreed that they understand the importance of recycling the solid waste in which 26.8% belongs to the private sector, and 13.0% belongs to the public sector while

26.6% of households disagreed that they understand the importance of recycling the solid waste in which 29.9% belongs to the private sector, and 23.7% belongs to the public sector. 2.6% of households were uncertain, of which 2.6% belonged to the public sector, and 2.4% belonged to the private sector.

6.2.3. Sub-index no. 3: Attitude and behavior of household about SWMS

The *p*-value for A1, A2, A3, A4, and A5, is 0.000, demonstrating that there is a noteworthy variance between the opinion of HH.

The mean value ($\bar{X}$) for variable A1: Every individual has the responsibility to contribute to the SWMS is 3.46 in the private sector and 2.65 in the public sector, A2: The waste collection authority treats all households equally in the public sector is 3.73 and in the private sector is 3.42, A3: Waste collection staff collects waste from our neighbourhood in the right/ needed time in the private sector is 3.45 and in the public sector 2.58. A4: I am concerned about the effect of SW on my health in the public sector is 3.72 and in the private sector 2.93 and A5: I always submit complaints to SWM authority regarding the SW problem in my area in the private sector is 3.63 and in the public sector is 2.83.

24.3% of households strongly agreed that every individual has the responsibility to contribute to the SWMS in which 25.3% belongs to the public sector, and 23.2% belongs to the private sector, while 26.6% of households strongly disagreed that every individual has the responsibility to contribute to the SWMS in which 38.2% belongs to the public sector, and 13.4% belongs to the private sector. 28.0% of households agreed that every individual has the responsibility to contribute to the SWMS in which 14.0% belongs to the public sector, and 43.9% belongs to the private sector, while 20.0% of households disagreed that every individual has the

responsibility to contribute to the SWMS in which 22.6% belongs to the public sector, and 17.1% belongs to the private sector. 2.4% of households remained uncertain, which belongs to the private sector.

Table 20: Attitude and behavior of household in peri-urban areas

Code	Variable		Type of Institute			Mean		*Chi-square test*
			Public	**Private**	**Total**	**Public**	**Private**	
A1	Every individual is responsible for contributing to the SWMS in our area.	SD	38.2%	13.4%	26.6%	2.65	3.46	X^2= 53.992 *p*-value = 0.000
		D	22.6%	17.1%	20.0%			
		Un	0.0%	2.4%	1.1%			
		A	14.0%	43.9%	28.0%			
		SA	25.3%	23.2%	24.3%			
A2	The waste collection authority treats all households equally.	SD	15.1%	15.2%	15.14%	3.73	3.42	X^2= 26.111 *p*-value = 0.000
		D	10.2%	14.0%	12.00%			
		Un	0.0%	11.6%	5.43%			
		A	35.5%	30.5%	33.14%			
		SA	39.3%	28.6%	34.29%			
A3	Waste collection staff collects waste from our neighbourhood in right/ needed time.	SD	37.1%	7.9%	23.4%	2.58	3.45	X^2= 124.295 *p*-value = 0.000
		D	8.6%	23.8%	15.7%			
		Un	29.0%	3.0%	16.9%			
		A	9.1%	45.7%	26.3%			
		SA	16.1%	19.5%	17.7%			
A4	The impact of SW on my health is concerning.	SD	11.3%	28.7%	19.4%	3.72	2.93	X^2= 27.804 *p*-value = 0.000
		D	14.0%	20.1%	16.9%			
		Un	0.0%	1.8%	.9%			
		A	40.9%	27.4%	34.6%			
		SA	33.9%	22.0%	28.3%			
A5	I always submit complain to the SWM authority regarding the SW problem in my area.	SD	27.4%	12.2%	20.3%	2.83	3.63	X^2= 45.339 *p*-value = 0.000
		D	24.7%	22.0%	23.4%			
		Un	0.0%	1.2%	.6%			
		A	32.8%	19.5%	26.6%			
		SA	15.1%	45.1%	29.1%			
	Total		**100.0%**	**100.0%**	**100%**			

17.7% of households strongly agreed that waste collection staff collects waste from our neighbourhood in the right/ needed time in which 19.5% belongs to the private sector, and 16.1% belongs to the public sector while 23.4% of households strongly

disagreed that waste collection staff collects waste from our neighbourhood in the right/ needed time in which 37.1% belongs to the public sector, and 7.9% belongs to the private sector. 26.3% of households agreed that waste collection staff collects waste from our neighbourhood in the right/ needed time in which 45.7% belongs to the private sector, and 9.1% belongs to the public sector while 15.7% of households disagreed that waste collection staff collects waste from our neighbourhood in the right/ needed time in which 23.8% belongs to the private sector, and 8.6% belongs to the public sector. 16.9% of households remained uncertain, of which 29.0% belonged to the public sector, and 3.0% belonged to the private sector.

34.3% of households strongly agreed that the waste collection authority treats all household equally in which 39.3% belongs to the public sector, and 28.6% belongs to the private sector, while 15.14% of households strongly disagreed that the waste collection authority treats all household equally in which 15.1% belongs to the public sector, and 15.2% belongs to the private sector. 33.14% of households agreed that the waste collection authority treats all household equally in which 35.5% belongs to the public sector, and 30.5% belongs to the private sector while 12.00% of households disagreed that the waste collection authority treats all household equally in which 14.0% belongs to the private sector, and 10.2% belongs to the public sector. 5.43% of households remained uncertain, which belongs to the private sector.

29.1% of households strongly agreed that they always submit complain to SWM authority regarding the SW problem in their area in which 45.1% belongs to the private sector, and 15.1% belongs to the public sector while 20.3% of households strongly disagreed that they always submit complain to SWM authority regarding the SW problem in their area in which 27.4% belongs to the public sector, and 12.2%

belongs to the private sector. 26.6% of households agreed that they always submit complain to SWM authority regarding the SW problem in their area in which 32.8% belongs to the public sector, and 19.5% belongs to the private sector while 23.4% of households disagreed that they always submit complain to SWM authority regarding the SW problem in their area in which 24.7% belongs to the public sector, and 22.0% belongs to the private sector. 1.2% of households remained uncertain, which belongs to the private sector.

6.2.4. Sub-index no. 4: Willingness of household about the SWM system

The *p*-value for all variables, i.e., W1, W2, and W3, is 0.000, indicating that there is a significant difference between the opinion of households.

The mean value ($\bar{X}$) for W1: I am willing to participate in WM seminar/event in the private sector is 3.67 and in the public sector is 3.53, W2: I am willing to do waste separation inside my house in the private sector is 3.17 and in the public sector is 3.14 and W3: I am willing to pay more for improved waste collection services in the public sector is 3.80 and in the private sector is 2.80.

25.4% of households strongly agreed that they are willing to do waste separation inside the house in which 29.0% belongs to the public sector, and 21.3% belongs to the private sector, while 25.7% of households strongly disagreed that they are willing to do waste separation inside the house in which 28.5% belongs to the public sector and 22.6% belongs to the private sector. 30.6% of households agreed that they are willing to do waste separation inside the house in which 36.6% belongs to the private sector, and 25.3% belongs to the public sector while 14.3% of households disagreed that they are willing to do waste separation inside the house in which 17.1% belongs to the private sector and 11.8% belongs to the public sector. 4.0% of households

remained uncertain, in which 5.4% belonged to the public sector, and 2.4% belonged to the private sector.

Table 21: Willingness of household about the SWMS

Code	Variable		Type of Institute			Mean		*Chi-square test*
			Public	**Private**	**Total**	**Public**	**Private**	
WI	willingness to participate in WM seminar/event.	SD	11.3%	15.2%	13.1%	3.53	3.67	X^2= 41.549 *p*-value = 0.000
		D	25.3%	6.1%	16.3%			
		Un	0.0%	2.4%	1.1%			
		A	25.3%	48.8%	36.3%			
		SA	38.2%	27.4%	33.1%			
W2	Willingness to do waste separation inside my house.	SD	28.5%	22.6%	25.7%	3.14	3.17	X^2= 10.430 *p*-value = 0.000
		D	11.8%	17.1%	14.3%			
		Un	5.4%	2.4%	4.0%			
		A	25.3%	36.6%	30.6%			
		SA	29.0%	21.3%	25.4%			
W3	Willing to pay extra for better WCS.	SD	11.3%	14.0%	12.6%	3.80	2.80	X^2= 79.810 *p*-value = 0.000
		D	12.4%	37.8%	24.3%			
		Un	0.0%	7.9%	3.7%			
		A	28.0%	29.9%	28.9%			
		SA	48.4%	10.4%	30.6%			
Total			**100.0 %**	**100.0 %**	**100.0 %**			

30.6% of households strongly agreed that they are willing to pay extra for better WCS in which 48.4% belongs to the public sector, and 10.4% belongs to the private sector, while 12.6% of households strongly disagreed that they are willing to pay extra for better WCS in which 14.0% belongs to the private sector, and 11.3% belongs to the public sector. 28.9% of households agreed that they are willing to pay extra for better WCS in which 29.9% belongs to the private sector, and 28.0% belongs to the public sector, while 24.3% of households disagreed that they are willing to pay extra for better WCS in which 37.8% belongs to the private sector,

and 12.4% belongs to the public sector. 7.9% of households remained uncertain, which belongs to the private sector.

6.2.5. Formulation of Social Sustainability Index (SSI)

The Social Sustainability Index (SSI) was developed by using four indexes. Each index has been assigned a code, i.e., Social Sustainability Sub Index (SSSI), and by combining all indexes, the social sustainability of the SWMS was measured. The index number, index name, and code are shown below.

Table 22: Formulation of Social Sustainability Index (SSI)

Sub-index no.	Sub-index name	Code
1	Satisfaction of household regarding SWM facilities	SSSI 1
2	Knowledge and understanding of household about the SWMS	SSSI 2
3	Attitude/ behaviour of household about the SWMS	SSSI 3
4	The willingness of households regarding SWMS	SSSI 4

6.2.6. Mean value sub-division for Social Sustainability Index (SSI)

To calculate the Social Sustainability Index (SSI), mean value ($\bar{X}$) of each variable was combined to calculate the mean value ($\bar{X}$) of each sub-index. Furthermore, each sub-index was combined to calculate the Social Sustainability Index (SSI). The mean value ($\bar{X}$) of sub-index was divided into four different slabs to measure social sustainability, which is shown below.

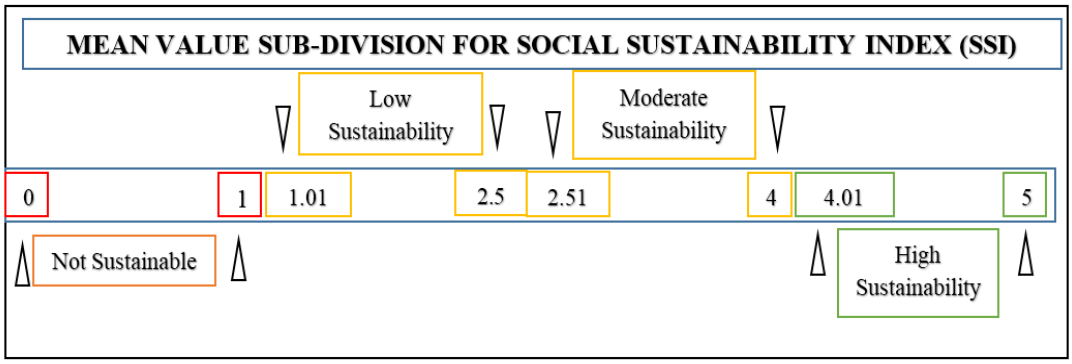


Figure 12: Mean value ($\bar{X}$) sub-division for Social Sustainability Index (SSI)

6.2.7. Mean value ($\bar{X}$) comparison of Social Sustainability Sub Index (SSSI) between the public sector and private sector

The mean value ($\bar{X}$) of SSSI 1: Satisfaction of households regarding SWM facilities in the private sector is 2.50, which falls in the slab of low sustainability, and the public sector is 3.39, which falls in the slab of moderated sustainability.

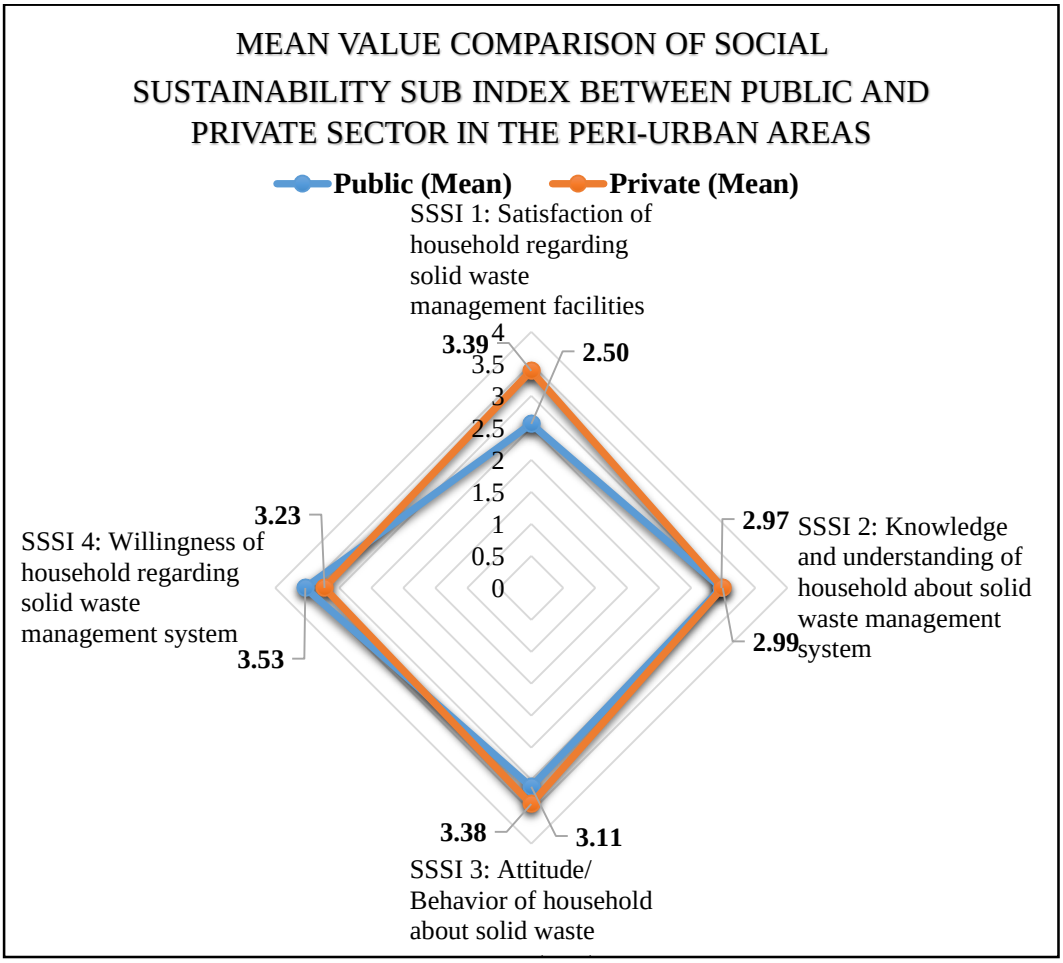


Figure 13: Comparison of SSSI between the public and private sector.

The mean value ($\bar{X}$) of SSSI 2: Knowledge and understanding of household about SWMS in the private sector is 2.99, and the public sector is 3.39. Both values fall in the slab of moderate sustainability.

The mean value ($\bar{X}$) of SSSI 3: Attitude/ Behaviour of household about SWMS in the private sector is 3.38, and the public sector is 3.11. Both values fall in the slab of moderate sustainability.

The mean value ($\bar{X}$) of SSSI 4: Willingness of household regarding SWMS in the private sector is 3.23, and the public sector is 3.53. Both values fall in the slab of moderate sustainability.

6.2.8. Comparison of Social Sustainability Index (SSI) between the public sector and private sector

The Social Sustainability Sub Index (SSSI) comparison between the public and private sector is carried out to understand which sector has a better Social Sustainability Index (SSI).

Amongst 100% of responses recorded from households in the public sector, 50.0% of households reflect that SSSI1 has low sustainability, 42.5% of households reflect that SSSI1 has moderate sustainability and 7.5% of households reflect that SSSI1 has high sustainability. Similarly, amongst 100% of responses recorded from households in the private sector, 21.3% of households reflect that SSSI1 has low sustainability, 51.8% of households reflect that SSSI1 has moderate sustainability and 26.8% of households reflect that SSSI1 has high sustainability.

Amongst 100% of responses recorded from households in the public sector, 21.5% of households reflect that SSSI2 has low sustainability, 74.2% of households reflect that SSSI2 has moderate sustainability and 4.3% of households reflect that SSSI2 has high sustainability. Similarly, amongst 100% of responses recorded from households in the private sector, 28.0% of households reflect that SSSI2 has low sustainability, 62.2% of households reflect that SSSI2 has moderate sustainability and 9.8% of households reflect that SSSI2 has high sustainability.

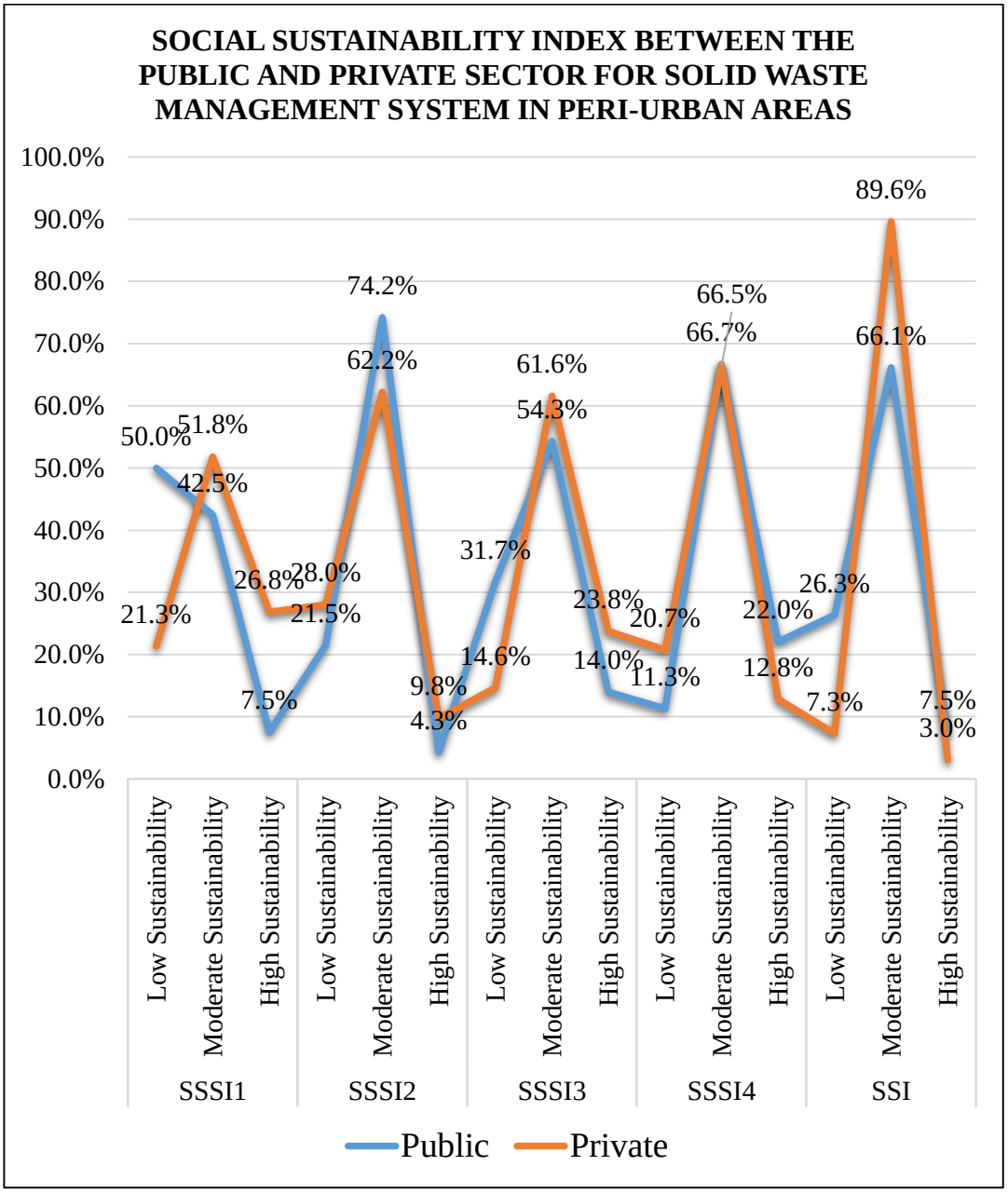


Figure 14: SSI between the public and private sectors for SWMS

Amongst 100% of responses recorded from households in the public sector, 31.7% of households reflect that SSSI3 has low sustainability, 54.3% of households reflect that SSSI3 has moderate sustainability and 14.0% of households reflect that SSSI3 has high sustainability. Similarly, Amongst 100% of responses recorded from households in the private sector, 14.6% of households reflect that SSSI3 has low

sustainability, 61.6% of households reflect that SSSI3 has moderate sustainability and 23.8% of households reflect that SSSI3 has high sustainability.

Amongst 100% of responses recorded from households in the public sector, 11.3% of households reflect that SSSI4 has low sustainability, 66.7% of households reflect that SSSI4 has moderate sustainability and 22.0% of households reflect that SSSI4 has high sustainability. Similarly, amongst 100% of responses recorded from households in the public sector, 20.7% of households reflect that SSSI4 has low sustainability, 66.5% of households reflect that SSSI4 has moderate sustainability and 12.8% of households reflect that SSSI4 has high sustainability.

The Social Sustainability Index (SSI) was calculated by combining all Social Sustainability Sub Index (SSSI), reflecting that the public sector has low sustainability compared to the private sector for the responses received from households. Similarly, the private sector has high responses reflecting moderate sustainability compared to the public sector. In terms of high sustainability, 3.0% of responses reflect high sustainability in the private sector, and 7.5% of responses reflect high sustainability in the public sector.

7. CHAPTER: CONCLUSION AND RECOMMENDATIONS

7.1. Conclusion

This research was mainly concentrated on assessing the effects of peri-urban development on SWM institutes and suggested an integrated framework for effective SWMS in peri-urban areas. Many frameworks were designed solely for a specific area, and therefore they cannot be used universally because every country has its dynamics and conditions. These frameworks are not flawless and require further research as suggested by their makers. Therefore, this study was carried out to suggest an effective framework for a SWMS in study area.

This study found that five areas of SWM institutes in study area are very poor and need improvement. The five areas of a SWMS that need improvement are explained below.

- Firstly, the major barriers in technical limitation and operations are the improper training of waste workers, inadequate waste treatment capacity, inappropriate waste recycling and separation facilities, inadequate use of modern technology and necessary instruments for collection, disposal, and recycling of solid waste, uncontrolled disposal sites, poor community engagement in WM activities, increase in a total area of operations and poor coordination between WM authorities in study area.
- Secondly, the major barriers to implementing of regulations are incomplete and poor implementation of regulations, poor data management, inadequate

knowledge about potential benefits of the effective SWMS, and haphazard growth in peri-urban areas.

- Thirdly, the major barriers in finance and human resource are insufficient funds for operations and research on the SWMS, uncertain waste collection fee system, and low capability of a human resource operating in peri-urban areas.
- Fourthly, the major barriers in household behavior are less awareness and irrational behavior regarding SWM in study area.
- Fifthly, the major barriers in operational capacity and equipment are lack of operational capacity and insufficient equipment for collection and disposal of solid waste.

This study found that 70% generation of the SW by HH in the public and private sectors was organic or vegetable waste and plastic waste. Furthermore, the public sector relatively generates a higher quantity of SW, i.e., 1.36 kg/day, compared to the private sector, i.e., 1.26 kg/day, because the average household size in the public sector was higher, i.e., 6.4, as compared to the private sector, i.e., 6.3, which conclude that rise in HH size is directly proportional to surge in SW generation. The solid waste was mainly stored in containers or plastic bags. 76.9% of households dispose of their household waste without separation. Although solid waste was majorly disposed of at the nearby container or handed over to waste collectors, 30.6% of households in the public sector were dumping household waste in open space/ vacant plots due to non-availability of bins or irrational behavior. The majority of the public and private sector households dispose of their household waste daily, while very few households dump their waste once a week. Solid waste has

been dumped alongside garbage bins by some households because the bin was always fully occupied in the public sector.

This study found that the private sector has better availability of public bins near houses. 29.0% of households do not have access to public bins in the public sector. 65.2% of public bins were in good condition, while 34.8% of public bins were in bad condition in the public and private sectors. 65.9% of public bins were emptied daily and 13.4% of public trash containers were emptied one time in a week in the private sector, compared to the public sector where 36.4% of public bins were emptied daily and 31.1% of public bins were emptied once a week. Overall, the private sector was improved than the public sector in the availability of public bins, the condition of bins, and their usage. The garbage collection service from houses was available in the private sector, while the public sector does not collect solid waste from houses. The household waste was collected from houses daily, and waste collection fees were charged from the households in peri-urban areas managed by the private sector.

Based on key performance indicators, it is concluded that the private sector was relatively performing well compared to the public sector in terms of operations by SWM institutes. Still, the solid waste practices inside the house, e.g., waste generation, storage, and separation, are almost similar in case study area. HH in the public sector have more concerns regarding solid waste in their area than the private sector.

This study found that HH perception is important for an effective SWMS in study area. As the residents of study area are one of the main contributors to the SW generation and disposal, the effectiveness of the SWMS in study area is mainly

dependent on the perception of these residents, i.e., satisfaction, knowledge or understanding, attitude or behavior and willingness.

The satisfaction of households about the overall performance of SWM authority, SW bin location and size, and waste collection fee system is higher in the private sector than the public sector. On the scale of SSI, satisfaction in the private sector has moderate sustainability, and the public sector has low sustainability. Furthermore, the knowledge and understanding of households about the importance of recycling, major environmental issues, sustainability, and effectiveness of SWMS are approximately the same in the public and private sectors. On the scale of SSI, the knowledge and understanding fall in the slab of moderate sustainability in the private and public sectors.

The willingness of households to participate in WM seminars/ events, practice waste separation inside the house, and pay more fees for improved waste collection services is higher in the public sector compared to the private sector. On the scale of SSI, willingness falls in the slab of moderate sustainability in the private and public sectors. The attitude and behavior of households are the same in the public and private sectors. On the scale of SSI, the attitude and behavior fall in the slab of moderate sustainability in the study area.

Overall, the private sector has 66.1%, and the public sector has 89.6% of responses concluding that perception factors have moderate sustainability. Furthermore, the private sector has 7.3%, and the public sector has 26.3% of responses concluding that perception factors have low sustainability. The private sector has 3.0%, and the public sector has 7.5% of responses concluding that perception factors have high sustainability.

7.2. Recommendations

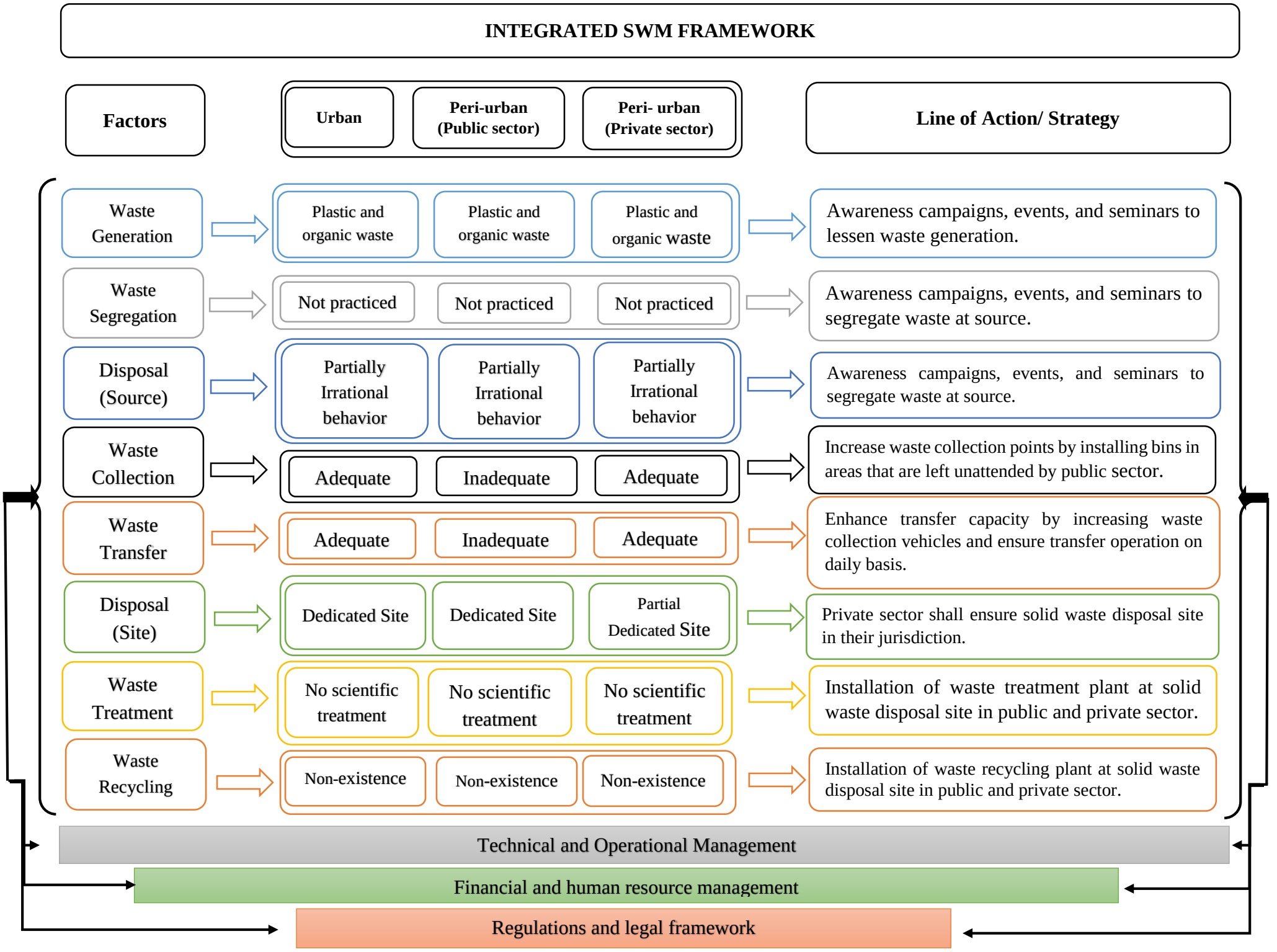
The recommendations for an effective SWMS are stated below.

- The government shall formulate all-inclusive policies and regulations by considering present social, environmental, and economic perspectives.
- The government shall include the relevant stakeholders in the decision-making process to foster acceptance of new policies, regulations, and initiatives. Furthermore, regulatory measures shall be enforced on the people to keep the environment clean and safe.
- The government shall take measures for coordination and communication between different SWM institutions to efficiently deliver WM operations.
- A financially self-sustained system is direly required for effective SWM. Therefore, it is recommended that cost recovery of WM services from waste producers shall be ensured for covering the operation and maintenance costs of WM.
- Public-private partnerships shall be introduced for effective WM operations. A fair procurement procedure for hiring private sector participants shall be established, and contracts shall be awarded and extended based on performance. The private sector shall be paid based on the total waste collected and disposed of at a pre-defined disposal site.
- The waste workers shall be trained to lessen the mishandling of SW. The waste workers shall be motivated for their efficiency and hardworking by giving them honorariums and awards.
- There is a lack of accurate and up-to-date data regarding solid waste generation, collection, disposal, etc. Therefore, it is suggested that WM authorities shall

establish a research and monitoring unit in institutions to maintain records and data because data availability is vital for formulating an effective SWM strategy.

- The public sector SWM authorities need to improve and extend their operations in peri-urban areas where solid waste is dumped in open space/ vacant plots by providing public bins and regularly emptying those bins. Furthermore, some public bins were in extremely bad conditions, which need to be replaced in peri-urban areas for effective SWM.
- Organic waste has the largest contribution to daily household waste generated. Therefore, Organic waste shall be recycled because organic waste is a rich source of nutrients used in agricultural land and urban forestry.
- SWM authorities need to introduce awareness campaigns through print, electronic and social media, seminars, and events regarding waste reduction by purchasing reusable or long-lasting products and waste separation by the household for segregating SW waste and proper disposal of solid waste in the nearby container to eradicate solid waste concerns, i.e., effect on human health, e.g., improper handling of solid waste attract germs and insects that spread disease, i.e., typhoid and cholera, etc. and environment, e.g., improper disposal sites can lead to contamination of water bodies and soils, impacting local ecosystems in peri-urban areas.

7.3. Framework for integrated SWM


INTEGRATED SWM FRAMEWORK
Factors
Urban
Peri-urban (Public sector)
Peri- urban (Private sector)
Line of Action/ Strategy
Waste Generation
Plastic and organic waste
Plastic and organic waste
Plastic and organic waste
Awareness campaigns, events, and seminars to lessen waste generation.
Waste Segregation
Not practiced
Not practiced
Not practiced
Awareness campaigns, events, and seminars to segregate waste at source.
Disposal (Source)
Partially Irrational behavior
Partially Irrational behavior
Partially Irrational behavior
Awareness campaigns, events, and seminars to segregate waste at source.
Waste Collection
Adequate
Inadequate
Adequate
Increase waste collection points by installing bins in areas that are left unattended by public sector.
Waste Transfer
Adequate
Inadequate
Adequate
Enhance transfer capacity by increasing waste collection vehicles and ensure transfer operation on daily basis.
Disposal (Site)
Dedicated Site
Dedicated Site
Partial Dedicated Site
Private sector shall ensure solid waste disposal site in their jurisdiction.
Waste Treatment
No scientific treatment
No scientific treatment
No scientific treatment
Installation of waste treatment plant at solid waste disposal site in public and private sector.
Waste Recycling
Non-existence
Non-existence
Non-existence
Installation of waste recycling plant at solid waste disposal site in public and private sector.
Technical and Operational Management
Financial and human resource management
Regulations and legal framework

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9. ANNEXURE-A : PRACTICES OF SWM

NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY (NUST)

SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING (SCEE)

DEPARTMENT OF URBAN AND REGIONAL PLANNING

Questionnaire for Household survey

This survey is a part of ongoing research in department of Urban and Regional Planning, SCEE, NUST. Your contribution will help us in assessment of solid waste management practices in your area. Your response will only be used for research purpose and shall be regarded as classified. For any query or information please contact (arham894@gmail.com).

SOCIO-ECONOMIC INFORMATION

Name of Town/ Area (Where you are living)? _____

1) Education of the household head? _____
2) Household size? _____
3) Household Monthly income? _____

SOLID WASTE MANAGEMENT PRACTICES BY HOUSEHOLD

4) What is Estimated amount of waste generated daily(Unit=kg/day)? ----------
5) Can you roughly identify the percentage composition of type of waste generated by your household?
   (Fill all given options)
   a. Plastic____% b. Glass___% c. Paper___% d. Organic or Vegetable waste_____% e. Metal_____% f. Other___%
6) Where do you store your solid waste in house?
   a. Rubbish bin/drum b. Plastic bags c. No storage – directly disposing to outside dump
7) Where do you dispose your household waste?
   a. Nearby container b. Dump in Nullah or Sewerage c. Open space/vacant plot
   d. Handed over to waste collector e. Other_____
8) How often you dispose your household waste?
   a. Every day b. 2-3 times in week c. Once in a week d. Once in two weeks
9) Are there any public bins available near your house?
   (If "No" Please move to Q no. 12)

a. Yes b. No

10) (If "Yes" in Q no. 9) | How can you define the condition of public bins near your house?

a. In good condition b. bad condition

11) (If "Yes" in Q no. 9) | How often is the public bin emptied?

a. Every day b. 2 times in week c. Once in a week d. Once in a month

12) Who is responsible for collection of waste in your area?

a. Municipality b. Contractor c. Scavenger d. Other_____

12a) Type of institution? a. Public b. Private

13) Is regular garbage collection service from houses available in your neighborhood?

(If "No" Please move to Q no. 16)

a. Yes b. No

14) (If "Yes" in Q no.14) | How often waste collector is collecting waste from your house?

a. Every day b. 2-3 times in week c. Once in a week d. Once in a month

15) (If "Yes" in Q no.14) | How much do you pay for waste collection service?

a. Rs/-_____

16) Do you practice waste separation inside your house?

a. Yes b. No

17) Do people dump their waste alongside the garbage bins instead of putting it inside bins.

a. Yes b. No

18) (If "Yes" in Q no.17) | In your opinion why people behave like this?

a. Difficult to put waste inside the bin due to waste and litter spread around the bin
b. Difficult to put waste due to height of bin
c. Bin is always fully occupied
d. Any other reason_____

19) Which of the following is the priority concern for solid waste in your area?

a. Littering and looks bad b. effect on human health c. effect on environment d. Other _____

10. ANNEXURE-B: QUESTIONNAIRE FOR PERCEPTION OF HOUSEHOLD ABOUT SWM

S. No.	Statement	Strongly Disagree	Disagree	Uncertain	Agree	Strongly agree
1	I understand the concept of sustainable solid waste management.					
2	Solid waste management has impact on sustainable development.					
3	Many environmental issues will be minimized if solid waste is managed properly.					
4	Solid waste is the major environmental issue in our area.					
5	New development process has impact on solid waste management in our area.					
6	Every individual has responsibility to contribute to solid waste management system in our area.					
7	The waste collection authority treats all household equally.					
8	Waste collection staff collects waste from our neighborhood in right/ needed time.					
9	I am satisfied with the waste collection fee system.					
10	I am willing to pay more for improved waste collection services.					
11	I am satisfied with the solid waste bin location near our house					
12	I am satisfied with the solid waste bin size near our house					

13	I have attended seminar/ events related to solid waste management	
14	I am willing to participate in waste management seminar/event.	
15	I am willing to do waste separation inside my house.	
16	I understand the importance of recycling of solid waste.	
17	I am concerned about the impact of solid waste on my health.	
18	I always submit complain to solid waste management authority regarding solid waste problem in my area.	
19	I am satisfied with the overall performance of solid waste management authority in my area.	

11. ANNEXURE C: QUESTIONNAIRE FOR BARRIERS OF SWMS

Subject: Expert opinion for assesment of barriers in solid waste management system in peri urban areas

Description: This survey is a part of ongoing research in department of Urban and Regional Planning, SCEE, NUST. Your contribution will help us in assessment of solid waste management barriers in peri urban area. Your response will only be used for research purpose and shall be regarded as classified.

Location (City in which respondent is working):

Age of respondent:

Education of Respondent:

Designation of Respondent:

Type of office i.e. Public or Private office:

Work Experience (Years):

S. No.	How much do you agree to the following statements?	Not a barrier (1)	Somewhat barrier (2)	Minor barrier (3)	Major barrier (4)
1	The regulations related to solid waste management system in peri urban area are incomplete.				
2	The implementation of regulations in per urban area are poor.				
3	The institutes are lacking capacity to operate in peri urban area.				
4	The funds are Insufficient to carry out solid waste management operation in peri urban area.				
5	Human resource operating in peri urban area has low capability to operate solid waste management.				
6	The funds are Insufficient for conducting research on solid waste management in peri urban areas.				
7	In peri urban area, waste collection fee system is uncertain.				
8	There is low financial viability of waste management system in peri urban area				

9	In peri urban area, there is low social viability of waste management system.
10	There is low environmental viability of waste management system in peri urban area
11	The total area of operation of solid waste has increased in peri urban area.
12	There is increase in total quantity of solid waste in peri urban area.
13	In peri urban area, there are inappropriate facilities for waste separation.
14	The disposal sites are uncontrolled in peri urban area.
15	There is inadequate waste treatement capacity in peri urban areas.
16	In peri urban area, the use of modern technology and necessary instruments are inadequate for collection of solid waste.
18	There is an inadequate use of modern technology and necessary instruments for disposal of solid waste in peri urban area.
19	The use of modern technology and necessary instruments are inadequate for recyciling of solid waste in peri urban area.
20	There is an improper training of waste workers working in peri urban area.
21	In peri urban area, operational equipments are insufficient e.g. dustbins, dumpsters for collection of solid waste.
22	The operational equipments are insufficient e.g. tractor trollyes, trucks for transfer of solid waste in peri urban area.
23	In peri urban areas the waste recycling facillities are not existing.

24	The haphazard growth makes waste collection difficult.
25	There is poor community engagement by organization in waste management activities in peri urban areas.
26	There is a lack of coordination and communication between solid waste management organization in peri urban areas.
27	The behavior of household is irrational regarding disposal of solid waste in peri urban area.
28	Household has less awareness regarding solid waste management in peri urban area.
29	In peri urban area there is poor data management by solid waste management institutes.
30	Solid waste management institues have inadequate knowledge about potential benefits regarding solid waste management system
31	Any other