Co-funded by the
Erasmus+ Programme
of the European Union

Master of Urban Climate and Sustainability (MUrCS)

Developing a Conceptual Framework for a Bio-Based Circular Economy Approach to Waste Management in Bahar Colony, Lahore-Pakistan

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August 2020

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Submitted in partial fulfilment for the requirements of

Master of Urban Climate & Sustainability (MUrCS)

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LAB University of Applied Sciences, Finland;
University of Huelva, Spain

Supervisors: Caroline Gallagher and Paul Carroll

August 2020

Declaration

'This dissertation is my own original work and has not been submitted elsewhere in fulfilment of the requirements of this or any other award'.

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SAMIRA NAZIR
16 August, 2020

“The fear of the LORD is the beginning of wisdom”

Proverbs 9:10

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Abstract

The traditional approach to economic growth is based on the concept of "take, make, use, and dispose". This has produced a 'throw-away' society that is not sustainable and is affecting the environment and human health, especially in developing countries where the waste management is mostly ignored. There is a need to move away from this, which has promoted many countries to identify a sustainable way of waste management. The most recent identified solution in this context is the "Circular Economy". This study explores detail on CE by reviewing the literature on Finland as an example and more precisely the "BIOREGIO project" Lahti, where all biowaste is being managed through CE practices. The study aims to assess the need and development of a conceptual framework based on CE principles for biowaste management of Bahar Colony Lahore, Pakistan. The methodology adopted to collect the data includes field surveys and interviews of BC residents, private waste collector, and Lahore Waste Management Company officials. Both qualitative and quantitative data have been gathered to critically analyse the baseline situation and issues of waste management from generation till disposal. The results revealed that the current system is mainly focused on waste collection and transportation, and besides the availability of sanitary landfill, controlled dumping and other illegal ways of waste disposal are being practiced. There is no formal system for waste segregation and recycling. The higher rate of organic waste production in the system showed CE potential, which was assessed through the Strengths, Weaknesses, Opportunities, Threats (SWOT) analysis. The conceptual framework developed based on the outcome of SWOT analysis and lessons learned from the BIOREGIO project further allows the visualisation of a new biowaste management process based on CE principles. The implementation of which will provides benefits to LWMC and the entire country not only in terms of waste management but also environmental, social, and economic improvements. The study concluded CE as a feasible solution for sustainable waste management, however, to implement CE LWMC first has to overcome the existing issues by following the recommendations proposed in the study.

Keywords: Waste management, circular economy, biowaste, BIOREGIO project, Bahar Colony, Lahore Waste Management Company, private waste collector, SWOT analysis, conceptual framework.

Acknowledgment

First of all, I would like to express my profound gratitude and sincerest appreciation to the GOD Almighty who is the entire source of wisdom and knowledge to mankind, who granted me enough knowledge, patience, and health to complete this study. I would not be able to do this work without his consent.

For completion of my thesis, I am highly pleased to express my heartiest indebted to my supervisors “Caroline Gallagher” and “Paul Carroll”. They not only supervised and helped me in conducting the study but also strengthened me whenever I felt down because of surrounding circumstances. I am thankful to them for giving me their precious time, intellectual guidance, and valuable suggestions whenever I needed it. Their support, cooperation, and encouragement help me a lot in the timely completion of the study. Deep appreciation is extended to “Rohinton Emmanuel” and “Eeva Aarrevaara” for organizing this programme and their constant support and motivation throughout the studies. I am thankful to all for providing me with the knowledge that will benefit me thoughtout my life.

I am grateful to the entire team of LWMC for allowing me to visit their department and cooperation of Manager and Supervisors for providing me with the data I required. I am also much thankful to the residents of BC for their immense support and time. Without LWMC and community support it would not have been possible for me to develop a case study.

Finally, I wish to express my sincerest gratitude and love to my parents ‘Nazir Masih and Surriya Barket’ for their prayers, support, and unending love without which it would not have been able for me to complete this study. I am thankful to my siblings Qaesar Nazir, Kenneth Nazir, Kashif Nazir, Samina Nasir, my brother in law “Nasir White” and their lovely daughters (Mishma, Cheryl, Maira, and Sara) for their constant prayers and love. My family remained my strength throughout the study.

Last but not the least, I convey my thanks to all my friends especially Sulakshana Joseph John and MUrCS colleagues with whom I shared moments of pleasure and anxiety, and their all support and encouragement during those moments.

Dedication

I dedicate this thesis to my most respectful and beloved parents, who raised me to be the person I am today and my entire family members for their continuous love and prayers that enabled me to achieve this.

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ABBREVIATIONS

CDGL	City District Government Lahore
CE	Circular Economy
CF	Conceptual Framework
GHGs	Greenhouse Gases
GoP	Government of Punjab
KWC	Kujala Waste Centre
LWMC	Lahore Waste Management Company
MSW	Municipal Solid Waste
P&C	Production and Consumption
PHJ	Päijät-Häme Waste Management Ltd
PPE	Personal Protective Equipment
PWC	Private Waste Collector
SDG	Sustainable Development Goal
SWM	Solid Waste Management
SWOT	Strengths, Weaknesses, Opportunities, Threats
TFS	Transfer Station
TUU	The Urban Unit
UC	Union Council
UNEP	United Nations Environment Programme
WB	World Bank

CHAPTER 1: INTRODUCTION

1.1. Background

The human population is increasing day by day and to meet the needs of this rapidly growing population resources are being exploited at a faster rate than they are being replenished at. This has resulted in the degradation of resources, loss of biodiversity, climate change, environmental pollution, and more waste generation. Waste is one of the main contributing factors to environmental pollution and problems. More waste means more attention and resources are required for its safe collection, disposal, and management which otherwise can cause health, water, soil, and air pollution that can put human life in danger.

1.2. Rationale / problem statement

For many years various attempts have been adopted by scientists and developers to implement different strategies and techniques that can mitigate the issue of waste management and can promote sustainability. One of the latest attempts is the Circular Economy (CE). This concept has recently gained importance among the developers and policymakers especially of European nations, China, and Japan. An evident example of this is the comprehensive European Circular Economy package. It involves a regenerative industrial system where resource input and waste, as well as any kind of leakage, are minimised by slowing down and closing material and energy loops (Geissdoerfer, et al., 2017). This ultimately reduces the consumption of resources and the amount of waste generation.

Waste is a big problem mostly in developing countries like Pakistan where waste segregation, recycling, reuse, and prevention are not much practiced. In many cases waste is disposed in available empty plots or spaces to avoid the expense related to waste management. Moreover, it is a common practice that developed countries are disposing of their waste in developing countries and Pakistan has become the favourite destination for this practice (Ilyas, 2018). This practice is severely affecting the health condition of the public and it has been estimated that approximately 5 million annual deaths alone are due to the waste-related diseases in Pakistan (Ilyas, 2018).

For the last 70 years, Pakistan had no scientific landfill for waste disposal but recently in 2016 a sanitary landfill has been constructed in Lahore at Lakhodair. This is the first-ever sanitary landfill of the country which is being used by Lahore city to dispose it's Municipal Solid Waste

(MSW). Before the construction of this landfill, the waste of the city was disposed at the Mehmood Booti open dumping waste disposal site, located on the eastern bank of river Ravi (LWMC, n.d.) and contributed to environmental pollution for many years.

The open dumping in the city is still practiced at many places and produces an unpleasant odour, acts as a breeding ground for bacteria and viruses, rats, and other vermin causing epidemic diseases. Furthermore, it contributes to the spread of dust and filth during the storms and winds and encourages the entry of illegal scavengers to extract recyclable material for formal and informal units working in the country. These units produce recyclable materials not safe for human health due to the lack of proper safety standards and guidelines (Akhtar & Zhonghua, 2014). At some sites, the scavengers burn the plastic materials also like shopping bags and other, to make molten plastic and sell it to steel industries to use as fuel. This sometimes causes breathing problems for the nearby communities (Gilani, 2016) because it produces a variety of gases and particulate emissions harmful to human health (The Express Tribune, 2018). Further, the burning of solid waste and crops is the major contributor to smog production in the city especially during the winter season (The Express Tribune, 2018).

The leachate produced from the open dumps contributes to water-borne diseases due to the presence of thousands of complex contaminants. According to a study conducted in 2010, sixteen points were selected near three open dumping sites (Mehmood Booti, Saggian and Baggrian landfills) located in various parts of the city for groundwater sampling and were found highly contaminated. The pollutant concentration was higher than the recommended upper limits of the Pakistan Standards and Quality Control Authority (PSQCA, 2004). Also, arsenic concentration in drinking water at most places was above the recommended level of the World Health Organization (WHO) (Akhtar & Zhonghua, 2014). Figure 1.1 presented below shows the various direct and indirect impacts of solid waste on the environment.

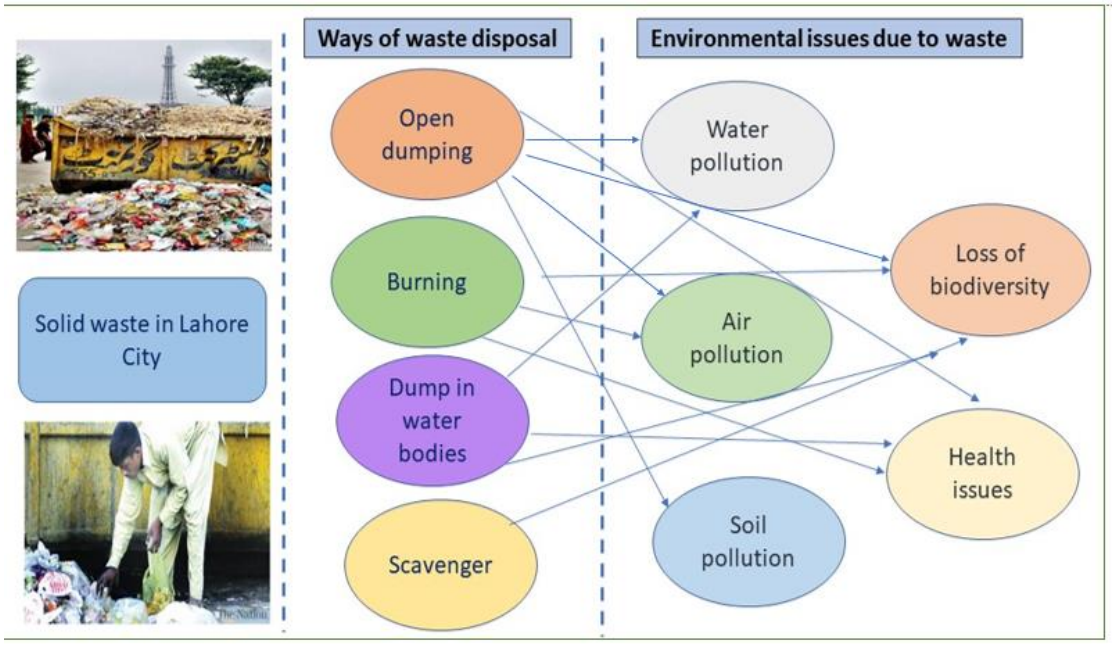


Figure 1. 1: Various environmental issues due to waste disposal. Source: (Author own)

The waste in Lahore city is being disposed without segregation. The study conducted in 2008 estimated that if recycling is adopted as an industry in the city it could generate revenues of Rs. 530 million (US$8.8 million) per year and can also save an enormous amount of energy and natural resources (Batoola, et al., 2008). The contributing factor to this could be the introduction of feasible strategies by means of CE that could bring positive changes in terms of sustainability in Pakistan.

To analyse the effectiveness of CE in Pakistan an area named “Bahar Colony (BC)” in Lahore was selected as a case study that helped in assessing the existing system and gaps in waste management practices. On basis of which Conceptual Framework (CF) has been formulated keeping in view the CE perspective and accordingly suitable measures were proposed to smoothen the implementation of CE principles. The main focus of the study is on the biowaste generated from households. The study is designed bearing in mind the fact that Pakistan is an agricultural country where recycling of biowaste combined with the relatively cheap labour cost could bring benefits and profits for the government, locals, and the environment. Moreover, Finland is taken as an example who is working in the field of CE and is known for bio-based expertise and innovative solutions (Business Finland, n.d.).

1.3. Aim and objectives

The study aims to develop a CF that promotes sustainable biowaste management in Bahar Colony, Lahore based on CE principles.

The objectives attached to the aim of the study are:

- Baseline survey of BC to assess the current waste management practices with specific reference to MSW.
- Critical analysis of existing issues in the current system through interviews of relevant stakeholders such as BC residents, informal Private Waste Collector (PWC), and Lahore Waste Management Company (LWMC) officials.
- Appraisal of Lahti bio-based waste management through CE, to identify key areas of good practices.
- Development of CF based on CE to address key problem areas of waste management of BC from generation till disposal.

1.4. Methodology outline

Lahore is the second-largest city of Pakistan with a population of 11 million. Although the majority of the city is urban whereas some parts such as the outskirts have rural areas and slums. The development of a CF requires an in-depth analysis of the current situation regarding the existing practices of waste management in the city. However, keeping in view the size of the city and time of the study the BC was selected as a case study which is an urban area and falls under UC 226 of Lahore city. In BC the waste management services are provided by the LWMC and PWC but still waste is being disposed at street corners, empty plots, and wastewater drain. Therefore, it was important to assess the gaps and how it can be minimised by the adoption of CE practices.

The methodology adopted to conduct the study was a mixed-method including literature review, preparation of questionnaires, field surveys, interviews, and focus group discussion. Due to the outbreak of COVID-19, other security concerns, and availability of locals total of 10 households were interviewed. For interviews, three different types of questionnaires were prepared which includes questionnaires for; locals, PWC and LWMC. The collection of both qualitative and quantitative data helped in conducting the SWOT analysis and the development of CF for biowaste management.

1.5. Structure of the report

This study is composed of six chapters. Chapter 1 of the report presents the introduction and scope of the research, its main objective, and a brief methodology. Chapter 2 deals with the literature review carried out to explain what other authors have written about the topic under discussion at the international and national levels. This gives a general picture of the overall situation and the role of CE in biowaste management. Chapter 3 defines the methodology that was adopted to collect data in order to achieve the defined objectives. Chapter 4 provides a baseline description and results of the collected data in the form of tables and graphs. It covers analyses of the current waste management situation in the context of practices from generation till disposal. Chapter 5 introduces the discussion on gathered information based on which a CF for the circularity of biowaste in the system was developed. The research work is concluded in Chapter 6 and based on the gaps identified in chapter 5 a set of recommendations were formulated to be followed by LWMC at various levels to improve the overall waste management system.

CHAPTER 2: LITERATURE REVIEW

2.1 Background

According to the worldometer calculations, the current world population is 7.7 billion as of May 2020 and this population is growing at a rate of around 1.05% per year (Worldometer, n.d.). The increase in population is negatively impacting the carrying capacity and ecosystem functioning of the earth. Moreover, it is contributing to resource degradation and waste production due to the inefficient use of resources that are being consumed to meet the needs of the growing population. The amount of waste production varies according to different activities and countries. However, it is been estimated that it is increasing worldwide (WB, 2019) and the contributing factor towards the increase in volume and complexity of waste is the modern economy (UN environment programme , n.d.) According to the World Bank (WB), in 2016, the worlds' cities generated 2.01 billion tonnes of solid waste, amounting to a footprint of 0.74 kilograms/ person/ day. Based on the current status, it is expected that there will be an increase of 70% from 2016 levels to 3.40 billion tonnes in 2050 (WB, 2019).

For disposal of the waste different countries have different methods but in the case of developing or low-income countries, the most common method is unregulated dumps and open burning. This contributes to the emission of Greenhouse Gases (GHGs) in the atmosphere that adds to global climate change (WB, 2019). It is estimated that uncontrolled landfills are the world's third-biggest source of methane emissions (Azam, et al., 2020) and contributes to about 5 percent of global GHGs emission (UN environment programme , n.d.). According to the Pakistan Environment Protection Agency (Pak-EPA), Pakistan ranked 135th for global methane emissions on a per-capita basis, contributing 0.8% of the total global GHG budget (Azam, et al., 2020). Therefore, to minimise the overall climate impact it is important to dispose the waste properly (Syeda, et al., 2017) which will contribute to sustainability also but it remains a challenge for many developing countries as it demands 20–50% of municipal budgets (WB, 2019). Therefore, unfortunately in Pakistan like many other developing countries it is the most neglected sector in overall environment planning. Due to this, the country is facing serious environmental problems (Syeda, et al., 2017).

2.2 Introduction

There are different types of waste such as municipal (household, commercial and demolition waste), hazardous (industrial), biomedical, electronic (e-waste), radioactive, etc (Solarimpulse

Foundation, n.d.). The focus of this study is on the MSW which normally does not include industrial, agricultural, medical, and radioactive wastes or sewage sludge (Upama & Karmacharya, 2012). In MSW the amount of biodegradable waste including garden, kitchen, and food waste is normally 1/3 of the total waste (Halkos & Petrou, 2016). The global production of MSW is approximately 1.3 billion tonnes per year which is expected to increase to approximately 2.2 billion tonnes/per year. Accordingly, the waste generation rate in the next fifteen years would increase from 1.2 kg to 1.42 kg/ person/ day (Iqbal, 2019). Therefore, Solid Waste Management (SWM) is becoming an issue of global concern. The health and environmental implications associated with waste are also mounting in urgency, particularly in the context of developing countries (Marshall & Farahbakhsh, 2013).

The mismanagement of waste in developing countries is mostly due to a lack of understanding and awareness regarding the fundamental characteristics of waste management. Limited data availability, unskilled workforce, lack of expertise, low level of services, ineffective legislation, and deficiency of funds adds to the constraints for effective SWM (Majeed, et al., 2018). Further, the adaption and implementation of other foreign strategies and policies become complicated due to variations in waste composition which differ between geographical regions, from country to country, among nations, cities, and even within a city. Broadly saying in developing countries it is mostly organic with high moisture content and low calorific value (Majeed, et al., 2018). The absence of educational programmes further adds to the problem of polices implementation because without a clear and proper understanding of policy it becomes difficult for states, provinces, and municipalities to determine the most appropriate solution for waste management (Diaz, 2017). Additionally, there is an absence of environmental legislation and a reliable framework as the limited investment is usually made in the SWM sector and it is mostly controlled by the weak government (Khatib, 2011). The situation in developed countries is comparatively different, they are good in managing their waste (Majeed, et al., 2018) and factors such as environment, climate change, resource scarcity, public health, awareness, and participation are acting as SWM drivers (Marshall & Farahbakhsh, 2013).

Waste management includes the proper collection, transportation, valorisation and disposal of waste (Halkos & Petrou, 2016). More broadly, it includes all activity from generation till final treatment and disposal (Solarimpulse Foundation, n.d.). Globally a lot of research is being conducted in waste management (Halkos & Petrou, 2016) and to-date wide range of waste management techniques are available such as landfills, incineration, recycling, composting,

waste collection, and energy recovery (Solarimpulse Foundation, n.d.). Some of these techniques convert waste into energy and fuel and hence promote public health, environmental protection, and minimum GHGs emission (Bogner, et al., 2008). Many European countries are following the waste management hierarchy presented in Figure 2.1, which encourages waste prevention as a top priority followed by reuse and recycling to avoid waste going to the landfill. By doing so they have minimised their waste production along with financial and environmental benefits, as depicted in Figure 2.2. It has been estimated that in 2012 the total municipal waste generation in EEA countries declined by 2%, despite a 7% increase in real household expenditure (Bourguignon, 2016).

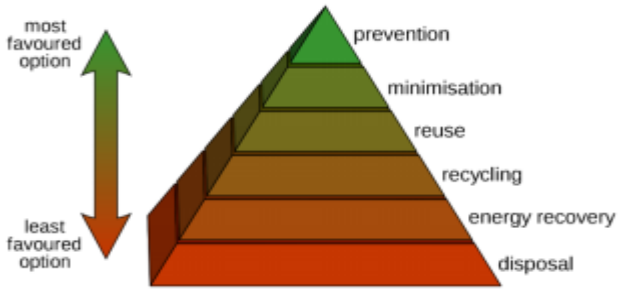


Figure 2. 1: Waste hierarchy strategies. Source: (Halkos & Petrou, 2016)

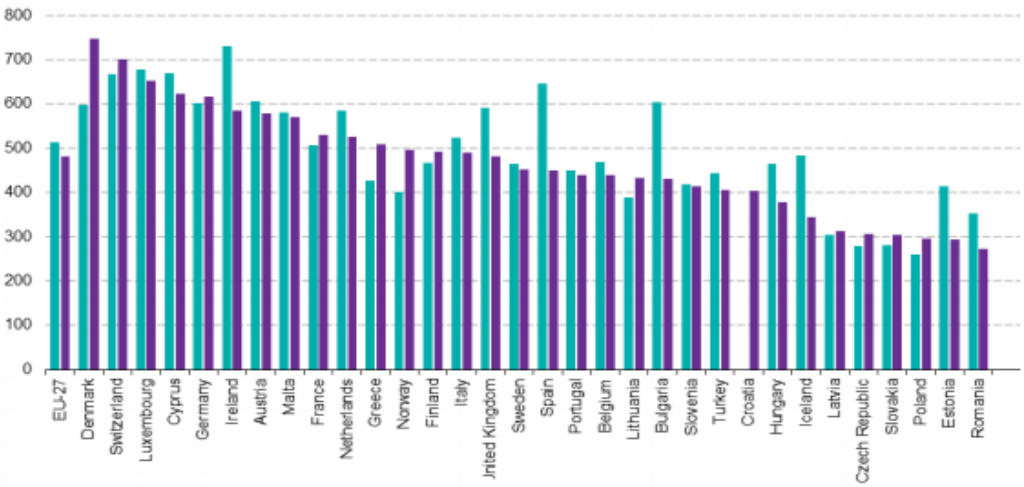


Figure 2. 2: Municipal waste generated kg per capita by countries in 2003 and 2013 (blue:2003 and purple 2013). Source: (Halkos & Petrou, 2016)

Although some of the waste management technologies are proven effective in minimising the waste production but still MSW is a widespread problem both for developed and developing countries (Abdel-Shafya & Mansour, 2018) because many of these emerging technologies are contributing to linear economy (Halkos & Petrou, 2016). In a linear economy, the waste which is a side result of the production process is discarded into the environment on the ground

surface and in watercourses, based on the principle of “take, make, consume and discard” as shown in Figure 2.3 (Drljaca, 2015).

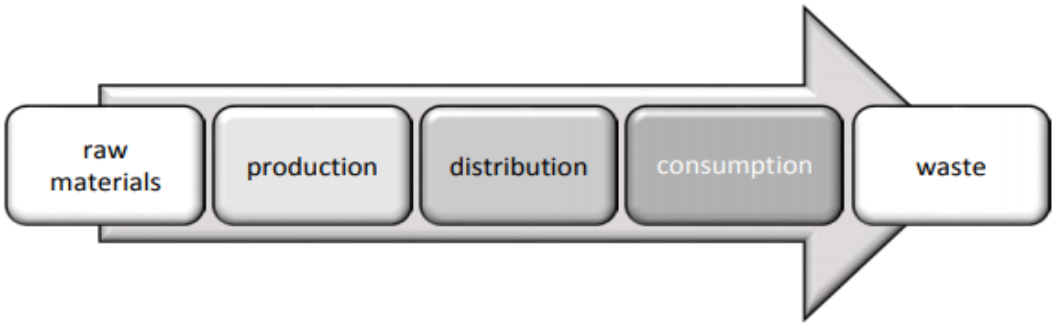


Figure 2. 3: Phases of the linear economy model. Source: (Drljaca, 2015)

In the case of developed countries, the abundance of material resources and energy has motivated the producers to adopt linear business models and neglect the adoption of recycling and reuse hence putting much emphasis on waste (Sariatli, 2017). While in the case of developing countries where landfills and open-dumping are considered as the cheapest and easiest options for waste disposal, recycling and reuse is almost ignored (Akhtar & Zhonghua, 2014). The disposal of a product in landfills means loss of all its residual energy. Although the incineration or recycling of discarded products recoups a small share of energy but not significantly as can be done by reuse (Ellen MacArthur Foundation, 2013). As a result, waste production is increasing which the world could not sustain in the longer run (Halkos & Petrou, 2016).

To overcome this problem there is a need to adopt a waste management technique that is more affordable, effective, sustainable, (Bogner, et al., 2008) environmentally friendly, feasible, and socially & legally acceptable (Abdel-Shafya & Mansour, 2018). This idea of sustainable waste management is highly related to the concept of CE (Halkos & Petrou, 2016) in which waste is treated in various ways by recycling, burning, and burying to generate power, produce fertilizer, or recycle material. This shows that waste management has moved from just being an environmental protection strategy to be an industry contributing to the economy (State of Pakistan Economy, 2009).

2.3 Conceptual understanding of Circular Economy

CE deals with a closed-loop system that involves equilibrium between economy and environment to bring social improvements by contributing to more financial benefits with less resource consumption and environmental pollution. It minimises resource input, waste generation, emissions, and energy leakages by slowing, closing and narrowing material and

energy loops through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling. Moreover, it incorporates different features and concepts that share the idea of closed loops like cradle-to-cradle, laws of ecology, looped and performance economy, regenerative design, industrial ecology, biomimicry, and the blue economy (Geissdoerfer, et al., 2017). Thus, the concept of CE is considered a viable, sustainable, and unavoidable alternative to cope with waste challenges (Sariatli, 2017). Figure 2.4 depicts the basic concepts of CE (Entrepreneurship Campus, 2019).

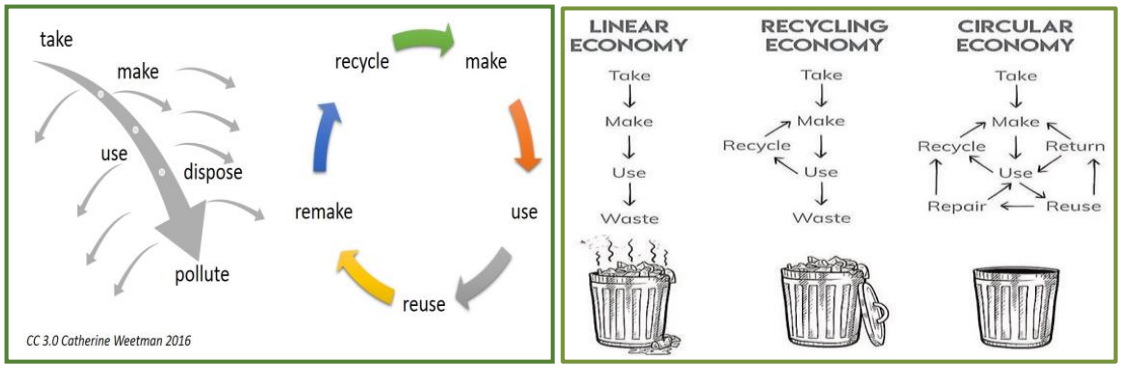


Figure 2. 4: Conceptual diagram of CE. Source: (Entrepreneurship Campus, 2019)

CE has both opportunities and challenges which are shown in Table 2.1 (Bourguignon, 2016):

Table 2. 1: CE opportunities and challenges. Source: (Bourguignon, 2016)

Opportunities	Challenges
• Reduce climate change issues by reusing the resources and better waste management.	• It would involve considerable transition costs and lack of appropriate finance for market innovations.
• Reduce landscape and habitat disruption which would in turn help to limit biodiversity loss.	• Incentives for producers and recyclers to work together to improve performance within and across specific value chains; and markets for secondary raw materials.
• Enhanced security of supply of raw materials.	• It would require technical skills which are currently not present in the workforce.
• It could strengthen growth and create new jobs.	• Systemic shifts in consumer behaviour who have little knowledge about potential benefits of CE and tend to be reluctant to adopt new business models.
• It triggers a large innovation for material and products redesign for circular use.	• Transition to CE would require action at many levels (e.g. international, European, national, local, business, and individual) and in many policy areas.

2.3.1 Timeline for CE development

CE is a new revolutionary concept of the 21st century economy, presenting a good quality response to the global environmental crisis and climatic changes (Drljaca, 2015). It has now

gained popularity among different countries which becomes evident in the comprehensive European CE package which aims to accelerate the European transition towards CE (Halkos & Petrou, 2016). Academic and industry are also realizing the opportunities promised by the CE.

It was first adopted by Germany, which was a pioneer in integrating the CE into national laws in 1996, with the enactment of the “Closed Substance Cycle and Waste Management Act”. Followed by Japan's 2002 “Basic Law for Establishing a Recycling-Based Society” and China's 2009 “Circular Economy Promotion Law of the People's Republic of China” (Geissdoerfer, et al., 2017). Later, the European Commission prepared a CE package in 2014 which has been replaced by a new package on 2 December 2015. The new package aims to 'close the loop' and contribute to meet the United Nation’s Sustainable Development Goals (SDG) adopted in 2015, particularly goal 12 on sustainable Production and Consumption (P&C). The package contains an action plan to be met by 2030 and four legislative proposals on waste, landfill, reuse, and recycling. It also highlights measures in five priority sectors which are: i) plastics, ii) food waste, iii) critical raw materials, iv) construction and demolition, and v) biomass and bio-based products (Bourguignon, 2016). In the new CE package (2016) European parliament restricted the incineration of recyclable and biodegradable waste by 2020, encourages to impose a gradual ban on landfill and to increase the recycling and reuse to atleast 70% of MSW and 80% of packaging waste by 2030 (Bourguignon, 2016).

2.4 CE and waste management

CE emphasises on designing out of waste and pollution by keeping products in use for longer and facilitating the regeneration of natural systems (Trueman, 2019). Unlike the traditional linear model-based pattern it is based on a closed-loop system, where products and the materials they contain are highly valued (Bourguignon, 2016). In this regard waste prevention and resource efficiency are considered as two main drivers, however, the uniqueness comes from two interrelated ideas which are the closed-loop economy and design to re-design approaches (Halkos & Petrou, 2016). CE closes the loop by taking into consideration a holistic framework approach from raw materials, design, production, distribution, consumption, collection, and recycling back to the reuse of materials (Halkos & Petrou, 2016). Hence, what used to be considered as 'waste' can be turned into a valuable resource (Bourguignon, 2016). CE is estimated to be worth $4.5 trillion globally by 2030 (Closed Loop Partners, n.d.)

2.4.1 Transition of linear to CE concept

As discussed above the current economy is growing on a "linear model" based on the assumption of easily available resources and their disposal (Drljaca, 2015) which is putting business and humanity at risk (Bue, 2015). Therefore, this is the time to undergo a serious transition with CE (Drljaca, 2015) that incorporates repurposing, redistributing, remanufacturing, and reusing of resources into processes (Bue, 2015). This will reduce manufacturing costs, provide consumers with more sustainable products (Closed Loop Partners, n.d.), and ensure enough raw materials for food, shelter, heating, and other necessities in the future (Govt. of netherland, n.d.).

The key assumption in the transformation of linear to CE is a feedback circle that returns the collected and recycled waste into the production cycle as a valuable raw material and only a small amount of waste is disposed that may not be recycled, as illustrated in Figure 2.5. (Drljaca, 2015). There are two kinds of potential for waste which include i) turning waste into a resource and ii) using waste as a source of energy in which potential energy from the non-recycled waste is extracted through incineration, anaerobic digestion and waste-derived fuels (FCC environment, n.d.).

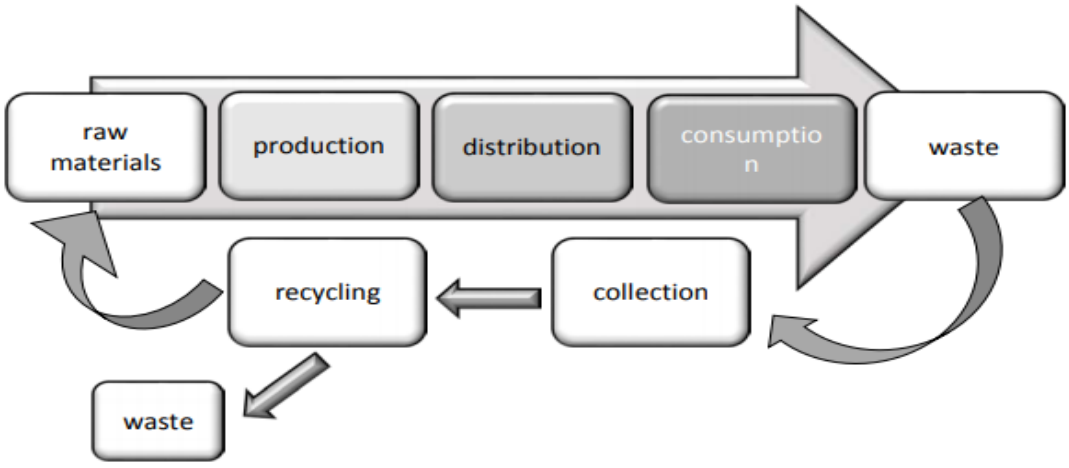


Figure 2. 5: Feedback circle for transforming linear to CE. Source: (Drljaca, 2015)

This reclaimed material in the production process avoids the extraction of natural resources from the environment (Ellen MacArthur Foundation, 2013) and kept the product in use for a longer time before it becomes waste. Depending on technological characteristics, a single type of waste may be recycled several times and reused in subsequent cycles of production processes. The fundamental principle thereby is an efficient use of material resources, waste collection, recycling, and reuse in the production process (Drljaca, 2015). CE implies a more

manageable waste. The SWOT analysis of CE versus Linear Economy is presented in Figure 2.6 (Sariatli, 2017).

Strength (S) • Proficiency in the reverse material flow cycle. • Quantifiable benefit of elimination of waste from the value chain. • Incorporating the attributes of CE in the R & D phase of operation yields the development of higher quality and more durable components. • Due to the closed-loop processes, the economy grows less exposed to price fluctuations of the materials and the flattened cost curve ultimately results in more efficient use of resources in terms of both value and volume. • Externalities are associated with the use and flow of material, lower material consumption evidently decreases the exposure to externalities.	**Weakness (W)** • CE requires amalgamation of the entire product life cycle from raw material provision to destruction. • No specific guidelines to sectors on how to implement circular economy. • There is still no internationally recognized standards institution to regulate the sector. • Public opinion about CE is yet inefficient and social marketing campaigns lack to access sectoral people. • There is still no special legal regulation about circular economy and its application. • Investments about circular economy to introduce the system to sector are not enough.
Opportunity (O) • By reducing the level of material input needed, the economy may save billions of dollars. • Deploying circular design in technological products, results in securing access to better and cheaper materials. • Developing expertise in legal, mechanical, operational or cross-sectoral challenges in circular solutions opens business opportunity for the enablers.	**Threat (T)** • Controlling entire life cycle by companies can easily cross-subsidize different activities and that can cause high prices and incapable products. • If producers could direct their own product-waste, it may be more difficult to benefit from waste management for those in scale economy. • A gradual or sequencing financial disruptions in the system can cause unpleasant outcomes for the interdependent sector due to complex and interlinked sector.

Figure 2. 6: SWOT analysis for CE versus linear economy. Source: (Sariatli, 2017)

The circular model encourages businesses and individuals to be more mindful of environmental issues (Upadhayay & Alqassimi, 2019). This depicts that CE is a promising technique for sustainable waste management and will help in the reduction of cost associated with the production, improve air and water quality, reduce GHGs emissions and food waste. Further, it will create jobs and enhance the quality of life by improving hygiene conditions and reducing health risks related to illegal dumping and inadequate waste collection (Solarimpulse Foundation, n.d.). CE is considered as the legs of sustainability (Manickam & Duraisamy, 2019). However, moving towards CE is challenging as it demands changing ways of thinking and managing waste (Halkos & Petrou, 2016).

2.4.2 Changes required for the transition

Transition is regarded as an improvement process. However, the transition from “linear” to “circular” economy is a complex process (Drljaca, 2015) because the linear model is dominant in the system since the onset of the industrial revolution. This transition would require a major transformation of our current P&C patterns, which in turn will have a significant positive impact on the economy, environment, and society (Rizos, et al., 2017). However, changing consumption and poor habits of people is incredibly hard (Trueman, 2019) because of the low level of awareness among the citizens and government (Sariatli, 2017). This demands the fulfilment of a series of requirements such as the development of awareness and knowledge regarding the change in habits and behaviour patterns, changes in priorities, development of the institutional framework, development of waste management infrastructure, provision of necessary resources, and defining and communicating new policies and new financial products supporting the CE concept (Drljaca, 2015), collaboration across the entire value chain, including product designers, recyclers, manufacturers, municipalities and the citizens (Closed Loop Partners, n.d.). It will be not enough for one or two stakeholders to change, every organization that forms the infrastructure and economy needs to embrace the new way of doing businesses (Trueman, 2019).

2.4.3 Biowaste and CE

At present, over 30% of food produced in the EU is wasted which means wastage of energy and natural resources, along with high costs associated with throwing away the food (Vanhamäkia, et al., 2020). Bioeconomy means reliance of industries on renewable biological resources which not always mean sustainable or circular. By combing the principles of both bioeconomy and CE, a bio-based CE, and the full potential of the CE can be achieved (Medkova & Vanhamäki, 2018) because it will close the biological loops (Vanhamäkia, et al., 2020) by managing biological resources in the economy for longer possible (Medkova, et al., 2017).

CE enriches the relationship between P&C since it returns the effects of consumption into the production process. (Drljaca, 2015). The P&C model is based on two complementary loops one for 'biological' and other for 'technical' materials (Bourguignon, 2016). The flow of technical and biological materials is depicted in Figure 2.7 (Ellen MacArthur Foundation, 2017). In both cases, the aim is to limit the leakage of resources and to encourage the use of products again (Bourguignon, 2016).

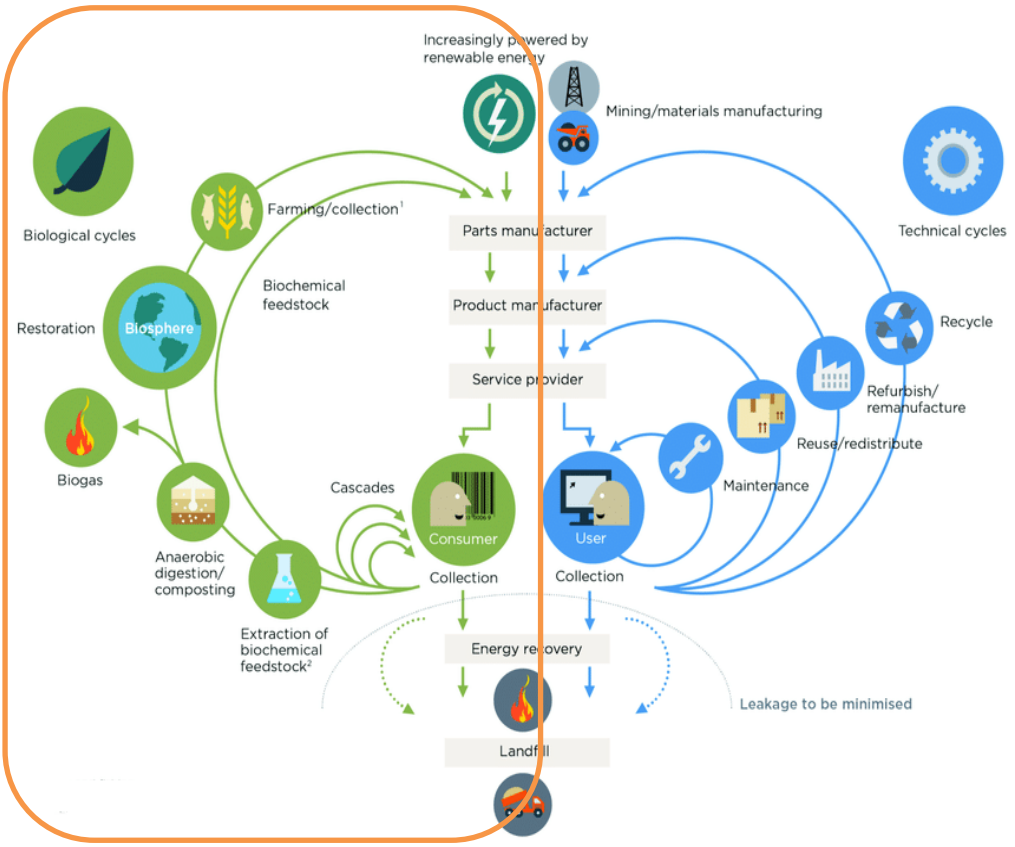


Figure 2. 7: CE biological and technical loops. Source: (Ellen MacArthur Foundation, 2017)

The figure presents that waste will not exist if the product is intentionally designed to fit within a biological or technical materials cycle or designed for disassembly and refurbishment. In the biological cycle, the ability to reintroduce products and materials back into the biosphere through non-toxic, restorative loops is at the heart of the idea (Ellen MacArthur Foundation, 2013). This can be done by conversion of biomass with the help of enzymes and bacteria into fibers, sugars, proteins, medicines, and fuels. This process will avoid the waste going to landfills and associated externalities such as its impact on land use including the societal burden associated with siting choices for landfills and GHGs emissions. Ellen MacArthur Foundation (2013), estimates that upto 7.4 million tonnes of carbon dioxide equivalent would be avoided by keeping organics out of landfills (Ellen MacArthur Foundation, 2013).

2.5 Bio-based waste management in Finland through CE

Finland aims to become a global pioneer in the field of CE and was the first country who prepared a national road map to a CE in 2016 (Sitra, n.d.). The updated version of the road map was published in March 2019 which includes the descriptions of all essential CE measures along with 30 additional actions required by Finland to become a pioneer in CE. It has been

estimated that CE has the value creation potential of EUR 1.5-2.5 billion for Finland's national economy by 2030 (Sitra, n.d.). The network of pioneering municipalities was formed as part of the "CIRCWASTE- towards CE in Finland project" with a total budget of EUR 19 million. The project aims to promote CE through practical measures in construction, agriculture, industry, food chain, and households (Lahti, 2017).

2.5.1 Lahti a pioneer city in CE

Lahti is a pioneer city in Finland in terms of CE. It is located on a bay at the southern end of lake Vesijärvi about 100 kilometres north-east of the capital Helsinki as shown in Figure 2.8. It is the centre of industrial design and offers opportunities for meeting place for companies, products, designers, training, and education. The other Finnish cities committed to CE are Jyväskylä, Ii, Kuopio, Lappeenranta, Porvoo, Riihimäki, Rovaniemi, Turku, and Vantaa.

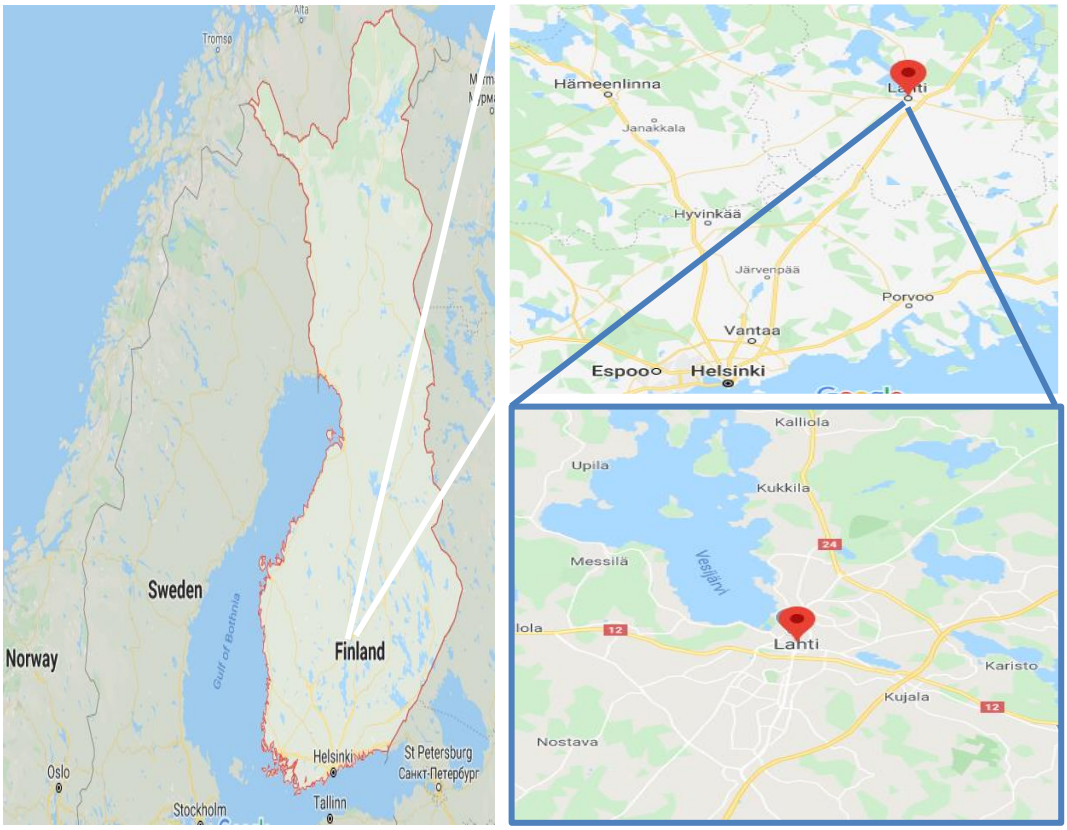


Figure 2. 8: Location map of Finland and Lahti. Source: (Google map, n.d.)

CE is bringing growth-oriented business and new sustainable solutions to the city which are increasing global attention. In 2017 and 2018 the city was a finalist and winner for 2021 in the European Green Capital competition. The city has started a new era of recycling and material processing innovation by making huge progress in recycling and creation of a unique regional

waste sorting and treatment culture. It has developed world-leading excellence in different waste to energy production models. The city has now set new targets of becoming a zero-waste city and curbing over-consumption by 2040 (Smart & Clean Lahti, n.d.). Moreover, it aimed to stop the incineration and landfilling of waste by 2050 (Lahti, 2017). The utilisation level of MSW has increased considerably within the last 10 years, from 54% in 2007 to 97% in 2018 which means only 3% of the total MSW was landfilled (Interreg Europe, 2020), as depicted in Figure 2.9 (Lahti, 2017). An example of CE practices can be seen at the Kujala waste management centre in Lahti (Lahti, 2017).

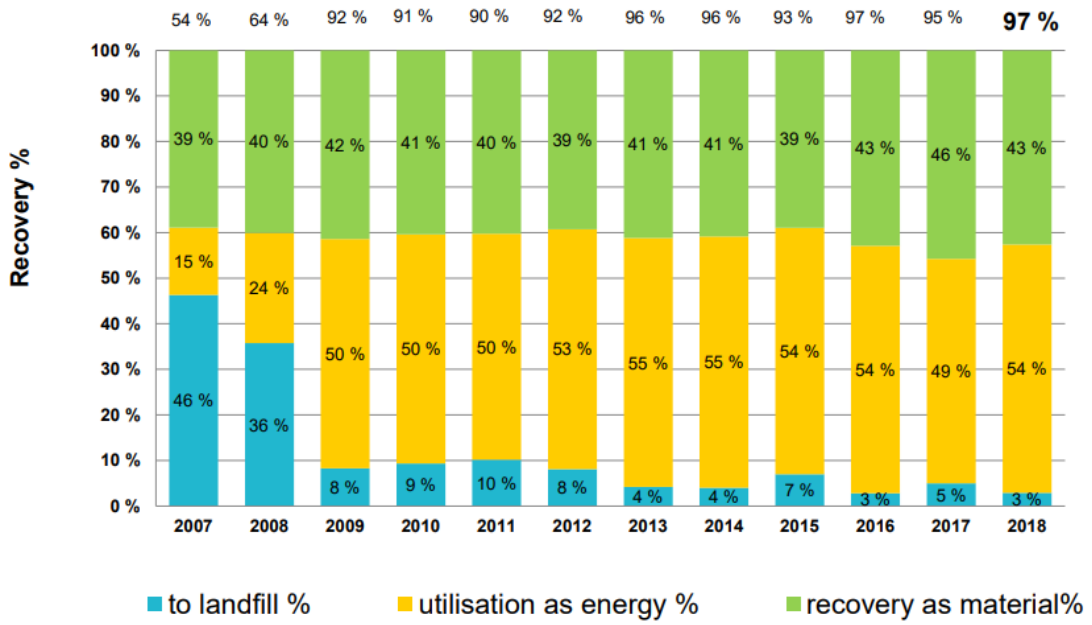


Figure 2. 9: Municipal waste recovery in PHJ. Source: (Vanhamäki, 2020)

2.5.2 Kujala Waste Centre (KWC)

Kujala Waste Centre (KWC) is the main site of Päijät-Häme Waste Management Ltd (PHJ) and it is the only waste treatment site in Lahti. It was constructed in 2001 at an area of 70 hectares in total. The layout of the centre is shown in Figure 2.10. PHJ serves over 200,000 residents and 13,000 companies. It takes waste from communities and production facilities for interim storage, handling, recovery, transfer, and final disposal. The amount of waste received each year is approximately 200,000 tons. Approximately 45-50 people are working there, which are employed by PHJ and contractors (PJH, n.d.).

Figure 2. 10: Pictorial presentation of KWC. Source: (KWC, 2017)

Out of the total waste received at KWC, 97% is reclaimed each year as recycled material or used in energy production through industrial symbiosis. Only a small fraction of the waste is disposed at the landfill in accordance with the environmental permit (PJH, n.d.). One of the five goals of the Päijät-Häme road map is related to bio-based CE. As a part of updating the road map to CE, the action plans for the BIOREGIO project were formulated (Medkova & Vanhamäki, 2018). The detail of BIOREGIO project is as below.

2.5.3 BIOREGIO project

BIOREGIO is a five-year-long Interreg Europe project financed by the European Regional Development Fund (ERDF) (Vanhamäki & Manskinen, 2017). Its first meeting was held in Lahti which brought together international guests from five European countries including Spain, Greece, Slovakia, France and Romania to introduced the bio-based CE practices in the region of Päijät-Häme (Vanhamäki & Manskinen, 2017). It has a collaboration of eight partners from five European regions mentioned above including LAB University of Applied Sciences, Finland. The total cost of the project is 1.30 euro million and its duration is from 1 Jan 2017 to 31 Dec 2021. The project will enhance bio-based CE through i) transfer of expertise about best available practices and technologies (biorefinery, biogas production), relevant cooperation models (ecosystems, networks, and administrative cooperation), and professional capacity development among stakeholders and public awareness, ii) improvements in knowledge regarding CE of biological materials (food waste/biowaste, municipal and industrial sludge and

agricultural residues) and its recycling, and iii) improvements in regional policy instruments to move towards bio-based CE (BIOREGIO, 2020)

To implement the project the designed actions are the transfer of knowledge through regional stakeholder group meetings, interregional events such as roundtable discussions, seminars and site visits as well as policy briefs, expert papers, and regional dissemination events (BIOREGIO, 2020). The monitoring of action plans implementation will be carried out over the period from 2020-2021 (Vanhamäki, 2018). One of the key aims of the BIOREGIO project is to identify and share bio-based CE Good Practices from the six partner regions on the Interreg Europe Policy Learning Platform to be available for other regions in the EU (Medkova, et al., 2017). In this context, seven good practices have been detected by the regional stakeholder group in Päijät-Häme, which are shown in Figure 2.11 (Medkova, et al., 2017).

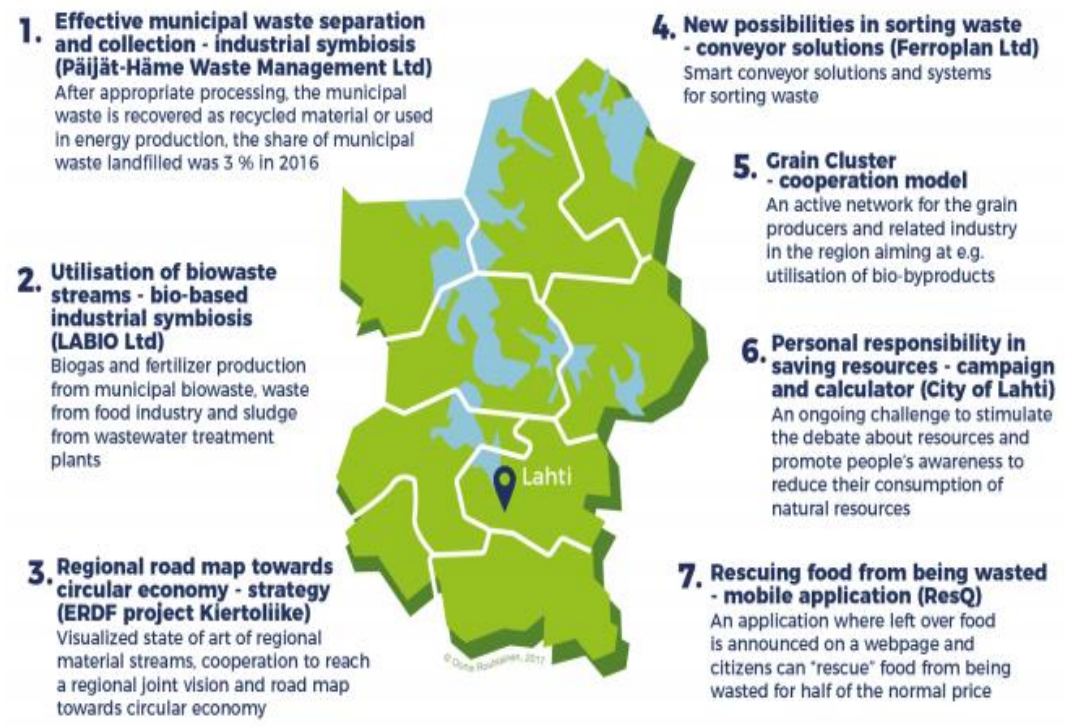


Figure 2. 11: Bio-based CE good practices in PHJ. Source: (Medkova, et al., 2017).

2.5.4 Good practices a lesson learned from BIOREGIO project

To understand in more detail the process of biowaste management through CE, the following information has been extracted from the good practices of the BIOREGIO project which shows that CE is a successful tool in managing the biowaste.

a) **Organic waste sorting at source**: The process starts with waste sorting at point of generation to avoids the valuable materials and nutrients lost in landfill and incineration. The separate collection of biowaste in Finland begun in 1994 (Vanhamäki, 2020). In PHJ the waste sorting is supplemented by the LATE sorting plant where the mixed waste is separated based on material size, shape, optical and physiological features into fibers, plastics, cardboard, and various metals for recycling. Waste that can't be recycled is used as energy and hence, only a small share of the waste such as rocks and other inorganic material is landfilled. Energy waste such as wood and household waste is processed into fuel to produce district heat and electricity for the region. PHJ waste sorting and processing systems are shown in Figure 2.12 (Vanhamäki, 2020). The detail on the biowaste treatment process is discussed below.

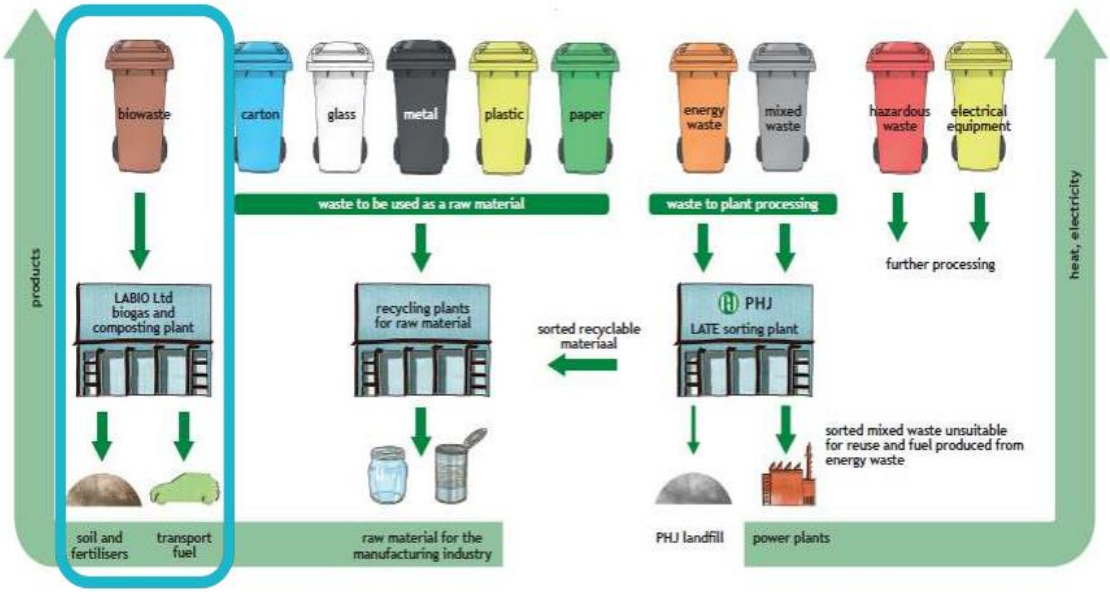


Figure 2. 12: **Waste segregation and recovery process in PHJ. Source: (Vanhamäki, 2020)**

b) **Processing of Biowaste at KWC:** All the waste brought to the KWC undergoes various treatment and industrial symbiosis. For biodegradable waste treatment KWC is home to LABIO Ltd´s biogas and composting plant, and Gasum Ltd´s biogas production plant, as depicted in Figure 2.13 (PJH, n.d.). The composting and biogas plants are operating since 2005 and 2014 respectively (Vanhamäki, 2020). It was the first and is the largest biogas production and refining plant in Finland (Bioregio, 2017).

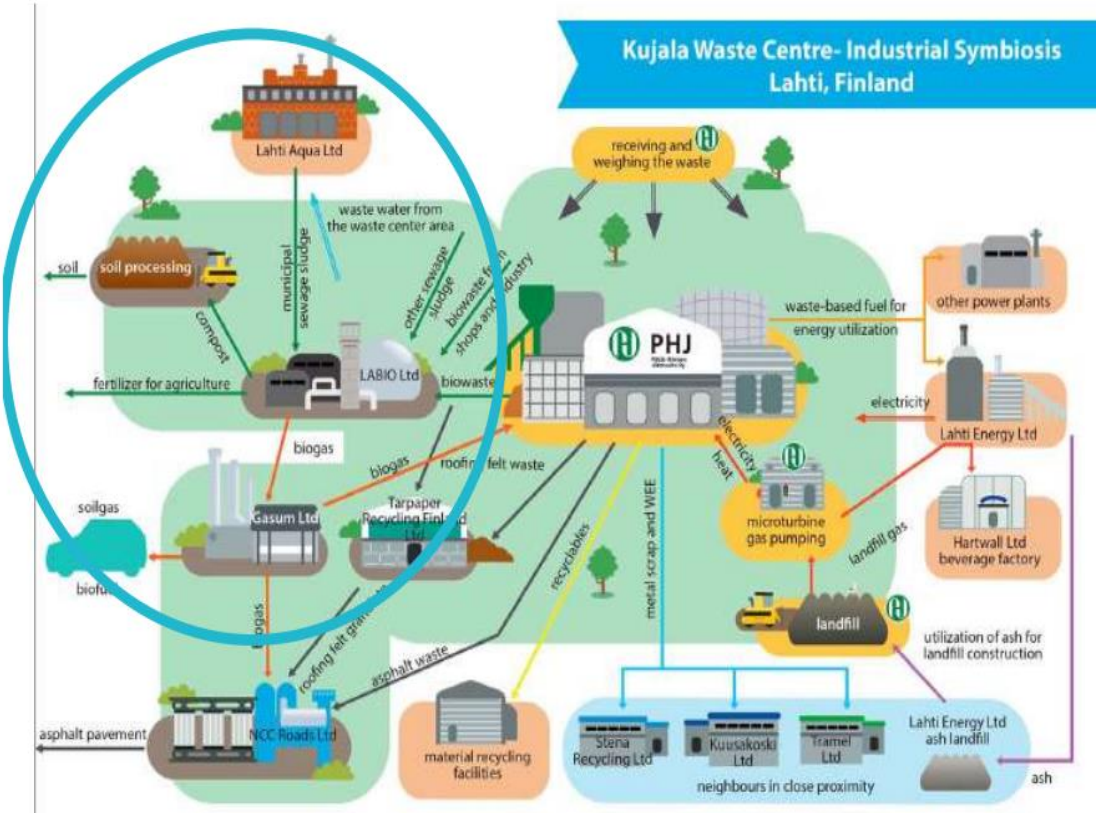


Figure 2. 13: Industrial symbiosis at KWC. Source: (KWC, 2017)

- At these plants, the incoming biowaste including waste from the households, food industry, sludge from wastewater treatment plants, biodegradable material from farming, forestry, fisheries (Bioregio, 2017), and garden waste is converted into biogas through dry fermentation (anaerobic digestion) process. This raw biogas is then processed into biogas similar to natural gas in composition which is then directed to the natural gas network and used as transport fuel (PHJ, 2018). The amount of biogas produced annually can provide fuel to 4500 cars and LABIO´s partner company Gasum is responsible for the distribution and sale of refined biogas (LABIO, n.d.). The remain or digestate from the fermentation process with other biowaste is transferred to the composting plant for compost production, which is used as a soil-improving agent (PHJ, 2018) in agriculture, landscaping, erosion prevention, cultivation, gardening, growing substrates and case by case basis for different technical applications. The compost produced is good in moisture and nutrient retention properties (LABIO, n.d.).

  The dry anaerobic digestion process offers an environmentally friendly, reliable, secure, and odourless production of biogas and compost (Vanhamaki, 2020) that

helped in the reduction of odour, GHGs, fine particles emissions, and the production of renewable energy (Interreg Europe, 2020). The process flow diagram of the LABIO plant is shown in Figure 2.14 (LABIO, n.d.).

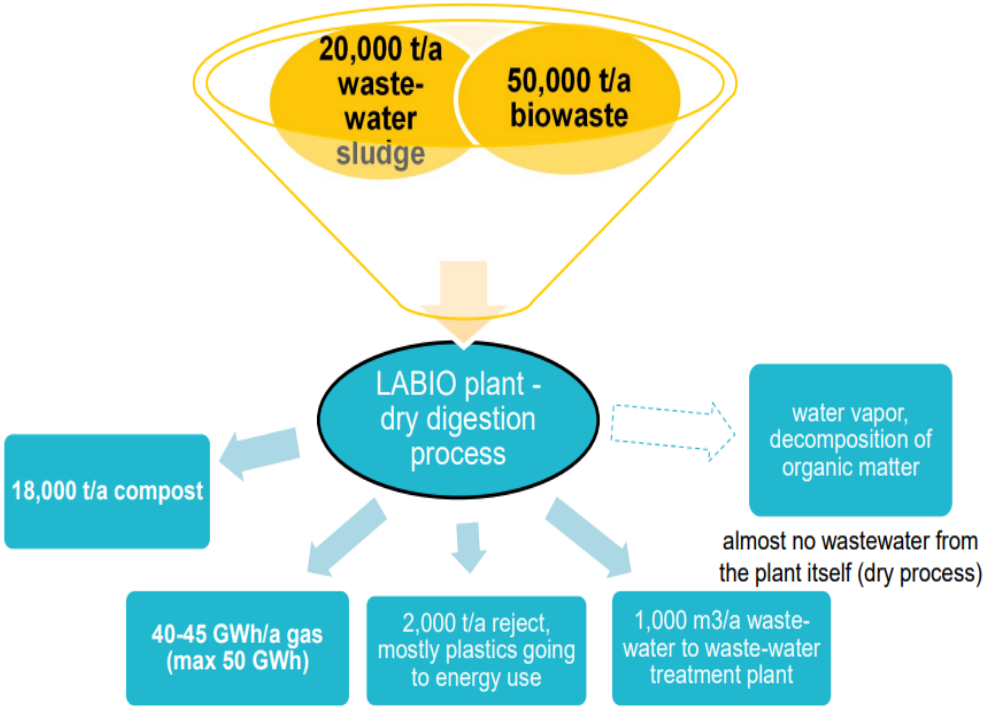


Figure 2. 14: **LABIO process flow chart. Source: (LABIO, n.d.)**

- The landfill gas generated due to the decomposition of organic food is being collected at Kujala since 2002 and is piped to Hartwall´s heating station, where it is used to generate process steam for the soft drinks plant. The remaining gas is used at KWC to generate electricity and heating from it (PJH, n.d.).

- Wastewater of KWC including the leachate from the landfills is treated at Lahti Aqua Ltd´s Ali-Juhakkala wastewater treatment facility (PJH, n.d.).

The key to the success of CE in PHJ is long-term cooperation between municipalities and companies which enabled the development of a functional system (Interreg Europe, 2020). However, there were challenges too, the main challenge was to increase the sorting of biowaste at the place of origin to get clean waste at the sorting plant. The others were about raising awareness and educating citizens and companies in changing their habits (Vanhamaki, 2020). Under the BIOREGIO project Spain adopted the following measures to raise awareness among the community regarding the waste segregation at source (Lora, 2020):

- Distribution of compost bags and information in the streets and at other social points.
- Workshops and development of a small vegetable garden to demonstrate to people the usefulness of compost.
- Environmental programmes for schools and citizens for producing compost by themselves in their own centers.
- Incentives like cinema tickets for people that voluntarily participate in the programme for good separation of waste.
- Visit of recycling and waste treatment plants for students and citizens.

2.6 Overview of waste management practices in Pakistan

Pakistan ranks number 5 in the world in terms of population. Its total population is 220,204,190 as of May 2020 (worldometer, n.d.). The country is currently struggling with various economic and social issues and the least attention has always been paid towards environmental conditions. Increasing population, urbanization, scarce resources, social inequality, communal perceptions, insufficient regulations, and waste generation are driving forces and have boosted the complexity of issues. Due to rural-urban migration the population as well as waste generation of major cities of Pakistan is increasing. Industrialization, changing consumption patterns and affluent lifestyle are the additional factors contributing towards the increase in waste production (Pak-EPA, n.d.). The condition of SWM in the country is very much reflective of a situation like in other developing countries (Majeed, et al., 2018).

Pakistan annually generates roughly 20 million tonnes of solid waste with a growth rate of about 2.4 percent (Lew, 2020). Most of it mainly originates from the major metropolitan areas of the country, as depicted in Table 2.2 (Iqbal, 2019). According to Pak-EPA, the waste ranges between 0.283 to 0.612 kg/capita/day, and the existing resources and capacity of municipal institutions are not enough to deal with the current and upcoming waste. Therefore, unfortunately, none of the cities in Pakistan have a proper SWM system for collection and disposal of waste and a big difference can be seen between the amount of waste generated to the amount of waste that reaches the final disposal site (Pak-EPA, n.d.) because much of the waste finds its way in dumping grounds, open pits, ponds, rivers, agricultural lands, and outside the city limits (MoF, 2015-16).

Table 2. 2: Waste generation and composition in Pakistan. Source: (Iqbal, 2019).

City	Population	Solid waste Generation per day in Tons
Karachi	20,500,000	9,440
Lahore	10,000,000	6,510
Faisalabad	7,500,000	4,883
Rawalpindi	5,900,000	3,841
Hyderabad	5,500,000	3,581
Multan	5,200,000	3,385
Gujranwala	4,800,000	3,125
Sargodha	4,500,000	2,930
Peshawar	2,900,000	1,888

Waste type	Percentage
Ash, Bricks and Dirt	18%
Glass	6%
Textile	2%
Cardboard	7%
Food Waste	30%
Leather	1%
Paper	6%
Plastic	9%
Rubber	1%
Metal	14%

Treatment technologies such as sanitary landfilling, composting and incineration are comparatively new in Pakistan. Therefore open dumping is commonly practiced throughout the country and dumpsites are sometimes set alight to reduce the volume of accumulated waste (Climate and Clean Air Coalition, n.d.). The poor management of waste in the country is responsible for a large number of communicable diseases and environmental destruction (MoF, 2015-16) which is putting the country's fragile eco-system in danger (MoF, 2012-13). It has been estimated that more than 5 million people die each year due to waste-related diseases. One drawback is that hospital and industrial waste are treated as ordinary waste (Iqbal, 2019) and are disposed most often in empty plots/land, open ponds, drains, sea, and rivers (Javaid, 2019).

The underlying causes for the deteriorating waste management crisis in Pakistan are the employment of corrupt individuals in the department of waste management, inefficient bureaucracy, obsolete infrastructure, and dearth of public awareness, no devolution of power to the local bodies, lack of political will, (Javaid, 2019) lack of stakeholders participation in decision making (Masood, et al., 2014), lack of reliable data and research, shortage of equipment and private operators, and financial and technical difficulties (Kaynat, et al., n.d.). Moreover, the institutions are primarily led by public sector workers and politicians who are not aware of waste management practices (Lew, 2020). Thus the big cities of Pakistan including Lahore is confronting severe issues in handling waste (Javaid, 2019).

2.6.1 Current laws and regulation on SWM in Pakistan

The proper management of waste from generation to disposal is essential and requires awareness of the public and municipalities so that they become active in dealing with it. Although Pakistan has formulated various laws and regulations on SWM but it remained unsuccessful in overcoming the issue properly (EPD Government of Punjab , n.d.). At the federal level, the ministry of environment is responsible for the development of policies and programmes. While, at the local level Tehsil Municipal Administration is looking after it which generally does not have the capacity to manage the issues (Pak-EPA, n.d.).

The complete list of legal rules and regulations dealing with SWM in the country is as follow (State of Pakistan Economy, 2009):

- Section 11 of the Pakistan Environmental Protection (PEPA) Act 1997 which prohibits the discharge of waste in an amount or concentration that violates the National Environmental Quality Standards (NEQS).
- Hazardous Substances Rules 2003.
- Guidelines for Hospital Waste Management prepared by the Environmental Health Unit of the Ministry of Health, Government of Pakistan in 1998.
- Hospital Waste Management Rules 2005.
- Islamabad Capital Territory Bye Laws, 1968 by Capital Development Authority Islamabad.
- Section 132 of the Cantonment Act 1924 which deals with Deposits and disposal of rubbish.
- Prime Minister's committee on Climate Change which has a sub-divisional level technical committee on Waste Management.
- Pakistan joined the Basel Convention in 1994 for the control of transboundary movements of hazardous waste and its disposal.
- World Bank is also assisting The Urban Unit of Government of Punjab for reforming the SWM practices in the Punjab Province.
- National Environment Policy Act (NEPA) 2005 prepared by Pakistan's Ministry of Environment which defines general principles of waste management (GoP, 2005).
- Draft Guidelines on Solid Waste Management 2005 prepared by Pakistan Environmental Protection Agency (Pakistan EPA, 2005).

Many of these existing laws are outdated and inadequate to manage waste efficiently. Therefore, there is a need for detailed and more specific regulations dealing with SWM in the country (Nasreen, 2012).

2.6.2 Baseline assessment of SWM in Lahore

Lahore is the capital of Punjab Province and is the second-largest city of Pakistan spread over an area of 1772 km^2. The total population of the city is 11 million (Ashraf, et al., 2016). It is bordered by the district Sheikhupura (north and west), India (east), and district Kasur (south), as depicted in Figure 2.15. The mean annual temperature is approximately 24°C ranging from 46°C in June to 2°C in January. June to September is considered as monsoon season in which the average annual rainfall is 575mm, which varies from 300 to 1200 mm (Akhtar & Zhonghua, 2014). The city is divided into 9 administrative towns such as Ravi, Shalamar, Wagha, Aziz Bhatti, Data Gunj Buksh, Gulberg, Samanabad, Iqbal, and Nishtar. These towns are further marked into 274 Union Councils (UC) (skyscraper , 2018).

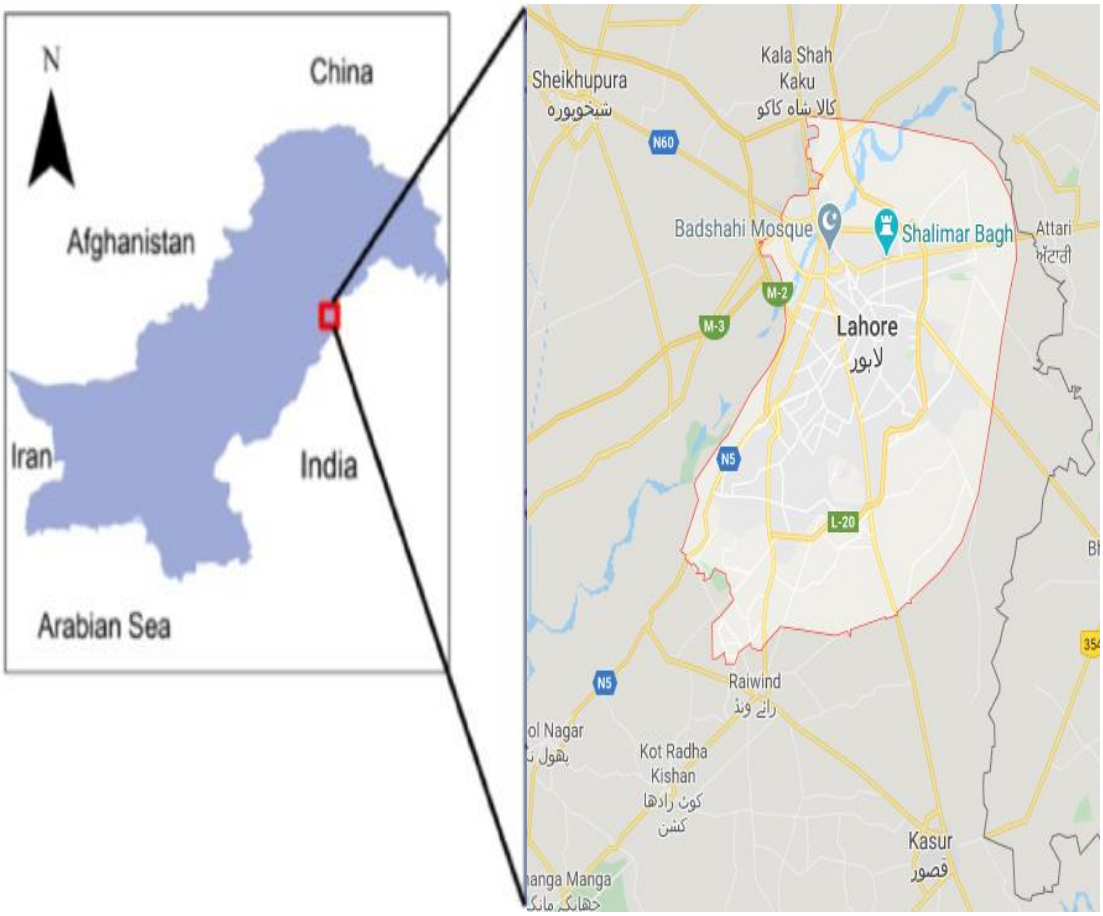


Figure 2. 15: Location map of Lahore-Pakistan. Source. (Google Map, n.d.)

The governance over waste management is hardly present in the city and SWM has long been a neglected sector due to lack of strong commitment on the part of the government (LWMC, n.d.). The detail on the baseline situation of waste management in the city is discussed below.

a) Solid waste generation and collection

The city generates about 0.65 kg/capita/day of solid waste, out of which the highest proportion is of biodegradable waste which is 65%, followed by Nylon 11%, textile 10%, paper waste 2% and hazardous waste 1% (Ashraf, et al., 2016). In 2014 LWMC conducted the waste characterisation study of the city, the graphical presentation of which is shown in Figure 2.16 (LWMC, 2015).

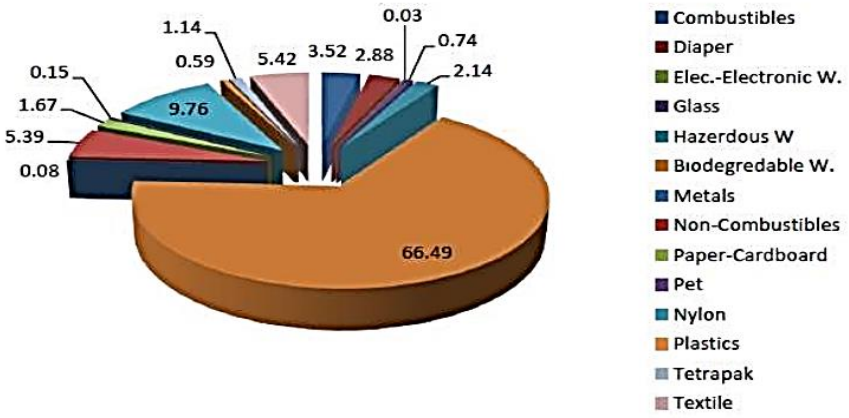


Figure 2. 16: Waste characterisation of Lahore. Source: (LWMC, 2015).

LWMC does not show the high-performance so far in waste management. Despite working in two shifts the waste collection efficiency is still (Lew, 2020) 68% approximately of the total waste generated daily (Masood, et al., 2014). Table 2.3 given below shows the waste collection efficiency of the city in different years. The difference in the collection is due to intra-city inequalities like lower waste collection in low socio-economic profile areas and higher waste collection in upper profile areas (Ashraf, et al., 2016). This ranges from zero percent in low-income rural areas to 90 percent in high-income areas. The only means of waste management in poorer areas is through informal scavenging by people and animals, natural biodegradation, dispersion, burning, and self-help disposal at informal/illegal dumping sites (Climate and Clean Air Coalition, n.d.).

Table 2. 3: Waste collection efficiency in different years. Source: (Ashraf, et al., 2016)

Year	Waste Generated	Waste collected
	Tons	Tons
2008-09	1777104	977318
2009-10	1777104	1182009
2010-11	1777104	1163481
2011-12	1882524	1231380
2012-13	1882524	1481580
2013-14	2130588	1884600

b) Solid waste disposal

The Government of Punjab (GoP) generates revenue by charging private societies, commercial markets, and the local public against the services provided by LWMC and this is added in the water bills provided by Water and Sanitation Agency (WASA) on monthly basis (Climate and Clean Air Coalition, n.d.). GoP is spending over Rs. 13 billion annually on LWMC but like waste collection it also remains unable to dispose waste in a scientific manner (Raza, 2018). Therefore the waste in the city is being dumped in topographic depressions, vacant plots, along streets, roads, railway lines, drains, and open sewers (Batool & Nawaz, 2009).

Before the construction of Lakhodair landfill the only scientific site constructed in the country and Lahore in 2016, the waste of the Lahore city was disposed at three dumping sites around Lahore city which were; i) Mehmood Booti Landfill located north of Bund Road, about 5 km away from River Ravi, ii) Saggian landfill located along the Ravi River, and iii) Baggrian landfill located in Nishtar which was the small site of only 5 acres within a 30m depression. These were open dumping sites and were unorganised having no facilities for collection of leachate and gases produced due to the decomposition of waste. Moreover, the waste after disposal was not covered by clay to avoid the spread of waste and rain penetration (Akhtar & Zhonghua, 2014).

Lakhodair Landfill has also now turned into a dumping ground (Raza, 2019) because the capacity of each lot of the sanitary landfill is only 2000 to 2500 tonnes of waste per day and the remaining around 4500 tonnes of waste is disposed in a traditional manner (Randhawa, 2017) such as semi-equipped landfills and open dumping (Azam, et al., 2020). Moreover, the absence of necessary operational machinery at the landfill is reducing the performance and damaging the basic structure of landfill constructed with around 1 billion Pak-Rupees. According to Raza (2019), the senior manager landfill worked as senior manager operations for a few months, meaning that he himself was involved in lifting and verification of waste at the landfill which added to the inefficiency of the system (Raza, 2019). It was claimed during the inauguration of the landfill that this new site will meet all the international standards of safe disposal (Randhawa, 2017) but it remained a dream of the citizens (Raza, 2019).

c) Waste segregation and recycling

LWMC planned to establish a recovery centre to segregate and recycle the waste of the city but they failed to do that. The centre was supposed to segregate 1,000 tonnes of waste

including debris from different construction places, plastic waste, metals, and other wastes from the southern areas of Lahore to utilised it in an effective way (Randhawa, 2018). The lack of waste segregation in the city is due to inadequate tools and equipment, lack of awareness, poor infrastructure, and shortage of educated and skilled professionals (Akhtar & Zhonghua, 2014). This is causing serious health risks to workers and the public (Akhtar & Zhonghua, 2014). The exact proportion of waste recycling in the city is not known, due to a fragmented system and lack of recycling regulations. Some units are working but most of them are informal and they recycle only 27% (on a weight basis) of the total waste (Azam, et al., 2020). In the informal process, scavengers sort the waste from dustbins, containers, waste heaps, and other available picking points (Batool & Nawaz, 2009).

2.6.3 Environmental and health impacts due to waste

The poor practices of waste handling and disposal in the city are creating multiple environmental and health problems. The Ravi River which plays an important role in groundwater recharge of the city and serves Lahore and its surrounding districts is now been contaminated due to the discharge of organic and inorganic pollutants directly and indirectly into it (Akhtar & Zhonghua, 2014). The list of negative impacts of waste on the environment and human health are discussed in Table 2.4.

Table 2. 4: Negative impacts of waste on the environment and human health

Water Pollution	The most serious problem from solid waste is groundwater contamination due to leachate generation (EPD Government of Punjab , n.d.). Landfills are major threat to groundwater pollution. Lakhodair (MSW) landfill is subjected to various biological, chemical, and physical processes which are producing gaseous emission and leachate. This leachate is seriously contaminating the ground and surface water because the semi-landfill facility does not have any leachate treatment system (Azam, et al., 2020) and citizens have to ultimately drink the poisonous water. Moreover, the lack of timely collection of waste from the overflowing containers resulted in chocking of water drains especially during the monsoon seasons (Raza, 2018).

Health Problems	The most common problem observed is skin and eye infections, whereas waste in the form of dust particles causes breathing problems as well. For workers involved in waste collection, the other diseases found were intestinal and parasitic. Dogs, cats and rats that breed on waste spread diseases such as plague and flea born fever, whereas for flies and mosquitoes diseases like diarrhea, dysentery, typhoid, hepatitis, cholera, malaria, yellow fever (EPD Government of Punjab , n.d.) and dengue are common. In 2010, more than 40,000 cases of dengue virus were reported in the country out of which 17,256 cases and 279 deaths were belonged to Lahore (Azam, et al., 2020). The open storage of waste in majority of households is related to the presence of houseflies in the kitchen which are associated with the incidence of childhood diarrhea also (Javied, et al., 2014). Waste picker and handler who closely deal with waste are more susceptible to diseases and may also act as a transmitter of these diseases, especially when they are engaged with the handling of hazardous waste mixed with MSW stream. The other serious problems could be birth defects, cancer and poisoning (Khan, 2011).
Air Pollution	Smog which is harmful to the health of citizens, the major cause of its production in Lahore is due to the burning of MSW, crop residue, tyres, plastic, polythene bags, rubber, and leather items (Khalti, 2019). Burning of waste is commonly practiced even by the LWMC itself (Spence, 2017) and when it is burnt heavy metals like lead, toxic gases such as carbon monoxide, nitrogen oxide, and soot are produced which are harmful to human health and are a source of air pollution (Khan, 2011). Organic waste decomposition also releases gases in the atmosphere such as methane. Waste when putrefies in sunlight produce bad smells (EPD Government of Punjab , n.d.) and this stinking and unhygienic atmosphere sometimes bother commuters, especially pedestrians (Raza, 2018).
Soil Pollution	The open disposal and decomposition of waste contribute to soil pollution also. The existence of heavy metals in MSW affect the microbiological characteristics of soil which are responsible for the transformations of nutrients to plants (Javied, et al., 2014).

Ecosystem disturbance	The pollution of air, water, and soil ultimately disturbs the ecosystem balance and could produce an alarming situation for both aquatic and terrestrial flora and fauna. Eutrophication conditions produced due to the discharge of a high concentration of nutrients flow, from the waste stream into the water body can change the water flow pattern and its bottom habitat (Khan, 2011).

2.6.4 Current activities and projects on SWM in Lahore

MSW management is recognized as one of the most important elements for sustainable development (Azam, et al., 2020). According to the United Nations Environment Programme (UNEP), there are currently six activities and projects working in Lahore towards efficient waste management which are mentioned below (Lew, 2020).

- Preparation of draft SWM Guidelines with the support of the Japan International Cooperation Agency (JICA), Japan.
- Conversion of agricultural biomass into energy or material source, a project by UNEP, IETC Japan.
- North Sindh Urban Services Corporation Limited, is assisting the district government in the design and treatment of water supply, sanitation, and SWM.
- The Urban Unit (TUU), Policy & Management department is conducting different seminars on awareness of wastewater, sanitation, and SWM.
- Lahore Compost (Pvt.) Ltd. is dealing with organic waste in cooperation with City District Government Lahore (CDGL).
- Involvement of different NGOs at a small scale for solid waste collection and recycling.

2.6.5 Gaps in methodology and approaches for waste management in Lahore

The literature conducted in sections 2.6.2, 2.6.3, and 2.6.4 depicts that despite the work of LWMC since 2010 and the number of other projects, Lahore is still facing serious SWM issues. This shows a gap and lack of research in the existing approaches and strategies. In this context, the selection of appropriate methodology and techniques are considered important factors to bring the change. The literature on the CE and examples of the BIOREGIO project shows that CE can also be a good tool for Lahore where more than half of the percentage of total waste generation is organic. However, the question is to check CE effectiveness and

applicability in the existing system. This demands an in-depth analysis of the baseline situation to identify the gaps and loopholes in the current methodologies and approaches where improvement can be made based on CE principles. Therefore, BC was chosen as a case study to conduct an in-depth analysis. The detail on the methodology adopted to carry out the study is illustrated in chapter 3.

CHAPTER 3: METHODOLOGICAL APPROACH

This chapter illustrates the detailed methodology of the study. The methodology is an important component that essentially maps out the methods adopted to fulfil the objectives of the study. Furthermore, it shows the research area, research approach, tools, and data collection methods used to gather all the relevant data required to conduct analysis and to develop inference. The conceptual understanding of the methodology adopted is shown in Figure 3.1.

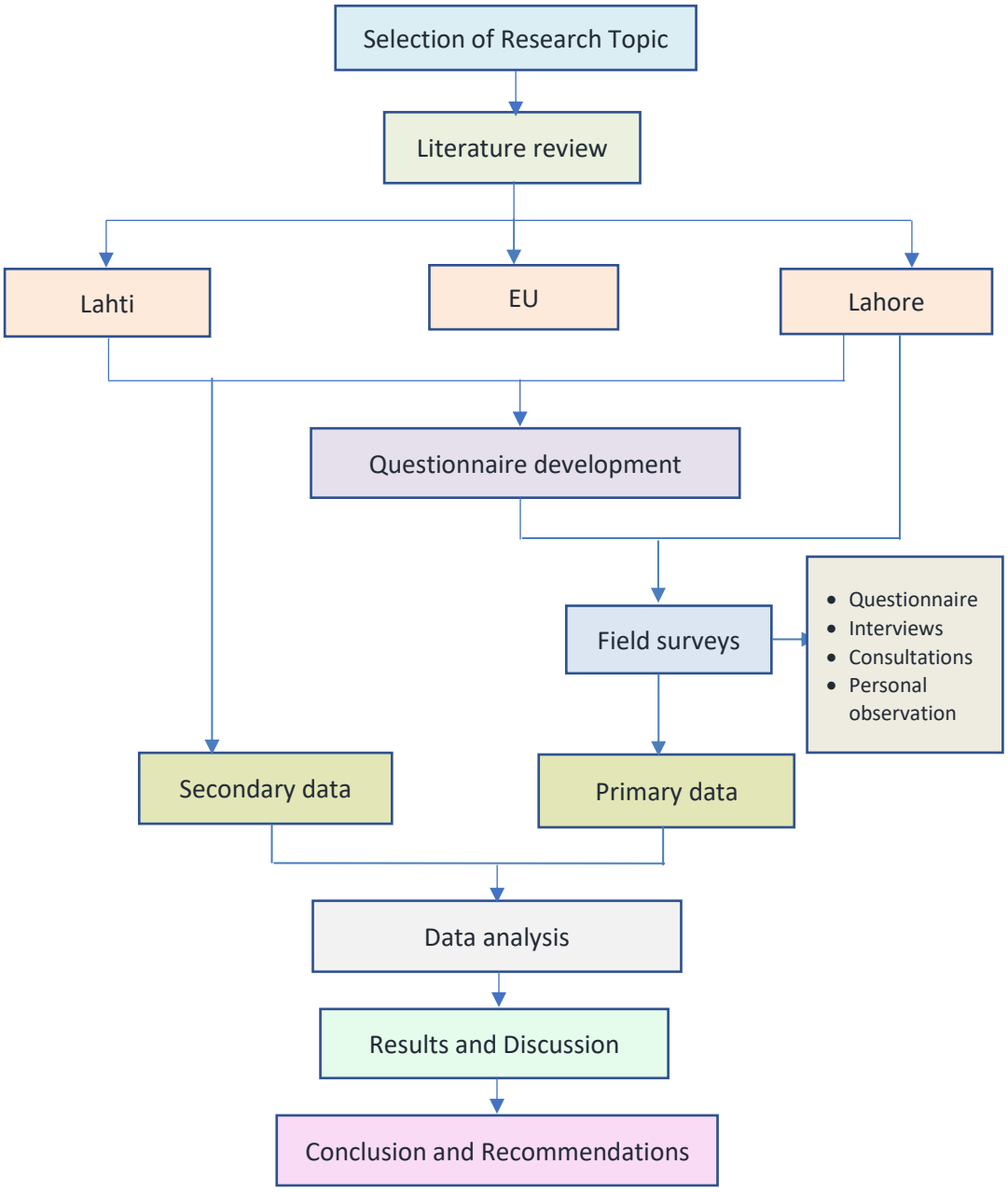


Figure 3. 1: Flow diagram of the methodological approach. Source: (Author own)

3.1 Description of methodology

A detailed description of each step is given below:

1. **Project selection:** Keeping in view the negligence of waste management practices and its importance as a resource for the country's prosperity and well-being, the current topic based on CE approaches for biowaste management has been selected.

2. **Literature review:** Accordingly, the literature review has been carried out to review the i) overall situation of developed and developing nations, ii) role of CE in reducing and managing the waste iii) BIOREGIO project as an example in Finland, and iv) current status and issues of waste management in Lahore, Pakistan.

3. **Case study:** The development of the case study is the most important aspect of research on the basis of which the understanding of the current situation can be developed. It helps in setting the geographical extent for data collection and scope of the study (Nasreen, 2012). Keeping in view the size, time, and population of Lahore city the study has been narrowed down to a locality named "Bahar Colony (BC)" as a case study. The case study aimed to provide deeper insights into why and how the transition towards circular models is important by discussing the existing system, issues, and opportunities. The area within Lahore city was selected because it is a pioneer city in the country for the establishment of a separate waste management company and a sanitary landfill.

   BC generally represents a similar situation of waste management like in most other areas of Lahore. A detailed analysis has been conducted from waste generation till disposal and accordingly, all relevant stakeholders were consulted including BC residents, informal PWC, and LWMC officials. This helped in the provision of more accurate, convincing, diverse, and rich data on ground truth regarding the existing pattern of waste flow. Based on which further analysis was conducted that allowed the development of CF. The focus of the study was only on organic waste but due to lack of waste segregation practices the overall waste stream was studied.

4. **Sample size:** The sampling process is carried out to select the elements from a population in a way that the sample size selected represents the population. There are different types of sampling techniques such as random, stratified, systematic, cluster, snowball, expert, quota, and convenience sampling. Keeping in view the limitation of the study such as

COVID 19 out-break and other security concerns convenient based sampling was chosen to conduct the study. In many other studies, convenient based sampling has been used by the authors to get information on household waste generation (Haider, et al., 2017). Although, no part of the population was selected and no sample size was drawn but to get the baseline data of the study area 10 households were selected for interviews.

5. **Research approach and tools:** The research approach used for the study is deductive, which is theory-testing, and enables the research to reason from generic to specific by studying what has been done, existing theories on the topic under consideration, and then testing of the hypotheses. It is considered as an approach that is typically associated with the scientific investigation (Pedraza, 2017).

   To make the study more reliable and authentic "system analysis platforms approach" was adopted which is predominately used in the academic realm. It includes the use of one or more assessment methods in combination to develop a more holistic view of the situation (Zurbrügg, et al., 2014). Accordingly, different research tools such as field surveys, questionnaires, interviews, focus group discussions, and personal observation were used. In situations where it was not possible to visit the site or to meet the officials the data was collected through telephonic discussion. Questionnaires were selected as a primary approach to build the case, as they are an efficient data collection tool and is the most widely used method in qualitative research. It encourages two-way communication between interviewer and interviewee as a result a large amount of detail can be gathered with this tool (Worldpress, n.d.) In this study, the purpose of using the questionnaires was to assess the existing situation properly and completely in an organized way, as no data was available on the waste management of BC on the internet. Additionally, interviews were also conducted to explore specific questions in more detail according to the response of the interviewees.

   Three different sets of questionnaires were prepared to collect data of BC these include data from the residents, informal PWC, and LWMC officials. The reasons for their selection were because residents are the main producers of waste, and PWC and LWMC play a vital role in the overall collection and disposal of waste of BC. The sample questionnaires used for the residents and informal PWC are attached as Appendices A and B respectively. The questionnaires for LWMC were further classified into two different sets to collect data from Manager Planning, and Manager Operation/ Supervisors of the study area (UC 226),

attached as Appendices C (I) and C (II) respectively. To develop the maps the most widely used tool such as Google Earth was used. All the answers to the major questions of the study were identified with the help of these tools.

6. **Field surveys**: After the finalization of questionnaires and devising a systematic approach the field surveys of both BC and LWMC were carried out from 07 March 2020 to 11 April 2020 using the research tools mentioned above. During the surveys, data on all the positive and negative aspects of the waste management practices was gathered which includes information on residents existing waste disposal practices, PWC methods and LWMC's role in waste management. The list of persons consulted during the survey is shown in Table 3.1 whereas the pictorial presentation of the interviews and group discussion with BC residents, PWC, and LWMC officials is shown in Appendices D, E, and F respectively.

Table 3. 1: List of persons consulted for data collection.

Name	Designation	Date	Venue
Mr. Nazir Masih	Local resident	07.03.2020	Bahar Colony
Mr. Teamothious Charles	Local resident	07.03.2020	Bahar Colony
Mrs. Abida Parveen	Local resident	07.03.2020	Bahar Colony
Mr. Saleem Aktar	Local resident	08.03.2020	Bahar Colony
Mrs. Surriya Yaqoob	Local resident	08.03.2020	Bahar Colony
Mrs. Nargis Inayat Gill	Local resident	08.03.2020	Bahar Colony
Mr. Mark John	Local resident	09.03.2020	Bahar Colony
Mrs. Attia Abeer	Local resident	09.03.2020	Bahar Colony
Mrs. Rubina Pervaiz	Local resident	09.03.2020	Bahar Colony
Mr. Azeem Daniel	Local resident	09.03.2020	Bahar Colony
Mr. Ansar Butt	Counsellor UC 226	26.02.2020	Bahar Colony
Ms. Aisha Nazir	Manager operation UC 226	27.02.2020 02.03.2020 15.03.2020 25.03.2020 07.04.2020 11.04.2020	LWMC and Bahar Colony
Mr. Muhammad Rafique	Supervisor UC 226	04.03.2020 15.03.2020 16.03.2020 09.04.2020 10.04.2020	Bahar Colony
Mr. Akbar	Informal private waste collector	10.03.2020	Bahar Colony
Mr. Zaman Khan	Senior Manager Lakhodair Landfill	04.04.2020 05.04.2020 07.04.2020	LWMC

Ms. Mehwish Hanif	Manager project and planning department	27.02.2020 09.03.2020 25.03.2020	LWMC
Ms. Mariam Kiani	Research Associate (Project and Planning Unit)	09.03.2020 14.03.2020 28.03.2020 09.04.2020	LWMC
Mr. Murad Rana	Consultant of World Bank	02.03.2020	LWMC
Muhammad Asif	Manager operation	27.02.2020 02.03.2020 07.04.2020 11.04.2020	LWMC

7. **Data collection:** The data collection stage is of the high inscription as it makes the research valuable and successful (Nasreen, 2012). Without proper and accurate information efficient and effective planning for waste management cannot be made (Javied, et al., 2014). In this study, the data collection has been categorized into two sub-stages; planning and data collection. In planning, the preparation and designing of questionnaires were completed, whereas, in data collection, the data was collected from the field. In data collection, two types of data were collected such as "primary and secondary data". The primary data includes information from field observation, questionnaires, interviews, and focus group discussions. Whereas secondary data includes information from already published data/ reports from various organizations and departments on the internet, newspapers, advertisements, brochures, and articles.

   The primary data further consisted of quantitative and qualitative data. Quantitative represent the information collected in a numeric form so that the statistical calculations can be made. While qualitative data represent information that is not in numbers and cannot be measured. Quantitative data helped in testing some hypotheses and increased the validity of the study, whereas qualitative data helped in constructing rich descriptions and explanations (Kirunda, 2009).

8. **Data analysis:** The data processing is also an important step to find out the results of the study. It involves two phases; data preparation & data analysis. In data preparation, data is checked for accuracy, errors, incompleteness, and gaps. Whereas in analysis all the information collected is analysed with the help of analytical tools (Nasreen, 2012). In this study, the data statistical tool such as Microsoft Excel has been used to analyse the data and to drive the results in the form of graphs. The data analysis helped in understanding

the profile of the existing waste management system on the basis of which SWOT analysis was carried out. SWOT analysis is an extremely effective tool that provides the ability to screen the appropriateness of the techniques by comparing the advantages and disadvantages (Handakas & Sarigiannis, 2012).

9. **Conclusions and recommendations:** Keeping in view the findings and discussion, conclusions have been drawn in the end with a set of recommendations. These recommendations were prepared to be followed by LWMC to enhance their waste management efficiency. The timeline of the study is attached as Appendix G.

CHAPTER 4: RESULTS AND ANALYSIS

Chapter 4 presents the results and thematic analysis of the data collected from waste generation till disposal through the field surveys and interviews of the BC residents, informal PWC, and LWMC officials. The data on the general profile of BC and LWMC was also collected to assess the existing loopholes and perspectives of the residents and LWMC officials on waste management practices and issues. Although the focus of this study was on organic waste but due to a lack of waste segregation practices the complete waste stream was studied.

4.1. Profile of Lahore Waste Management Company (LWMC)

4.1.1 Establishment of LWMC

The SWM in the city was formalised in 1978 after becoming the part of Lahore Urban Development Project (LUDP), the main component of which was upgrading of SWM system. In November 1980, the project was addressed by a pre-appraisal mission of the WB for the first time in the city. The executing agency of the project was the Metropolitan Corporation of Lahore. At that time CDGL was responsible for the collection and disposal of waste, which was established under the Punjab Local Government Ordinance (PLGO). Later it was realized by the TUU who has the overall responsibility to assist the government in the matters of development projects, that the capacity of CDGL was not enough to manage the waste of the city. Further to minimise the impacts of waste on the environment and human health the traditional ways of waste management were needed to be modernised. In this context, in 1997, a qualified doctor was initially hired by CDGL to guide and help them in looking after the management of health issues due to the waste but the problem of waste management remained the same. Again in 2008, new technical staff including some engineers and scientists were hired and few board members were also replaced by politicians and social surveyors to strengthen the capacity of the unit but there was no improvement and problem was not solved. Later, on 19 March 2010, a separate entity named “Lahore Waste Management Company” was established under section 42 of the companies ordinance 1984 with a vision to “improve and modernise the SWM services in Lahore”. On 25 June 2011, LWMC made a “Services and Asset Management Agreement (SAAMA)” with CDGL to manage the solid waste of the city.

The following year LWMC realized that its capacity was not enough to manage the waste of the city based on its resources and therefore planned to hire private consultants. Resultantly

"ISTAC" a Turkish firm was selected who conducted the solid waste survey of Lahore and prepared a review report. Based on the results of the report it was recognized that waste management is a big problem in the city and it would not be possible for a single firm to manage it alone. Hence, in March 2012, LWMC outsourced and privatised the provision of SWM services to two Turkish companies named "Albayrak and OzPak", to manage the waste of Lahore. The timeline presentation of the development phases of SWM is shown in Figure 4.1.

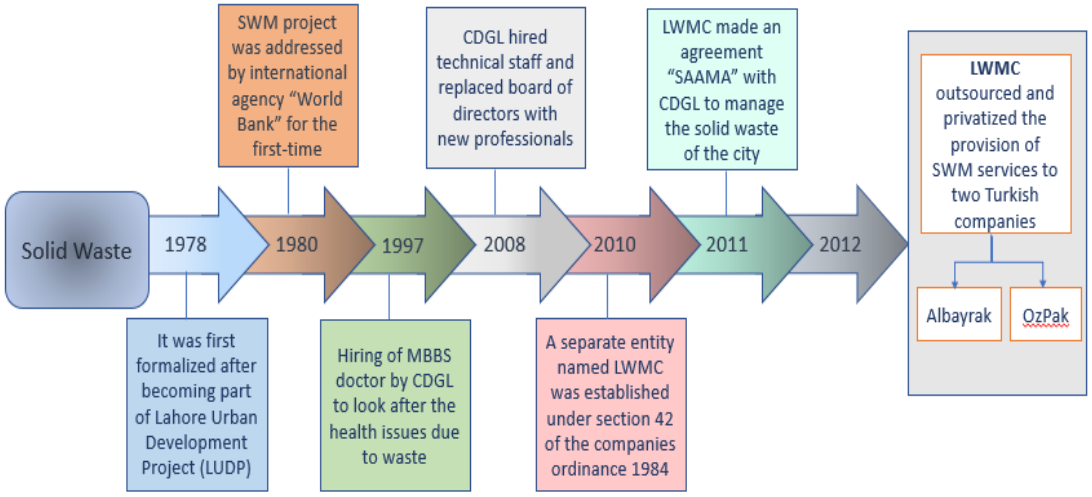


Figure 4. 1: Timeline of SWM development phases in Lahore. Source: (Author own)

For waste management LWMC has almost equally divided the 274 UCs of Lahore into two zones which are Zone 1 and Zone 2. Zone 1 (eastern side) is under the jurisdiction of Albayrak and Zone 2 (western side) is under OzPak, as depicted in Figure 4.2. For suburbs or extended areas of the city, LWMC is directly looking after them. The study area BC falls under Zone 2.

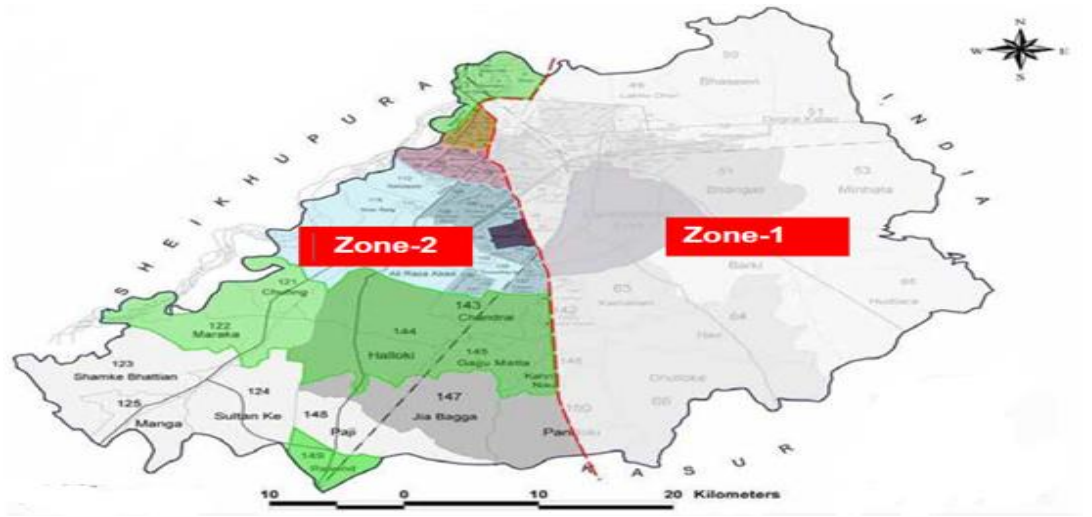


Figure 4. 2: LWMC zones division of the city for SWM. Source: (LWMC)

4.1.2 Role and responsibility of LWMC

LWMC has the overall responsibility to ensure waste management of the city and is answerable to the government for all its activities. It is mainly looking after the MSW which predominantly includes household waste (domestic waste) with sometimes the addition of commercial wastes, construction and demolition debris, sanitation residue, and waste from streets. The other waste types including industrial and hospital waste are not under the responsibility of LWMC. However, in most cases, no discrimination has been made between commercial and household waste. LWMC has seven departments which include i) Operation (the backbone of a company), ii) Planning & Project, iii) HR and admin, iv) MIS, v) Communication, vi) Legal & Corporate affairs and vii) Finance. The total number of workers in LWMC is 10,150 employees, which includes 150 corporate and 10,000 field staff (including zonal officers, supervisors, and sanitary workers). The organogram of organizational setup dealing with the waste management of the study area is shown in Figure 4.3.

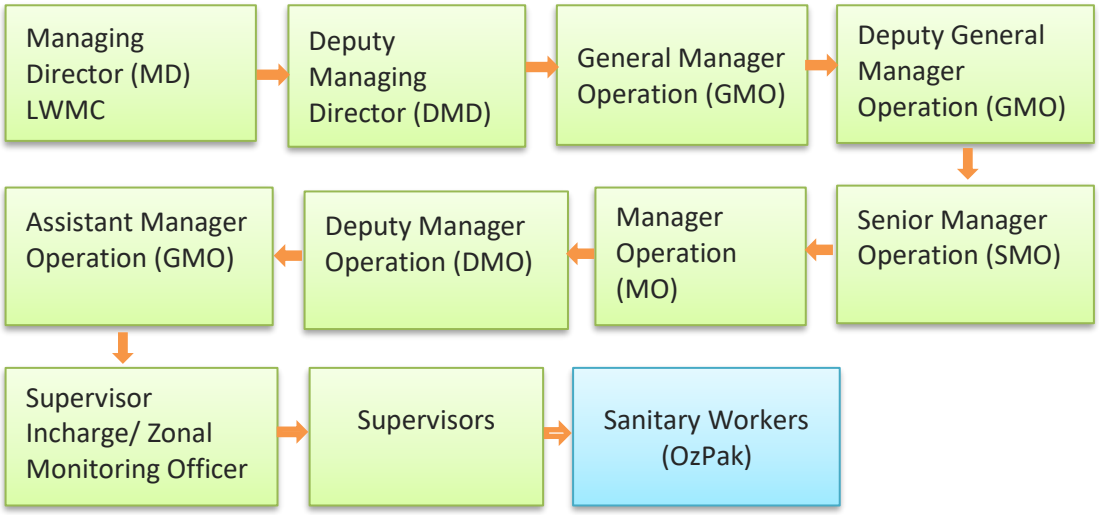


Figure 4. 3: LWMC organizational setup dealing with BC waste. Source: (Author own)

Albayrak and OzPak which are the private contractors of LWMC are responsible for; manual sweeping, mechanical sweeping, mechanical washing, waste collection, door to door collection, container-based collection, and waste transportation to the disposal site. Their overall work and performance are being supervised and monitored by the LWMC. The list and number of vehicles available with the Albayrak and OzPak are given in Table 4.1. This table also shows the vehicles used by OzPak in the study area which mainly includes dumpers and compactors.

Table 4.1: List of vehicles available with Albayrak and OzPak. Source: (LWMC)

Vehicle type	Albayrak	OzPak	Vehicles used in the study area by OzPak
Mini dumpers	72	73	
Dumpers	22	15	
Pickups	42	25	
Compactors	86	134	
Trailers	3	11	
Loaders and excavators	3	9	
Private dumpers	33	13	
Chain arm rolls	17	0	
Mechanical sweepers and washers	18	22	

4.1.3 Workers health and awareness

Field or sanitary workers are the ones who deal and interact with the waste directly. Therefore, to ensure their health and safety LWMC has provided Personal Protective Equipment (PPE) to all the field staff which includes proper uniforms, raincoats, gloves, masks, caps, shoes, and their monthly health screening, as reported by LWMC official. The common health diseases reported among workers were respiratory and skin problems because they generally don't wear proper PPE while working as they feel uncomfortable, which also was noticed during the field surveys. This has increased their chances of getting cuts and other infections as well.

For awareness, LWMC has organised monthly or quarterly training programmes for employees in which the message is disseminated through lectures, presentations, discussions, and conferences. Awareness programmes have been formulated for the general public and schools as well where the message is delivered through print and electronic media.

4.2. Profile of Bahar Colony (BC)

Bahar Colony (BC) is located in "Gulberg Town" of the city which is divided into three zones i.e.13, 12, and 11. Zone 13 includes eight UCs which are 208, 209, 210, 211, 223, 224, 225 and 226. BC falls under UC 226 which lies between 31°28'12.43'' N and 74°20'25.50'' E. The location map of UC 226 (green) and BC (blue) is presented in Figure 4.4.

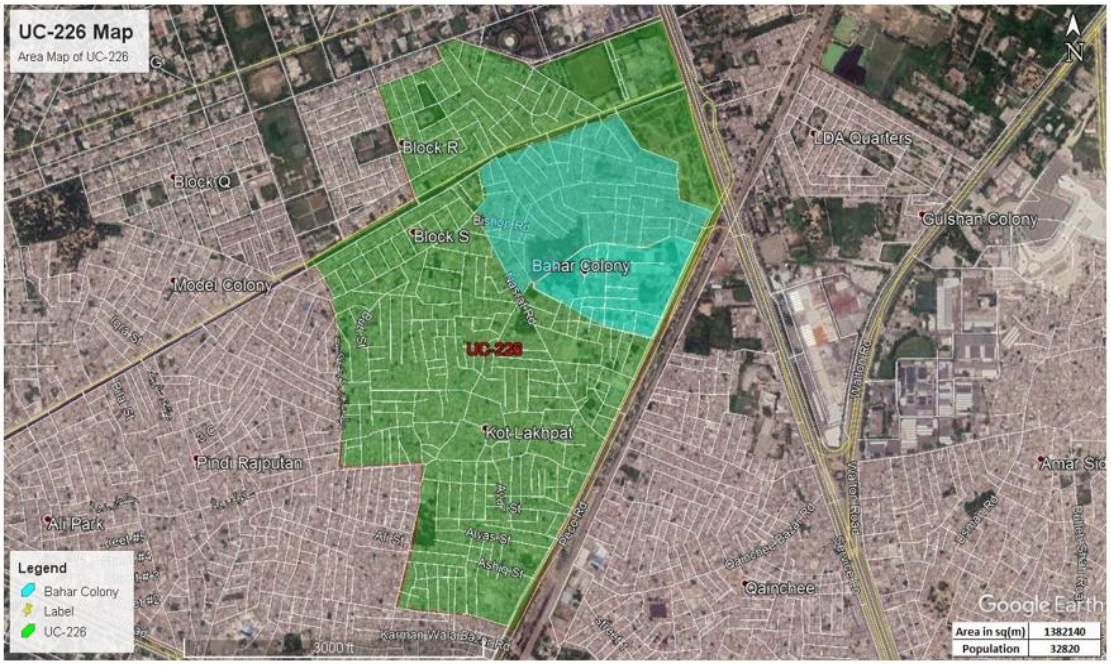


Figure 4. 4: A map showing the boundaries of UC 226 and BC. Source: (LWMC)

BC is comprised of middle-class income people and around 80% of them are educated, as reported by the Union Counsellor. The area is inhabited by 16,241 persons living in 1320 dwellings. It is located adjacent to the main highway "Ferozpur Road" which ends up in India. It is a residential area and includes churches, schools, small parks, and an open wastewater drain. The SWM of BC is under OzPak who is answerable to LWMC for all the waste-related issues of the area and accordingly, LWMC can impose penalties on OzPak in case of delays in the timely resolution of complaints. The door-to-door waste collection in the area is being practiced by the informal PWC. The detailed information on waste generation, collection, and disposal of BC gathered from residents, informal PWC, and LWMC is discussed below.

4.2.1 Waste generation

According to LWMC the total waste generation of Lahore is 5500-6500 tonne/ day which means it ranged from 0.55 to 0.65 kg/capita/day. The informal PWC of the study area reported that waste generation of BC is around 3-4 tonne/ day, out of which 1-2 tonne is organic. Although there was no data and precise information available either with the LWMC and PWC on the waste composition of BC. However, according to the data collected from residents 70-80% of the total household waste they produced daily is organic, and the remaining is mixed waste which includes paper, plastic, metals, iron and steel, e-waste, and other waste. This shows biodegradable waste remained the most dominant component in household waste. No

segregation is being practiced and all waste is disposed collectively in the common bin of households. However, in some cases, informal segregation of reusable and recyclable materials is being carried out by the homeowner or maids which are then sold in the market to waste dealers for cash. Nevertheless, as it requires time thus it is mostly practiced in houses that have maids, while others dispose it without segregation in the bins. These bins are then placed at the doorstep of households daily for the PWC to empty it. The pictorial presentation of the waste flow with PWC is shown in Figure 4.5.

a) Waste generation at a household

b) Waste disposal without segregation

c) View of waste disposal bins

d) Placement of bins outside the door

Figure 4. 5: Process of waste flow in BC with PWC. Source: (Author own)

It is important to note this is not the case for all residents there are groups of people who do not want to avail the facility of PWC to avoid the cost associated with it. These people normally dispose waste in available empty plots, streets corners, and wastewater drain of the area. In some cases they also burn it. The pictorial presentation of waste flow without PWC is shown in Figure 4.6.

a) Waste disposal in empty plots

b) Waste disposal in street corners

c) Waste left unattended in streets

d) Waste disposal in wastewater drain

Figure 4. 6: Process of waste disposal in BC without PWC. Source: (Author own)

4.2.2 Waste collection

The waste of the study area is collected by both PWC and OzPak. PWC collects it from door-to-door, whereas OzPak is responsible for streets sweeping, removal of unattended waste bags and heaps from streets, and collection of waste from LWMC containers. The waste thrown in the wastewater drain is neither the responsibility of PWC nor the OzPak but is removed by the WASA through excavator whenever needed or mostly during rainy seasons to avoid blockage of the drain. The waste collection authorities working in the BC are shown in Figure 4.7.

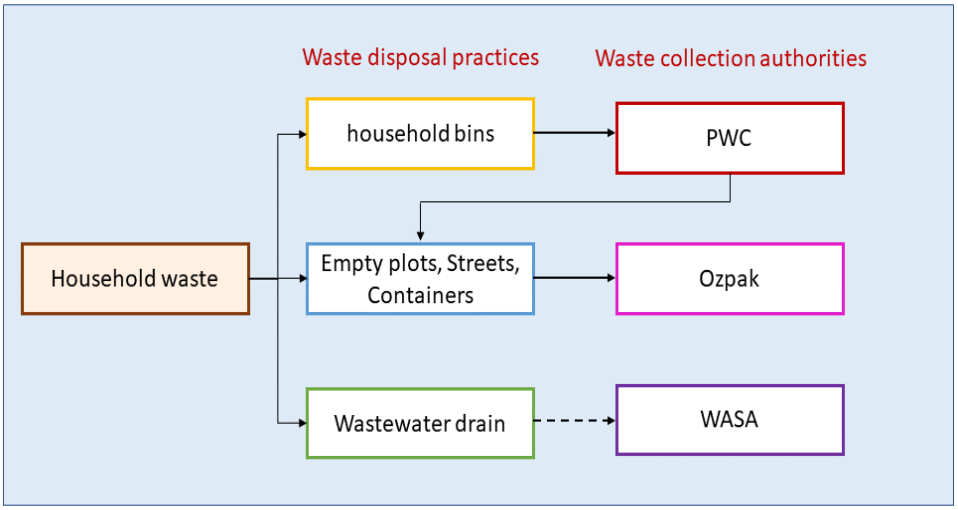


Figure 4. 7: BC waste collection responsible authorities. Source: (Author own)

The detail of both PWC and OzPak system is as follow.

a) Private collection: Due to the lack of OzPak door-to-door waste collection facilities, the waste from the households in BC is predominantly being collected by the PWC. The respondents showed satisfaction towards the private system as they found it convenient solution for waste disposal on a daily basis. However, to avail this facility residents have to pay 200 Pak. Rupees/ month to PWC. There are around 7-8 informal PWC working in the UC 226 to collect the waste from different areas using different vehicle types such as motor rickshaw, hand and donkey cart. The vehicle used by the PWC of BC is a motor rickshaw with a capacity of 0.2 tonnes/ day.

The waste from household bins is sorted by the PWC at the source and is placed in different allocated bags attached to its vehicle. This avoids the mixing of recyclable materials with other waste types which are then sold in the market to waste dealers to earn additional revenue which later is used by the recycling industries. The remaining leftover waste is mostly organic which is then disposed in the LWMC waste containers. The pictorial presentation of waste collection and segregation process of PWC is shown in Figure 4.8.

a) Waste bin present outside the door

b) Waste bin collection by PWC

c) Waste segregation at source by PWC

d) Different bags for different waste types

Figure 4. 8: Waste collection and segregation process by PWC. Source: (Author own)

b) OzPak collection: The total waste collected by OzPak from UC 226 is almost 35 tonnes per day, out of which 10-12 tonnes belong to BC. Nearly 85% of this total waste is organic which ultimately ends up in landfill, as reported by LWMC UC 226 Supervisor. The frequency of waste collection by the OzPak workers in the area is 2 or 3 times a day which sometimes reduces to one depending on the waste quantity. However, this frequency and waste collection priority changes during the rainy seasons in which the waste is mostly collected from roads, not containers to avoid the choking and flooding of roads.

Total 33 workers are working in UC 226 including 21 males and 10 females, out of which around 14 are responsible for the waste collection of BC. Their working hours are from 6 am to 2 pm. The tools used by workers to clean the streets are broom, shovel, and scrapper. The picture of all tools provided to the workers for cleaning are shown in Figure 4.9. The condition of streets sweeping of BC reported by most respondents was fair. The waste collected from the streets is then hauled to the containers through hand carts.

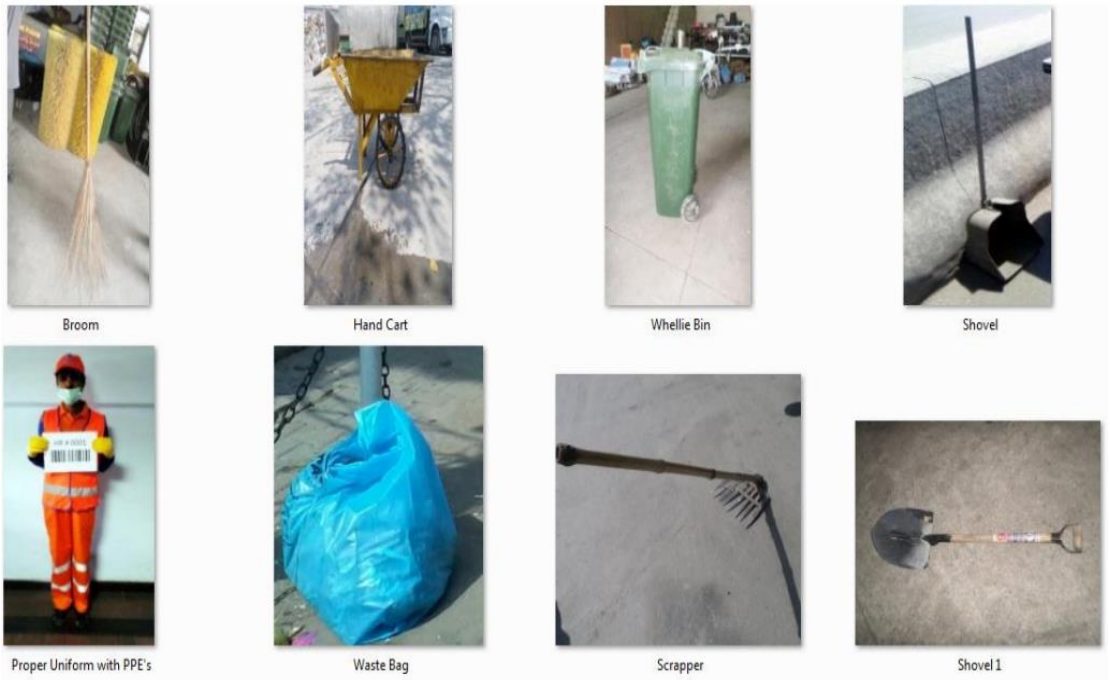


Figure 4. 9: Waste collection tools used by sanitary workers. Source: (Author own)

There are total 31 containers placed in the UC 226 at different points, 10 of which are allocated to locals of BC for waste disposal. The location and distribution of these containers are shown in Figure 4.10. The capacity of each container is 0.225 tonne. These containers are made up of iron and most of them were found rusted during the field survey. Further, they are not provided with any cover which creates problems during the rainy seasons when water gets mixed with waste and increases its leachate production which then spreads on road due to leakages in containers. It was also noticed that waste is commonly thrown outside the containers and the reasons reported for this were inappropriate height, numbers, and capacity of containers. These problems not only have increased the activity of flies, mosquitoes, stray animals, and scavengers on waste heaps but is also affecting the aesthetic of the area.

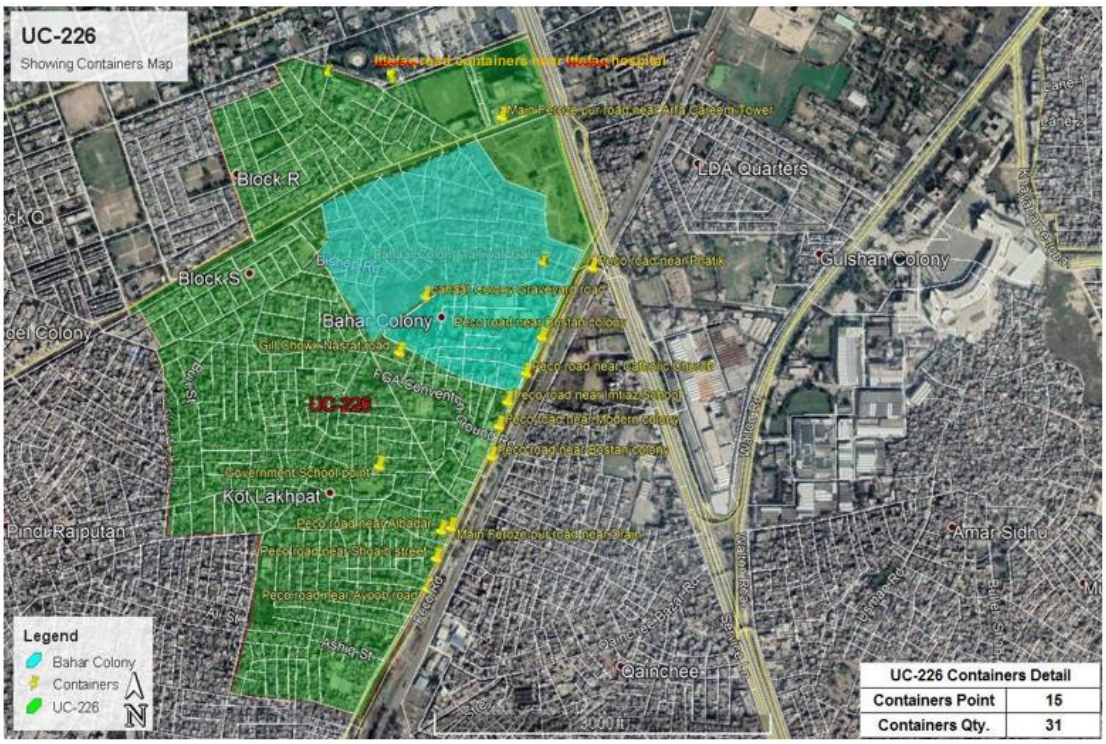


Figure 4. 10: A map showing the location of waste containers. Source: (LWMC)

The waste from the containers is then emptied mechanically into the compactor with the help of a driver and two sanitary workers. There are two compactors each with different capacities; 4-5 tonnes/ day and 8-10 tonnes/ day deployed for waste collection of the UC 226. They make 2-3 trips per day to lift the waste of the area. Apart from this, a dumper of 5 tonnes/day capacity is also sometimes used to collect the remaining waste which is also then unloaded into the compactor. The pictorial presentation of the OzPak waste collection process from the containers is shown in Figure 4.11.

a) Waste containers and informal scavenger

b) Unloading of waste into a compactor

c) Mechanical lifting of the container by the compactor

d) View of the area after waste collection

Figure 4. 11: Waste collection process from containers by OzPak. Source: (Author own)

The waste from compactors is then transported to the Transfer Station (TFS). There are three TFS/ workshops established for OzPak in the city which are Valencia TFS, Outfall workshop and Sikandaria workshop, and only one for Albayrak. The difference in the number of TFS is due to the travel distance required by the trucks to reach the landfill which is comparatively more in the case of OzPak than Albayrak. Therefore, in most cases Albayrak is directly disposing the waste in the landfill through compactors, whereas OzPak is using TFS.

The TFS used for the waste of study area is "Valencia TFS" where the waste is unloaded from the compactors and transferred to the Trailer for its final transportation to the landfill. The capacity of the trailer used is 35-40 tonnes/ day. The Valencia TFS also acts as a workshop for OzPak vehicles where they are checked for fuel and any mechanical issues. The pictorial presentation of Valencia TFS is shown in Figure 4.12.

a) Entrance of Valencia Transfer Station

b) View of OzPak vehicles at TFS

c) Unloading of compactors at TFS

d) Loading of Trailers with waste

Figure 4. 12: Unloading and loading of waste at Valencia TFS. Source: (Author own)

4.2.3 Waste disposal

The waste from the TFS is brought to the "Lakhodair Landfill" which is under the management of LWMC. The construction of the landfill commenced in 2014 and was finalized in 2016. The site is located 15 km away from Lahore city. The reasons reported for selection of this site were; easy transportation, a distance of 2.2 km from the settlement and 4 km from River Ravi, and agricultural land which was easy to get from the farmers. The total area of the site is 52 hectares, out of which 28 hectares are allocated for sanitary landfill and the remaining is for other activities and possible future extension. In order to avoid the hazards from the previous Mehmood Booti landfill site, LWMC has recently taken steps for its rehabilitation which includes plantation of 14,500 trees of different species on the eastern side and the installation of 4 gas vents on the southeastern side of the landfill as a pilot project.

The total number of workers at the landfill is 50 including both corporate and operational staff. Only MSW is brought to the landfill as the other waste types including industrial, construction, and hospital waste is not under the jurisdiction of LWMC. Out of total waste brought to the landfill daily, almost 65% is biodegradable, as reported by the Senior Manager LWMC. Apart from MSW, another important waste type brought to the landfill is "Offal" which is generated every year in the country during the Eid-ul-Azha due to the sacrifices of animals. In 2019, LWMC dumped around 293 tonnes of offal in an excavated pit and installed gas vents in it as a pilot project. The gas from these vents is currently being flared into the atmosphere. The reported remaining life of the lakhodair landfill is 5-6 years. It was reported since the construction of landfill the groundwater level of the area has been reduced, which was 73 feet

before the construction and is 190 feet below the land surface now. However, the quality of groundwater is still the same, as reported by the Senior Manager landfill. The location map of the Lakhodair Landfill is presented in Figure 4.13.

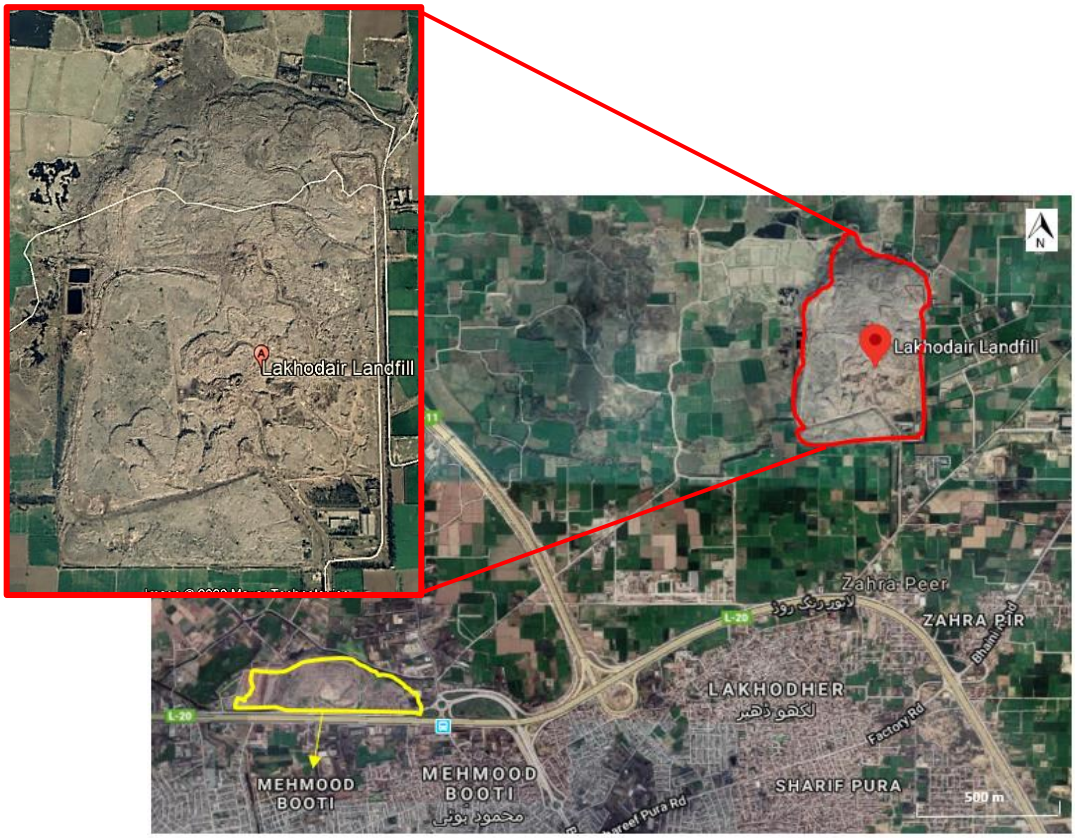


Figure 4. 13: Location map of the Lakhodair landfill. Source: (Google earth)

The vehicles at the landfill are first weighed at the weighing bridge and then diverted to the dumping sites for unloading. The total waste brought to the landfill is 5500-6500 tonnes/ day, of which around 5000 tonnes is diverted to the controlled dumping site and the remaining 500-1000 tonne to the sanitary landfill site. The sanitary landfill site is divided into 6 lots, the construction of which is still not completed yet. Lot 1 and 2 were operationalised in 2016 but now it has reached its capacity and cannot be further used. These lots were designed with proper scientific specifications including facilities for leachate collection and circulation, and installation of gas vents. Recently the construction of lot 3 and 4 was also completed and is under use for the dumping of the waste but unfortunately these lots are not designed for waste disposal in a scientific manner. At these sites, the waste is being disposed without any segregation and treatment in a controlled way, which means the disposed waste is just compacted and then covered by a layer of soil without any facilities for leachate and gas collection.

It was reported that waste segregation at landfill was in practice until 2019, in which 800 tonnes of RDF and 500 tonnes of organic waste were separated from the total waste on a daily basis and were transported to the DG cement industry and LWMC composting plant. The cement industry was using RDF as a fuel, and LWMC was making compost of the organic waste which it was supplying to the near-by farmers to use as a fertilizer in crops as a pilot project. However, due to some political and internal issues, the LWMC contract with the DG cement industry had been terminated and the composting plant is not running anymore. Moreover, the quality of compost delivered to the farmers was not upto the level to meet the requirements of sufficient productivity. Thus currently, no segregation is being practiced at the landfill. However, the informal segregation is still in practice which is being carried out by the scavengers who remove the reusable and recycled material from the waste such as "paper, plastics, and metals" and sold it in the market to waste dealers or recycling industries to earn money. There is a total of 150-200 families who are involved in it and they usually collect 5-6% of the reusable materials from the total waste brought to the landfill daily.

Due to lack of waste segregation, the average height of waste heaps at controlled dumping site has reached 80 feet, for lot 1 & 2 it is 30 feet, and for lot 3 & 4 it is 45 feet, whereas the reported recommended level according to TUU is 20 feet. Further, as there is no gas collection and utilisation system at the landfill this had become a reason for fire hazard at landfill many times especially during the summer seasons when the temperature was high or someone had accidentally dropped a cigarette on waste heaps. The fire at the landfill can stay burning for upto 4-5 days due to the flammable composition of waste, as reported by the landfill manager. Apart from this, the waste is sometimes set alight by the workers also especially during the winter season when the temperature is low and they want to keep themselves warm.

There is no drainage system designed to collect the runoff water during the rain, which sometimes creates problems for the management and vehicle movement. LWMC has the monsoon emergency plan only for the city but not for the landfill. Presently, there are no landfill regulations or standards available with the LWMC for compliance and monitoring. The pictorial presentation of waste disposal and heaps at the landfill is shown in Figure 4.14.

a) Unloading of waste at landfill

b) Organic waste disposal at landfill

c) Waste burning and scavengers

d) Waste heaps at Lakhodair landfill

Figure 4. 14: Waste disposal and heaps at Lakhodair Landfill. Source: (Author own)

4.3. General perspective and feedback on waste management practices

The data gathered through questionnaires and interviews on general feedback of locals, PWC and LWMC officials on waste management practices and issues is given below.

4.3.1 Residents of BC

In total 10 households were surveyed, and the proportion of males and females interviewed was the same. During the interviews the feedback on questions regarding the existing issues and general feedback on waste management practices was gathered which is as follows.

a) Issues and barriers to waste management:

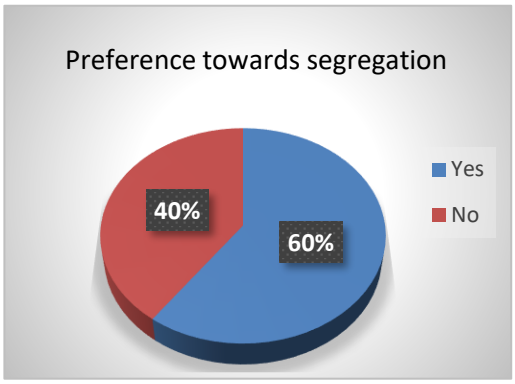
- The lack of government facilities on the door-to-door waste collection and inappropriate distance of LWMC containers affect the overall waste disposal

efficiency of the area. The number and capacity of containers are not enough considering the waste generation due to which containers are normally remained overflowed.

- As respondents have to buy their own bins for waste disposal thus they usually prefer to buy only one bin for all waste types.
- Almost all respondents reported that they have never seen any awareness message on television and media regarding the SWM.
- Lack of awareness among the respondent regarding the LWMC complaint redressal system. Only one respondent was aware.
- All respondents showed dissatisfaction towards the role of OzPak sanitary workers regarding the waste collection of the area. Moreover, they are not cooperative and regular in performing their duties. Additionally, LWMC never consulted them in any decision-making process.
- LWMC never took any action against the people involved in illegal disposal of waste, this has encouraged them in the continuation of waste disposal at street corners, empty plots, and wastewater drain.

b) General feedback on waste management practices and participation:

- 80% of respondents showed interest to have proper knowledge on waste-related issues and management.
- 60% of respondents showed willingness towards waste segregation at source if some facilities like different bags, proper awareness, and waste collection from doors were provided to them by the government. While the remaining 40% mentioned that they are satisfied with the existing system and practices, as depicted in Figure 4.15.
- For awareness deliverance, the reported preferred options were seminars and workshops followed by media awareness activities and brochures, as depicted in Figure 4.16. It was reported that in most cases the message delivered on media is generally ignored by locals and therefore is not useful.



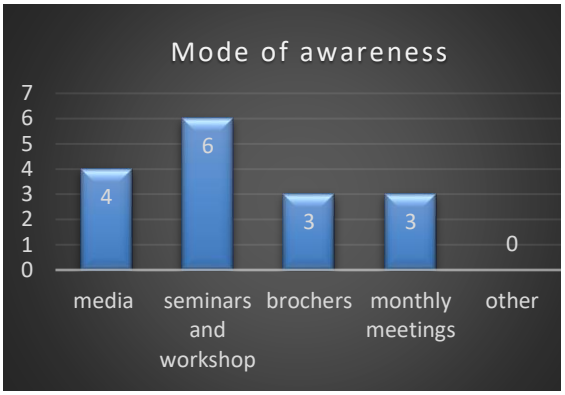


Figure 4. 15: Graph showing respondents preference towards waste segregation

Figure 4. 16: Graph showing respondents preference towards modes of awareness

- 70 % of the household reported that they are interested in using electricity and gas produced from biogas, but only if it is happening at the state or government level, not at the individual level.
- On being asked regarding the concerns towards environmental components, 80% of the respondents showed concern for air and water pollution and not for solid waste pollution, as shown in Figure 4.17. However, almost all of them reported a positive response towards the attitude, that leaving a better environment for further generations is something very important.

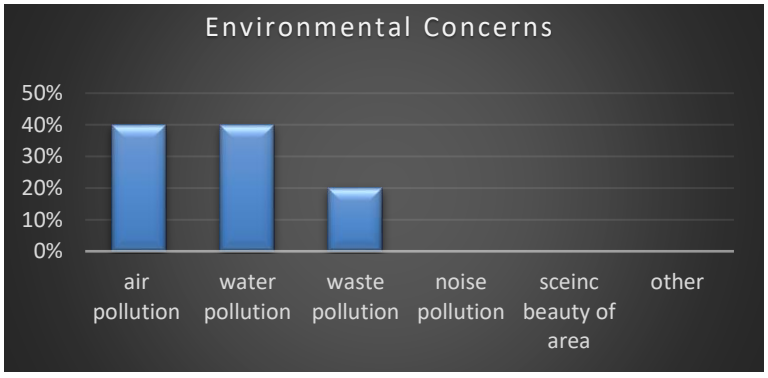


Figure 4. 17: Graph showing respondents concern for environmental components

4.3.2 PWC

On being asked regarding the waste management issue, it was reported no proper place has been allocated for PWC to dispose the waste. They have to pay to the waste dealer for waste disposal at a specific place. Thus to avoid this cost they dispose the waste at LWMC waste containers but LWMC officials are not cooperative and supportive towards PWC to use LWMC

containers. This normally generates conflict between both of them therefore, to avoid this conflict PWC practices this activity secretly.

4.3.3 LWMC

The interviews conducted with LWMC officials including supervisors, managers, and research associate highlights the following issues which are acting as a barrier for LWMC in waste management.

a) General feedback on issues:

- No cooperation and coordination of locals towards waste management practices and dissatisfaction in locals towards the work of LWMC.
- Lack of waste segregation practices both by the government and the public.
- Lack of interest of LWMC in involving and having a proper contract with the PWC. On being asked regarding the reason for not allowing the PWC to dispose waste in LWMC containers, it was reported because LWMC supervisor is responsible for daily waste removal from the containers, the waste disposal in containers by PWC results in filling of the containers again which if not removed timely, penalties and warning can be issued to the supervisor from the senior managers.
- The involvement of stakeholders and politicians not having proper education and awareness on the waste-related issue affects the decisions and implementation of projects. Further, in some cases due to political pressure LWMC cannot impose penalties on persons violating the rules.
- Waste disposal outside the containers usually becomes the reason for blockages of drains and flooding of streets during the rainy seasons.
- Workers' ignorance and negligence to work in areas where construction activities are in process.
- No legal measures to deal with the issues of informal waste disposal and collection activities by scavengers.
- The dependability of LWMC on government funds affects its self-sustaining ability.

4.4. Waste segregation and recycling system in Lahore

There is no formal waste segregation and recycling system in the city. The waste is segregated by informal units at three different levels which are segregation at; i) household-level mostly

by private sweepers (maids), ii) waste containers by poor people and scavengers, and iii) landfill by informal scavengers. It was reported by the WB consultant that several studies have been conducted in Lahore by TUU to assess the correct number of recycling units in the city, but they remained unsuccessful in getting the correct figure. This is because many of the informal units are not yet registered with the government and some belong to big mafia groups.

4.5. Future plans of LWMC

It was reported that LWMC is planning to supply 2000 tonne of MSW waste to China in order to produce electricity for Lahore and accordingly LWMC will pay them. The complete detail on the project was not available with LWMC as this is just in the planning stage and implementation of which is not yet confirmed.

The above information depicts that LWMC existing strength and capacity is not enough to manage the waste of the city and therefore is thinking to rely on China to produce electricity for the city. This highly demands the introduction of feasible and cost-effective solutions such as CE that will manage the waste and will enhance the efficiency of LWMC. Additionally, this will help in the production of own electricity with several other benefits for the country. The conceptual understanding of how to achieve this objective is discussed in chapter 5.

CHAPTER 5: DISCUSSION

Based on the literature review presented in chapter 2 and the results of chapter 4, the CF has been formulated in this chapter. It also discusses the gaps and opportunities in the existing system that needed to be considered for the development and successful implementation of the framework.

5.1 Existing issues and gaps of the system

The finding in the previous chapter reveals that despite the continuous efforts of LWMC since its establishment the SWM is still a problem. Although some improvements have been made especially in the context of the waste collection but these have not been sufficient to resolve the problem efficiently. The two important stages such as waste generation and disposal are almost ignored in the context of waste management. Moreover, knowing the exact data on the amount and composition of waste is the first and most important thing required for effective planning but there was no data available from LWMC on this. LWMC is using its own estimation and results of the previous study conducted in 2014 to assess the current composition of waste. Furthermore, the difference in data provided by PWC and LWMC regarding the waste generation of BC was due to a lack of coordination, an informal and fragmented system where there is no exchange of information and data. Also, no information is available on the amount of waste being illegally disposed in the wastewater drain of BC.

Apart from this, the other major gaps identified in the existing system are listed below which are contributing to the health and environmental hazards of the city and country. These gaps show that holistic approach has not been taken into consideration by LWMC in waste handling, designing, and management. The visualization of waste flow and current waste management practices is shown in Figure 5.1.

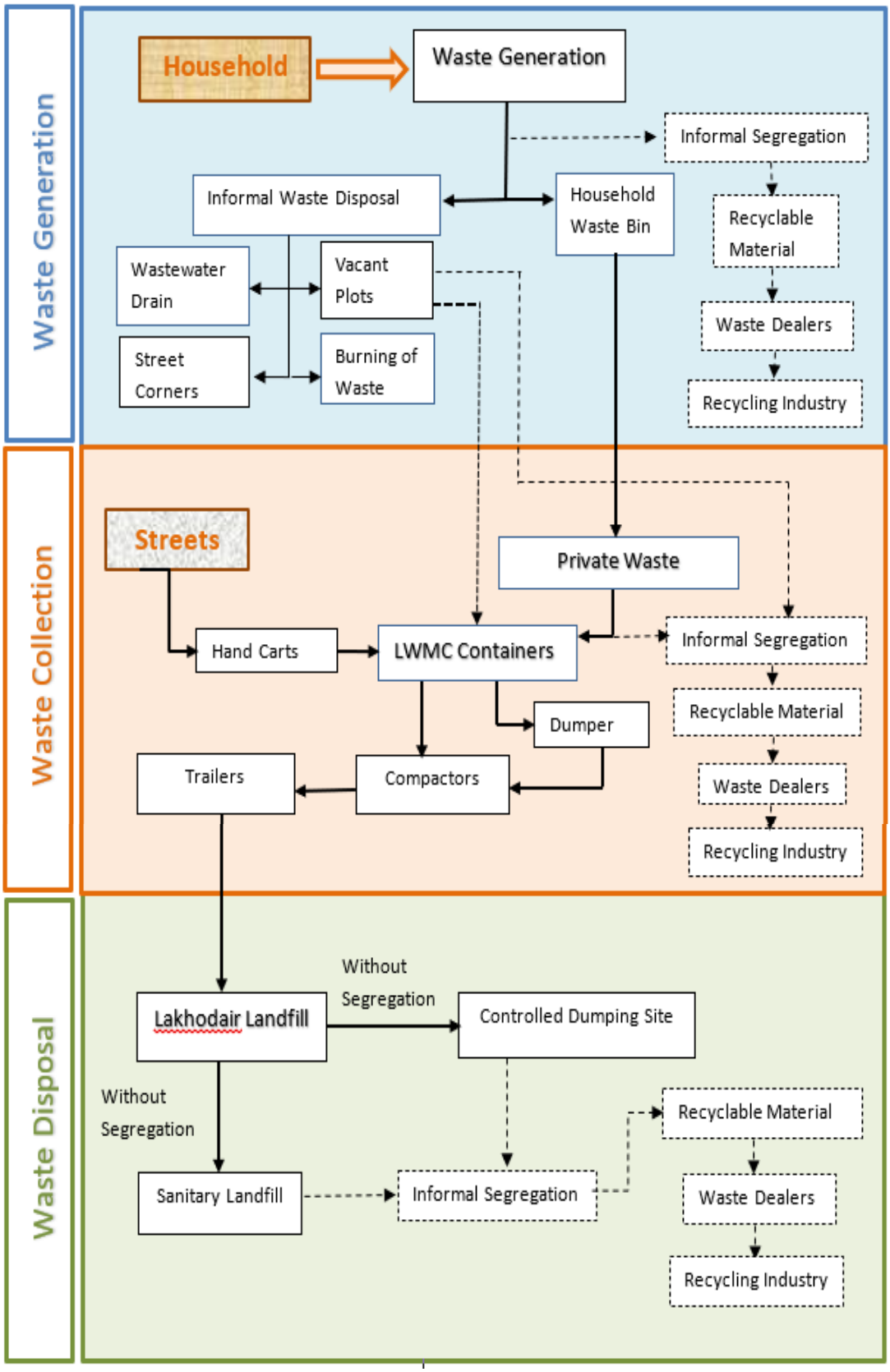


Figure 5. 1: Flow diagram of existing waste management practices. Source: (Author own)

5.1.1 Linear system

Figure 5.1 clearly illustrates that the existing system of waste management is linear and less attention is being given to waste reduction, reuse, and recycling practices. Due to these least sustainable practices, the burden on the landfill is increasing, as depicted in Figure 5.2. Such a linear system based on the concept of infinite resources that can be extracted and disposed easily whenever required is contributing to the wastage of resources and is negatively impacting the environment.

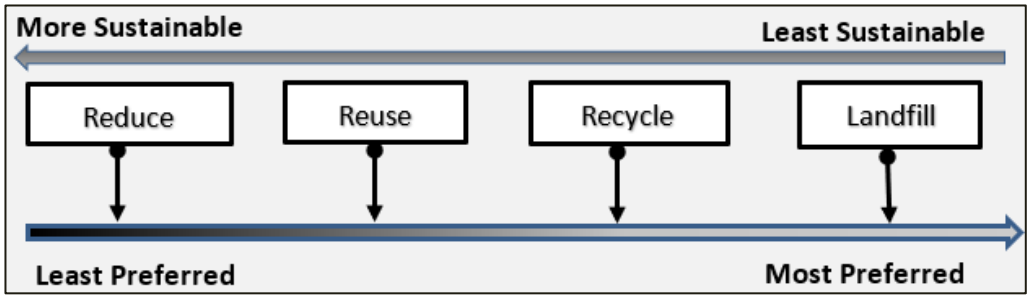


Figure 5. 2: Preferred practice of waste disposal in the system. Source: (Author own)

5.1.2 Lack of waste segregation

The factors such as urbanization and lack of waste segregation, reuse, and recycling in the existing system are increasing the production of waste generation and accordingly the size of waste bins, as depicted in Figure 5.3. More waste means more demand of resources to manage it properly. There is no specific policy in the city on reuse and recycling of waste. It is dumped together in the landfill which contaminates the overall waste that later can leads to the production of low-quality products which eventually can reduce the benefits to the recyclers. Such has happened in the case of LWMC compost where the quality of compost was not a convincing factor for the farmers to use it for long-term as a fertilizer. The organic waste in the existing system is considered useless and is thrown without realizing its real value. This shows a lack of awareness among locals and relevant stakeholders regarding the benefits that can be achieved through the reuse of organic waste. Therefore, LWMC has to enhance the awareness of stakeholders to increase waste segregation efficiency.

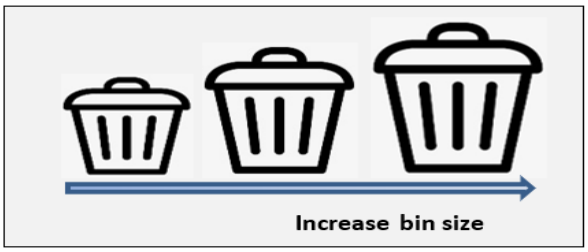


Figure 5. 3: Lack of recycling and segregation demands bigger bins. Source: (Author own)

5.1.3 Lack of awareness

The above discussion shows that waste segregation is an important element to enhance the quality of reuse and recyclable materials which is not possible without proper education and awareness of stakeholders. The results reported by LWMC show that it is providing awareness to the general public daily through media whereas the data reported by residents depicts that they have never come across any awareness programme on media and in schools regarding waste management practices. Due to which lack of awareness among the residents on reckless waste disposal practices was noticed and is common. This depicts a gap and inefficiency of the LWMC communication system.

Therefore, LWMC has to adopt different methods of awareness dissemination to deliver proper awareness to the residents, which should be more interactive and participatory such as through seminars and workshops, as also indicated by the respondents. This will enable and encourage them to learn more through open discussions and practical experience. Other than this, LWMC can also arrange a training platform for interested candidates where they can learn different techniques of waste reduction and segregation at source. Further, to demonstrate the benefits of organic waste the development of small community vegetable gardens can be a motivational and real based experience for the residents to see the use of compost for planation. The other step could be the provision of incentives to the UCs or individuals for the best utilisation of biowaste. As almost 80% of the population of BC is educated thus the deliverance of proper awareness can make changes in the system.

5.1.4 Lack of technical capacity

The result indicates that the involvement of stakeholders having inappropriate skills in the decision-making process sometimes negatively impacts the progress and implementation of the projects. Therefore, LWMC has to resist the participation of stakeholders having poor knowledge and awareness on waste management. It further has to enhance the involvement of locals in the planning process and to improve the awareness of all stakeholders that are part of the system to get positive outcomes and better efficiency of the projects. Additionally, the hiring of professionals with relevant backgrounds can help LWMC in achieving its objective of waste management by bringing in new ideas.

5.1.5 Lack of stakeholders coordination

The other major barrier identified is a lack of coordination and cooperation of stakeholders which includes all formal and informal stakeholders working at different levels from generation till disposal. This is affecting the efficiency of waste management practices and is contributing towards the development of irresponsible behaviour among stakeholders. It was noticed from the feedback of officials and locals that no one is ready to accept the responsibility of waste-related issues in the area and they both blame each other for ignorance towards waste management. The lack of involvement of locals in the decision-making process further demotivate them to participate in waste management practices because LWMC is high influenced by political forces and most of the decisions are made in favour of them. Additionally, the lack of interest of LWMC in having formal coordination with the PWC further leaves a gap in waste management practices.

As mentioned in the literature, the key to the success of CE in PHJ Finland was the long-term cooperation of municipalities and companies which enabled them to develop a functional system. Therefore, in order to organize and enhance the waste management efficiency in the existing system, LWMC also has to formalise the coordination and cooperation of all stakeholders. Additionally, as the number of recycling units in the city is not known by doing the proper collaboration with waste dealers the improvement in the recycling industries can be made along with revenue generation for the country. Figure 5.4 depicts the essential components that are required to run the system smoothly.

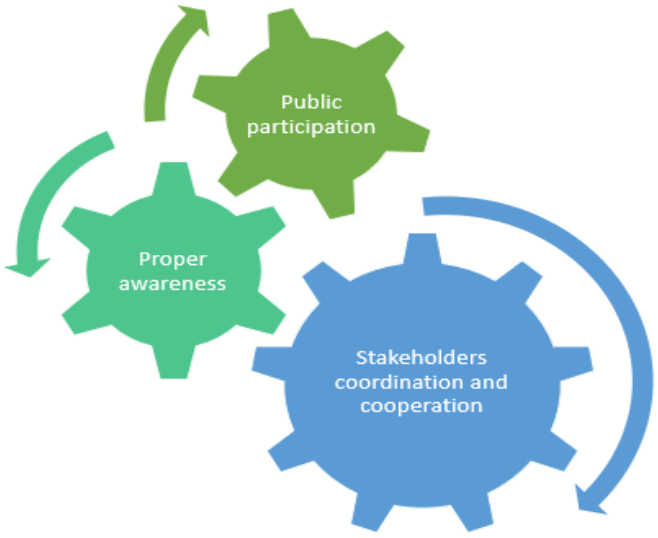


Figure 5. 4: Essential components required to run the system. Source: (Author own)

5.1.6 Lack of energy utilisation

As data indicate that waste is being disposed without any segregation at the Lakhodair landfill this is producing biogas due to the decomposition of organic waste. This biogas mainly in the form of methane is a potential source of energy that currently is being lost in the atmosphere at both sites of the landfill which includes controlled dumping site and sanitary landfill site. At a controlled dumping site where no gas vents have been installed biogas is directly emitted into the atmosphere, whereas at sanitary landfill site it is converted into carbon dioxide by flaring. Methane is a more powerful GHG than carbon dioxide and can stay in the atmosphere for thousands of years. The emission of both gases in the atmosphere is contributing to climate change. Therefore, LWMC has to adopt proper measures to prompt the collection and utilisation of gases.

All the major gaps identified and their impacts in the form of pictorial presentation is presented in Figure 5.5.

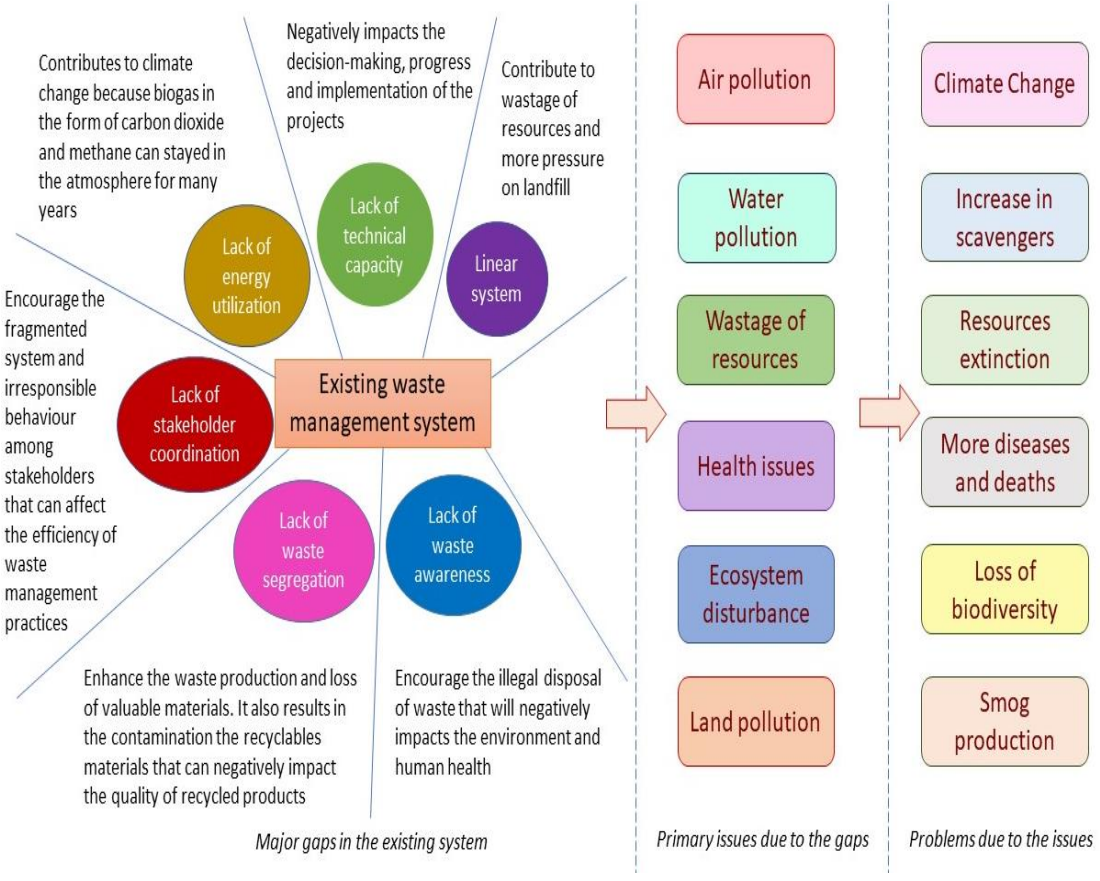


Figure 5. 5: Gaps and associated problems. Source: (Author own)

5.2 SWOT analysis

The gaps discussed above clearly depict that the existing system is not sustainable and is directly and indirectly affecting waste management efficiency. The continuation of such practices and behaviours will lead to serious threats, and damages to the environment and human health which ultimately can affect the other dimensions of economic and social aspects that support and enhance our well-being. Thus, it is essential to change the existing system and allow the adoption of a sustainable way of waste management through the implementation of sustainable strategies. As the study focuses on biowaste management the literature demonstrates that CE is the most feasible and relevant principle for biowaste management because it helps in designing out the waste by enhancing its circulation into a biosphere again. However, to assess the potential of CE in the existing system was important and has been carried out through the SWOT analysis, as depicted in Figure 5.6. This helped in the understanding of all the internal and external factors that can impact the implementation of CE principles.

Strength (S)

- In the total waste, the percentage of the organic waste fraction is higher than other waste types.
- Availability of cheap labour.
- It is easy to transfer knowledge and awareness to educated residents.
- Favourable environmental conditions for the composting process.
- Availability of enough land at the Lakhodair landfill site to organize and operate different waste treatment and recycling facilities.
- Allotment of specific land for the sanitary landfill at Lakhodair landfill where hazardous waste can be disposed of properly.
- Availability of PWC and waste dealers in the system for waste collection and segregation.
- Availability of waste recycling industries.
- Availability of informal scavengers for the collection and segregation of recyclable materials.
- Daily and door-to-door waste collection system.
- The willingness of residents towards waste segregation.
- The negative impacts of organic compost on the environment and health are less than the synthetic fertilizers.
- Manpower available with LWMC is enough to run the system after proper training.
- Access of LWMC to the general public through the media and communication department.
- Existing LWMC monitoring system for complaints and vehicle movement.
- Methane gas from the landfill is a source of energy.
- Availability of LWMC composting plant and formal contract with cement industry for supply of RDF.
- The willingness of residents to use biogas for electricity production and heating and cooking purposes.
- The use of recycled products is common among poor people.

Weakness (W)

- Lack of waste segregation at the source which contaminates the overall waste.
- Lack of awareness among residents for waste management practices.
- No relevant education of officials on waste management and CE.
- No coordination and cooperation of stakeholders.
- Absence of proper and relevant laws.
- Absence of waste management strategy.
- Ignorance towards waste management.
- Linear and fragmented system.
- Free disposal of waste in empty plots, street corners, and wastewater drain.
- No penalty from the government for illegal dumping and burning of waste.
- Absence of infrastructure for the supply of renewable energy to locals.
- Informal waste collection and segregation practices.
- Loss of energy from landfill in the atmosphere.
- Dumping of waste without a leachate collection system.
- Lack of consent of stakeholders and involvement of politicians affect the planning process.
- Insufficient planning of LWMC.
- No incentives for waste management and recycling.
- Non-recognition towards the role of informal sectors.
- Difficult to change behaviour of some residents.
- Public satisfaction and cooperation.
- Lack of database and record keeping.
- The slow pace of new initiatives.

Opportunity (O)

- More effective waste management is direly needed.
- CE provides cost-effective ways of waste management.
- Compost, biogas, recyclable products, RDF, and electricity can be produced from waste.
- A shortage of electricity and gas can be met.
- Pakistan is an agricultural country and fertilizers are expensive, the supply of good and cheap compost can be a relief and provide financial savings for farmers.
- As LWMC's current contractors are Turkish and it is also planning to send waste to China, this shows the good links of LWMC with both these countries. Thus, with the technical assistance of these countries, LWMC can install waste treatment and recycling facilities at the landfill and can produce its own energy and electricity.
- Revenue generation through the export of recyclables.
- Improvement in overall environmental condition.
- Minimise the transmission of diseases and health issues.
- Provision of incentives to encourage recycling.
- Reduce the import of products can save billions of dollars.
- Enhance the business opportunity for enablers.
- Enhance job opportunities in the system.
- Reduce the burden on the landfill and accordingly their demand.
- Remove the gaps and can organize the waste disposal mechanism.
- Enhance opportunities for energy generation.
- The circularity of products will minimise the wastage of resources.
- Long term benefits can be attained with a circular system.
- LWMC can become a pioneer in the country in the field of CE.

Threats (T)

- As waste management is the most neglected component in the country, government actions, and funding towards its improvement could be an issue.
- Allotment of financial resources from the government on waste management.
- Uncertainties in government policies.
- A rigid attitude of political forces for whom waste is only useless trash.
- Corruption in the system.
- Acceptability of organic compost among the farmers as a replacement of synthetic fertilizers.
- Acceptability and willingness of stakeholders for CE.

Figure 5. 6: SWOT analysis of CE potential in the system. Source: (Author own)

The SWOT analysis illustrates that besides the number of weaknesses and threats, there exists a huge potential of CE in the system to manage the biowaste. The applicability of CE specifically for BC is also studied in the form of a transitional diagram with the help of the PPP (Problem, Potential, and Profits) approach, where the situation "without and with CE" is discussed, as shown in Figure 5.7.

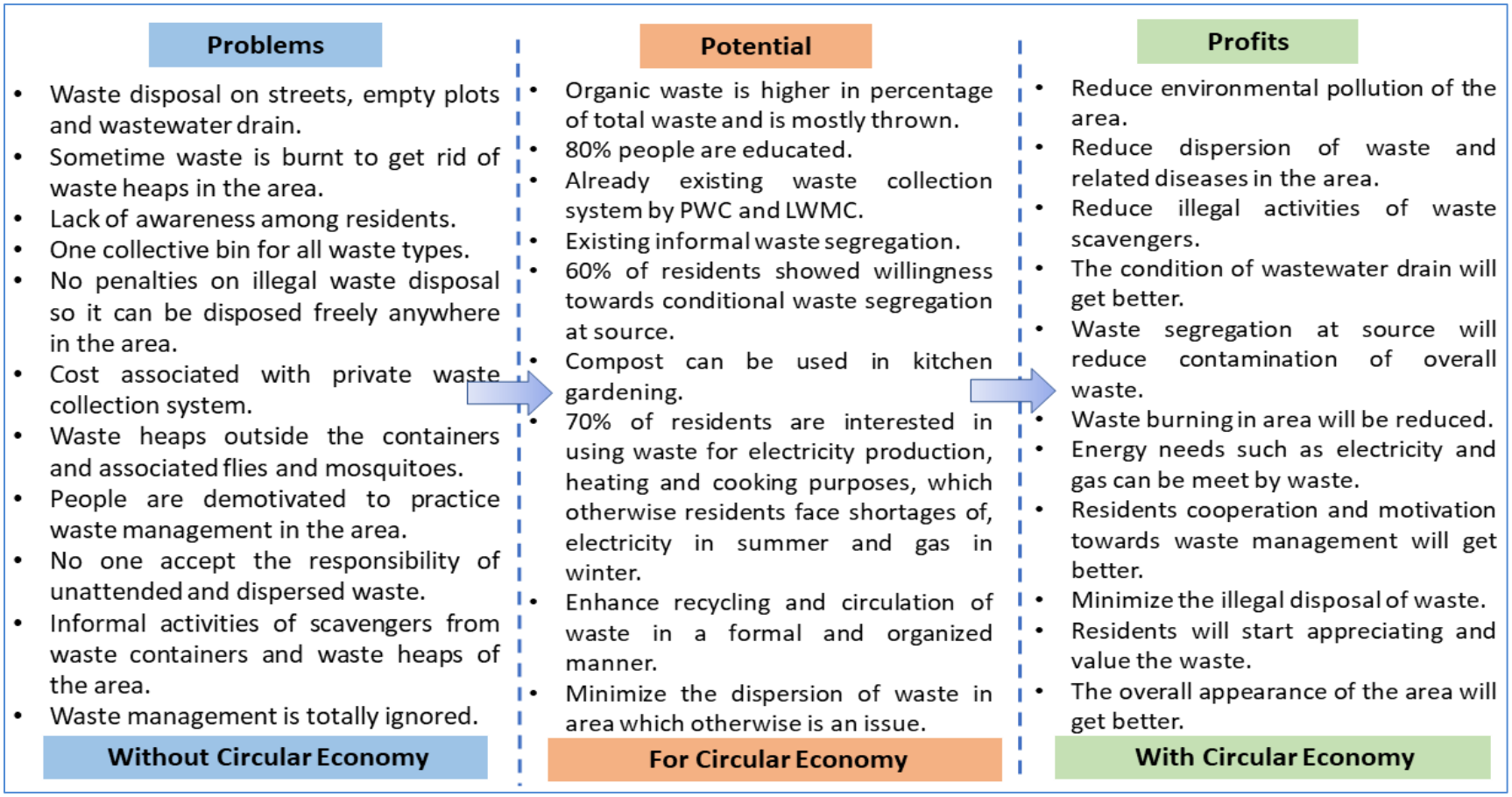


Figure 5. 7: Problem, Potential, and Profits of CE in BC. Source: (Author own)

5.3 Development of Conceptual Framework based on CE principles

Figure 5.7 and SWOT analysis of the overall system confirms that CE sees the potential for biowaste management in the existing system. Keeping in view this and the example of the BIOREGIO project mentioned in chapter 2, the CF has been formulated based on CE principles, as shown in Figure 5.8. In this framework, the fragmented ends of the existing system are connected in a formal way to enhance system efficiency. The detail of the proposed process suggested in the CF is given below.

The process starts with waste sorting at source in different colour-coded bins or bags, which will be collected by the PWC and waste dealers from homes through a formal contract with LWMC. PWC should be responsible for the collection of organic, mixed, and hazardous waste, whereas the other wastes including recyclables will be collected by the waste dealer. Both PWC and the waste dealer will then handover the waste to LWMC, PWC by disposing the waste in LWMC containers allocated for different waste types, and the waste dealer by transporting the waste to the landfill. The waste from containers will then collected by compactors and other waste picking machinery and transported to the landfill.

After reaching landfill the waste of PWC will undergo both mechanical and manual sorting to ensure complete segregation of organic, hazardous, and recyclables fractions (if any). At this stage, it will be ensured that all necessary measures are taken in place to avoid any contamination and mixing of waste. While the recyclable waste brought to the landfill by the waste dealer will then passed to the other waste dealer majorly responsible for further classification of waste into Refuse Derived Fuel (RDF), recyclables material, and hazardous waste. The segregated RDF will be delivered to industries as a fuel, recyclables to the recycling plant and industries, and hazardous waste to a sanitary landfill where it will be disposed after proper treatment. Any gas released from landfill will be diverted to the biogas plant.

The organic waste will be diverted to biogas and composting plants where it will be treated to produce biogas and compost respectively. The biogas will be supplied to homes as a source of fuel for heating and cooking purposes and in the form of electricity generated from the biogas, whereas compost will be used as soil fertilizer in agriculture farms to produce fruits and vegetables, which will then be ultimately consumed by the households. The remaining digestate from the biogas plant will be transferred to the composting plant. In this framework, the landfill is no longer the first choice for waste disposal but the last step after consideration of all possible measures for material and energy recovery. This will save the land that could be used for other productive purposes.

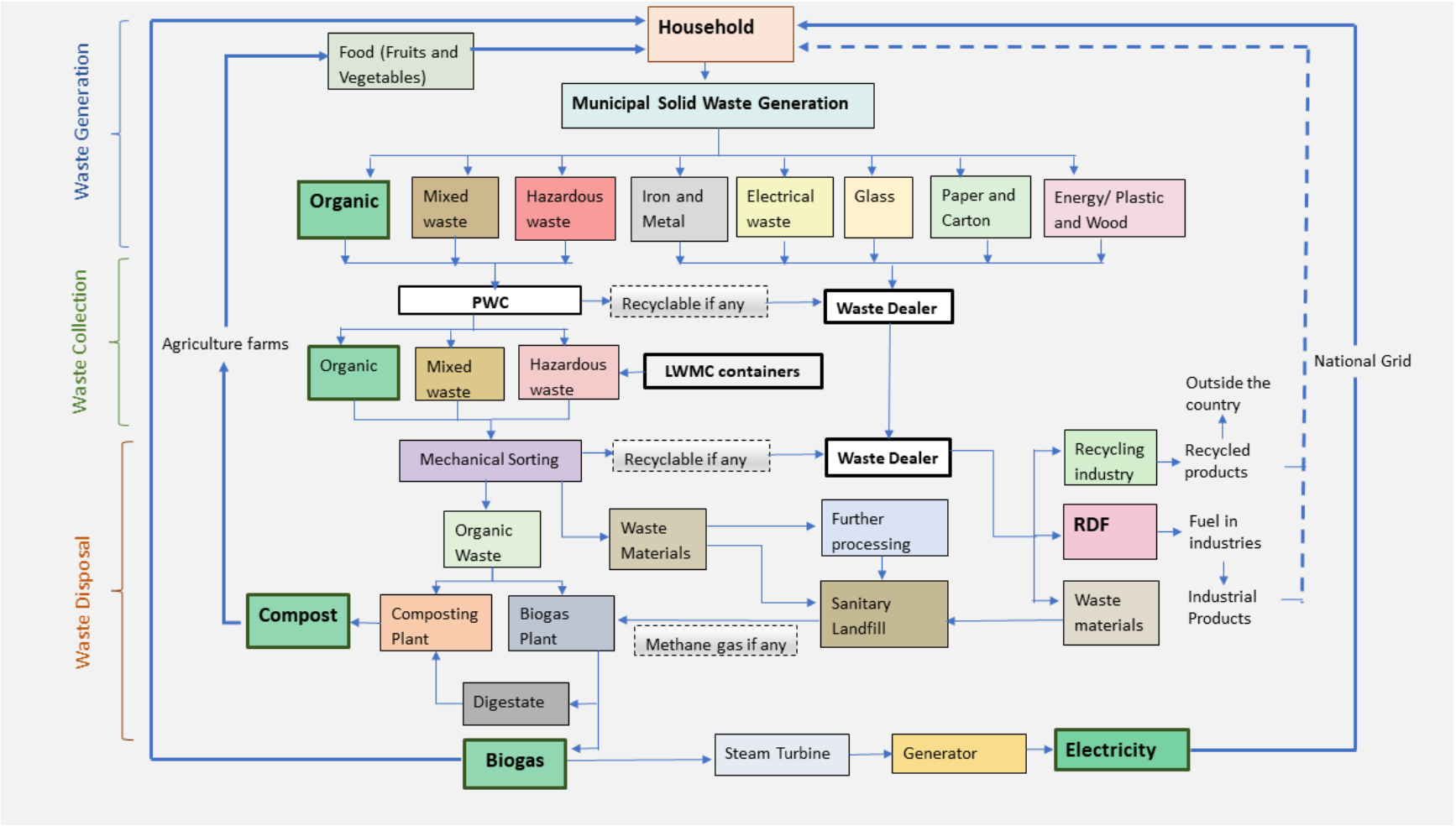


Figure 5. 8: Proposed CF based on CE for the existing system. Source: (Author own)

By following this framework LWMC can efficiently manage the biowaste of the study area by keeping the biowaste out of the landfill and getting the energy out of it. However, this transition requires three major changes in the existing system which include i) introduction of waste segregation at source and landfill, ii) formal involvement of PWC and waste dealer, and iii) development of a proper network for supply of energy to the locals. The detail is given below.

i. As MSW or household waste is highly heterogeneous and has variable physical characteristics, the sorting of waste at two different levels will enhance the efficiency of the treatment and recycling process which otherwise will be a major setback in its meaningful utilisation.
ii. To further enhance the efficiency of the system, LWMC has to make a formal contract with PWC and waste dealers. Under this contract, they have to be paid according to the amount of waste they will collect from the area. This will not only encourage them to collect all leftover/ unattended waste from the area, but PWC will motivate residents also to give them the waste rather than disposing it in the drain or empty plots.
iii. As the system efficiency is highly dependent on the active participation of waste generators and how they comply with the principles of waste separation. The supply of energy in the form of fuel and electricity will encourage and motivate residents to participate in waste management and segregation practices because currently there is no motivation for them to do so.

Apart from increasing efficiency and circulation of biowaste, the proposed framework will also help in meeting the objective of SDG such as: SDG 1 (by allowing the poor people to use recycled products), SDG 2 (by reducing food waste and enhancing the use of organic waste), SDG 3 (by reducing the number of death and illness from waste), SDG 4 (by enhancing environmental awareness and training), SDG 6 (by avoiding the contamination of surface and groundwater from waste), SDG 7 (by ensuring the supply of affordable and renewable energy), SDG 8 (by enhancing job opportunities for informal and poor scavengers), SDG 9 (by enhancing innovative ways of waste management), SDG 10 (by providing equal opportunities to stakeholders in decision making process), SDG 11 (by reducing environmental impact of city through waste management), SDG 12 (by ensuring sustainable P&C pattern), SDG 13 (by avoiding emission of GHGs from the landfill), SDG 14 (by avoiding the disposal of plastic bags and leachate in marine ecosystem), SDG 15 (by avoiding the land requirement for landfills), SDG 16 (by reducing corruption and development of effective, accountable and transparent system at all levels) and SDG 17 (by encouraging partnership to enhance capacity building).

The complete list of environmental, economic, and social benefits that can be achieved with this proposed CF is illustrated in Figure 5.9 which shows that the proposed framework is environmentally effective, economically affordable, and socially acceptable. However, for its successful implementation, LWMC needs to resolve all the existing gaps identified in this chapter which in turn will collectively contribute to the efficient functioning of the system. In this context, the list of measures that are required to be followed in the form of recommendations is given in chapter 6.

- Reduce generation and emission of GHGs.
- Enhance conservation of resources.
- Avoid loss of agriculture land to landfill sites
- Enhance recycling of products.
- Reduce obnoxious smell from solid waste.
- Minimise air and smog pollution due to waste.
- Reduce surface and groundwater pollution due to waste.
- Avoid land and soil pollution.
- Extend product life cycle.
- Enhance overall aesthetic.
- Reduce waste pollution.
- Restore and maintain ecological balance of the system.
- Provide source of renewable energy.
- Minimise transmission of diseases and health impacts due to waste.

- Enhance revenue generation from waste.
- Reduce import of energy and resources from outside the country.
- Enhance financial savings from resource recovery and waste-to-energy.
- Formal market for recyclables.
- Availability of resources at less price.
- Develop opportunity for export of recyclables.
- Innovative business model and image in the market with low carbon footprints.
- Low cost energy.
- New opportunities for business by attracting new customers and partners.
- Gain competitive advantage in the market.
- Enhance new job opportunities.

- Improve wellbeing of communities.
- Enhance coordination and cooperation of stakeholders.
- Motivate community participation in waste management practices.
- Enable local participation in decision making process.
- Enhance functioning of a proper and organized system.
- Encourage industrial symbiosis.
- Provision of energy and services.
- Society welfare will grow by cooperation.
- Better quality of life for present and future generations.

Figure 5. 9: Benefits of proposed CF. Source: (Author own)

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

Conclusion and recommendations were drawn based on the literature review conducted in chapter 2, results stated in chapter 4, and discussion presented in chapter 5.

6.1 Conclusions

In the city different waste management strategies have been adopted in the past years, ranging from municipal services to private organizations but the problem of waste management remained the same. This is because the adopted strategies were not effective and well-planned to manage the waste properly. This has been observed in the current system of LWMC also, which is the latest entity developed to manage the waste of the city. It remained unsuccessful in proper collection, segregation, treatment, and disposal of waste due to gaps in the system which depict the inefficiency of the LWMC. These gaps are because LWMC is currently focused on waste collection and transportation and is almost neglecting the other two essential stages such as “waste generation and disposal”, without which sustainable waste management cannot be achieved. Additionally, waste disposal is always considered and taken as a resource-intensive and expensive solution. Therefore, keeping in view the financial status of the country the cheapest option such as landfill is always been preferred. Such practices are increasing the volume of waste and associated environmental and health hazards such as water pollution, soil pollution, land degradation, air pollution and smog, ecosystem disturbance, climate change, and health issues day by day. These problems are currently being ignored and never adopted as a priority by the waste generators and responsible authorities, the continuation of which can cause serious threats in the future.

This demands LWMC to take immediate and serious actions to manage the waste of the city through the adoption of sustainable and cost-effective solutions such as CE. As presented in the literature that CE is the most efficient way of waste management, by showing the real example of the BIOREGIO project where all biowaste is being managed by enhancing the circulation of waste into a system as a resource. The results of the current study show that biowaste is higher in the total proportion of the waste stream produced daily and disposed at Lakhodair landfill which highlights the relevancy of CE in the existing system as well. This was critically assessed and verified with the help of SWOT analysis that reveals the concrete opportunities of CE in the system. Moreover, the development of a conceptual framework based on SWOT analysis further demonstrates that LWMC can effectively manage the biowaste with CE principles which would have multiple benefits for LWMC and the entire country, not only in terms of waste management and energy flows but also on the factors relating to

environmental, social and economic sustainability. As the financial, technical, and social strength of institutions influences the overall waste collection, transportation, and disposal efficiency. This concludes that CE can be a fundamental solution for LWMC in meeting its objectives of sustainable waste management which also ultimately will improve its efficiency in a continuous cyclic way, as presented in Figure 6.1.

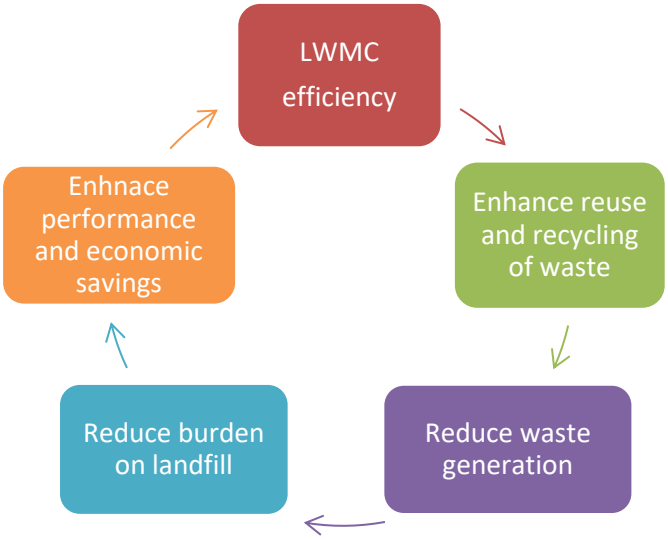


Figure 6. 1: LWMC continuous efficiency improvement cycle. Source: (Author own)

To achieve this target of efficiency LWMC first has to resolve the existing gaps and barriers which otherwise could affect the successful implementation of the proposed framework. In this context, the set of recommendations has been prepared, the implementation of which will help to effectively overcome the existing issues.

6.2 Recommendations

The recommendations are formulated phase-wise for LWMC to specifically understand the requirement of each phase and are listed below.

Waste Generation:

- Enhance the participation of residents in waste management practices by ensuring the delivery of proper awareness through the effective and interactive mode of communication and training. The distribution of awareness material like leaflets, brochures, and pamphlets can also be helpful in information dissemination.
- Ensure the provision of awareness to all ages of people from small children to seniors for effective results. The experience and information sharing from good practices can further motivate the people.

- Ensure all residents are familiar with the LWMC complaint redressal system.
- Provide facilities such as different colour-coded bins or bags to residents, to initiate waste segregation at the source which once become habit, residents will start managing at their own.
- Improve communication and link with residents by encouraging their involvement in the decision-making process, as they can suggest good options for what is and could be feasible for them on the ground.
- Provide incentives to motivate residents towards waste management practices.
- Encourage people to use organic waste as compost for kitchen gardening wherever possible.
- Place roadside small dustbins to avoid dispersal of waste in the area.

Waste Collection:

- Formalise the involvement of PWC and waste dealers in the system to prompt and enhance the waste collection and segregation efficiency.
- Ensure the availability of enough workers to clean the area properly and regularly, especially in the monsoon season.
- Ensure placement of proper size and number of containers at suitable locations keeping in view the waste generation rate and population density of the area.
- Place separate containers for different waste types with proper labeling to enhance waste segregation practices.
- Ensure proper designing of containers keeping in view the suitable material and height.
- Ensure proper covering and good condition of containers to avoid the direct contact of insects and rain with the waste. This will reduce the transmission of disease, dispersions of bad smell, and leakages of leachate from the containers.
- Adopt proper measures to avoid the involvement and activities of waste pickers or scavengers at waste containers.
- Ensure regular street sweeping and collection of all unattended waste from the area.
- Use GIS to optimize the position and collection of waste from the containers by assigning the data to each street and containers. This will enhance the waste collection efficiency by taking into account the quantities of waste actually collected by the vehicles.

Waste Disposal:

- Encourage mechanical waste sorting at the landfill to enhance waste segregation.

- Avoid contamination and mixing of waste through its proper classification and storage.
- Discourage the practices of controlled dumping at the landfill which does not include the leachate and gas collection system.
- Encourage the proper use of the sanitary landfill site to fulfil the purpose it was made for.
- Restrict the activities of informal waste pickers or scavengers at the landfill, by making them part of a formal system to help in waste segregation practices.
- Ensure regular and proper monitoring of groundwater contamination due to leachate generation.
- Proper collection and treatment of leachate.
- Encourage and formalise the marketing of organic compost and other recyclables.
- Operationalise the already existing LWMC composting plant and incorporate measures that can enhance the quality of compost.
- Ban and impose penalties on illegal dumping and burning of waste.
- Prohibit the disposal of any organic and recyclables in the landfill.
- Hazardous waste should have to be properly segregated, treated, and disposed.
- Avoid the emission of landfill gas in the atmosphere by the installation of gas vents and other necessary measures that can promote its collection and utilisation as a fuel.
- Ensure the construction of proper runoff drains near the waste heaps.
- Ensure the installation of proper safety signs and boards to avoid any hazards.
- Adopt measures to prompt and introduce waste treatment technologies such as waste-to-energy techniques.

General:

- Formulate and enforce laws and regulations to comply with waste management practices by enhancing recycling and reuse of waste.
- Enhance awareness and knowledge of all stakeholders including LWMC staff regarding sustainable waste management by providing them with proper education and training.
- Ensure workers wear proper PPE while handling the waste.
- Ensure the hiring of relevant and competitive staff to enhance and strengthen the technical capacity of the institution.
- Ensure proper funding from the government to operate the system efficiently.

- Ensure proper monitoring of work and workers' performance at all three stages of waste management. In this regard, third-party validation can be introduced to enhance transparency and accountability.
- Ensure good record keeping of data.

In addition to the above, the most important step is to “improve the coordination and cooperation of all stakeholders” because planning, designing, operating, and maintaining an SWM plan is not a simple task. It requires a holistic approach to take into account the environmental, social, technical, and economic aspects. Moreover, as waste is an inevitable result of human activities, therefore, the proper understanding and collaboration of everyone at macro, meso, and micro levels are needed to promote the change, otherwise the success of even the best conceived plan would become questionable.

Limitations of the study

The study covers a review of the international to national model of waste management and CE practices and focuses as a case study on the shortcomings of a local community which is practicing both legal and illegal ways of waste disposal. Even though the attempts were made to investigate all the possible aspects and avenues of the topic and issues, owing to COVID-19 outbreak and time constraints the following major limitations were faced during the study:

- Only 10 households showed a willingness to give the interviews and to have a discussion due to the COVID-19 outbreak and other security concerns.
- The field visit to the Lakhodair landfill was cancelled because the concerned person was diagnosed with COVID-19. Therefore, all the information regarding the landfill was taken through a telephone conversation.
- The website of LWMC is not updated to get the relevant information.
- Initially, it was planned to visit the KWC, Lahti as well to conduct the interviews of officials there but due to the COVID-19 outbreak this plan was also cancelled.

Way forward

Keeping in view the upcoming prospects and markets of CE in the field of waste management and sustainability the following way forward is suggested:

- The literature and field surveys showed that CE has not been introduced in Pakistan so far and this is the first study conducted in the field of CE. This study only aims at introducing CE at the conceptual level, therefore the introduction of CE at the educational and institutional level will enhance the awareness and practical implementation of CE at the field level.

- As CE is a new concept for Pakistan there is a great need and pool of research to further assess its applicability and limitations. This can also be supplemented by examining the examples of other countries and successful projects.

- Keeping in view the time limit, the current study was mainly focused on biowaste of BC, to obtain the holistic view of waste management in Lahore future studies have to be carried out on other waste types and areas of Lahore.

- For follow up studies a large sample size of households is recommended to develop sound and representative data on the feedback of locals regarding waste management and related issue of the system.

- The current study showed that LWMC does not have reliable and accurate data on the waste generation and composition and is using the generalized value based on previous studies and observation. This demands LWMC to manage a proper team and resources to conduct and organize annual waste characterisation studies and record-keeping of the data which will help it in better planning and management of waste.

- The framework presented in this study is qualitative, to further add value to this framework the addition of quantitative information would be beneficial.

- This study will be useful for waste management professionals and researchers to help understand how circular models are constructed and in setting up of priorities based on the issues highlighted in the study. This will also help them in the formulation of appropriate policies.

- LWMC can follow this framework and based on its success the same model can also be replicated in other parts of the country because the factors controlling the waste composition are less likely to make any noticeable differences between the cities. Furthermore, the general pattern of waste collection and disposal in other cities is more or less similar to Lahore especially in areas where LWMC's sister companies are working. This will extend the waste management practices and cooperation of stakeholders.

- Waste has not been identified for its real value for long but considering the ongoing issues of sustainability, it is high time to change the way we think about waste by starting prioritizing and appreciating it as a resource that can meet our needs. In this context, the initiation and continuation of even small steps and actions will matter because instead of cursing the dark we can light a candle.

"You don't have to be great to start but you have to start to be great" by Zig Ziglar.

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APPENDICES

Appendix A

QUESTIONNAIRE FOR LOCAL/COMMUNITY MEMBER

Date: _____

Name of the Area: _____

Union council number: _____

Total No. of houses: _____

Total population of the area: _____

Name of Respondent: _____

Gender: _____ Age: _____

Number of people live in the same household: _____

Q. What are the common practices for waste disposal in the area? _____

_____

Q. Are there any waste bins present for disposal of community waste?

a) Yes b) No

Q. If yes, how often are the waste bins emptied? _____

Q. Distance to get access of these storage bins?

a) Good b) Fair c) Bad

Q. If No, how often and where do you dispose your solid waste?

_____

_____

Q. Can you roughly estimate the percentage composition of your waste?

Waste type	**Percentage**
kitchen	
garden	
paper	
plastic	
Iron and steel	
other	

Q. The waste collection service you use is?

a) Public b) Private

Q. If it is private what you think why are you availing this?

a) No public facilities b) less expensive c) most convenient option
d) door to door facility e) daily collection of waste

Q. Machinery used for Door to Door waste collection?

a) Hand carts b) Rickshaws c) Donkey carts d) Others_____

Q. Per month disposal cost required? _____

Q. Are you satisfied with current practise of waste collection?

a) Yes b) No

Q. What you use to store household rubbish and who provides you that?

a) plastic bags b) cardboard boxes c) rubbish bin/drum
d) others_____ e) no storage direct disposal to any available vacant space
f) provided by _____

Q. Do you segregate waste before disposal?

a) Yes b) No

Q. If Yes, what kind of waste and what you do with it?

_____

_____

Q. According to your point of view what is solid waste management and how it should be managed?

_____

_____

Q. Any facility or support provided by government for waste segregation and management?

_____

Q. Would you do proper waste segregation if you are facilitated by the government?

a) Yes b) No

Q. If yes, in your opinion what those facilities should be?

_____

Q. Please identify some of the main problems with the current solid waste management system?

a) disposed in existing water body
b) it is burnt
c) thrown in street corner or any available vacant space
d) lack of access to waste bins
e) blockage of water drains
f) other

Q. What is general quality of street sweeping in your street?

a) Good
b) Fair
c) Bad

Q. Who cleans the street and frequency of cleaning the street?

_____

_____

Q. Equipment used for street sweeping?

a) Brooms with hand carts
b) Brushes with wheelie bins
c) Any others

Q. Does solid waste block/chock the water drainage system of your area?

a) Yes
b) No
c) Sometimes

Q. In your opinion which of these is a priority concern about waste in the area?

a) Littering and looks bad
b) Effect on human health
c) Effect on environment
d) Other

Q. Do you think that the media has raised your awareness about solid waste management?
a) Yes
b) No

Q. What type of mass media component was more effective in generating awareness?

a) Radio
b) Television
c) Newspaper
d) Broacher/Pamphlets
d) Social media

Q. Or according to your opinion what could be best mode for transfer of knowledge?

a) through media
b) seminar and workshops conducted by govt
c) distribution of brochures
d) monthly meetings
e) others _____

Q. Is there provision of waste related Complaint redressal mechanism in your area?

a) Yes
b) No

Q. Is the complaint resolved in time?
a) Yes
b) No
c) Sometimes late response

Q. Are you interested in knowing proper and safe waste management and handling practices such as segregation at source, composting, recycling and other?

a) Yes b) No

Q. Keeping in views the shortage of gas and electricity supply in winters would you like to use biodegradable waste for production of compost, gas and electricity?

a) Yes b) No

Q. If yes at what level?

a) Own level: _____

_____

b) Govt level: _____

_____

Q. In general what you are more concerned about?

a) Air pollution b) Water pollution c) Waste pollution
d) Damage to scenic beauty e) Noise pollution f) Others

Q. Do you think that leaving a better environment for future generations is something?

a) Important b) Very important b) Not important at all

Q. Any other remarks by the respondents?

_____

_____

_____

THANKS FOR YOUR TIME AND COOPERATION

Appendix B

QUESTIONNAIRE FOR PRIVATE WASTE COLLECTOR OF UC 226

Q. Total waste generation in the study area (kg)? _____

Q. Type and quantity of waste generation?

Waste type	Amount	Percentage
Biodegradable/organic		
Paper		
Iron and metals		
Construction		
Medical		
Garden waste and leaves		
Wood		
Aluminum		
Hazardous		
Flammable		
Glass and ceramic		
Textile		
Radioactive		
Plastic and rubber		
Other		

Q. How the waste of the study area is being collected?

a) door to door collection b) communal bins c) private bins

Q. Frequency of waste collection? _____

Q. How the collected waste is treated?

_____

_____

Q. Who is responsible for waste disposal and how it is disposed or where it ultimately go?

_____

_____

Q. Enlist challenges and problems faced by you during waste collection and disposal?

_____

_____

Q. Do you have any contact or contract with the waste management company?

_____

_____

Q. Any facilities being provided to you by the government for waste collection?

_____

_____

Q. According to your opinion, how the system can be organized and waste can be best used?

_____

_____

_____

THANKS FOR YOUR TIME AND COOPERATION

Appendix C (I)

QUESTIONNAIRE FOR LAHORE WASTE MANAGEMENT COMPANY

Date: _____

I). GENERAL INFORMATION

Firm Name: _____

Address: _____

Year of establishment: _____

Population of city: _____

Name and designation of respondent: _____

Total number of workers: _____

Firm Status:

a) Government b) Semi-government c) Private

Main functions/activities of firm:

_____

_____

Q. What is the organizational setup for waste management?

_____

_____

II). SOLID WASTE GENERATION AND COLLECTION

Q. Total waste generation per day in Lahore? _____

Q. Quantity of waste collected by your company per day? _____

Waste type	Amount	Percentage
Biodegradable/organic		
Paper		
Iron and metals		
Construction		
Medical		
Garden waste and leaves		
Wood		

Aluminum		
Hazardous		
Flammable		
Glass and ceramic		
Textile		
Radioactive		
Plastic and rubber		
Other		

Q. The above-mentioned data is based on actual measurements or estimation?

_____

Q. Percentage of organic and inorganic waste?

a) organic: _____ b) inorganic: _____

Q. Area of jurisdiction for waste collection?

_____

_____

_____

Q. What is the waste collection method?

_____

_____

Q. Do you facilitate door to door collection?

a) Yes b) No

Q. If yes, in which areas and out of total how much percent of Lahore population is being facilitated by LWMC?

_____

Q. Does the department have a storage bin standardization policy? If so, please briefly outline the policy.

_____

_____

Q. Type of storage bin used?

a) Metal bin b) Plastic bin c) Plastic bag
d) Oil drum e) concrete bin f) Roll-on roll-off others

Q. No and owner of collection bins? _____

Q. Number of waste storage and collection points?

_____

Q. Frequency of waste collection from the storage points?

_____

_____

Q. What about people cooperation in the Solid waste management system?

a) Good b) Fair c) Bad

Q. Level of satisfaction among the community?

a) Good b) Fair c) Bad

Q. Mode of transportation for transfer of waste from storage point to disposal point?

_____

_____

Q. Number and types of vehicles use for solid waste collection and disposal?

Vehicle type	**Number**

Q. Does the department has its own workshop to maintain and repair its vehicles and equipment?

a) Yes b) No

Q. Number of shifts per day by vehicles? _____

Q. What are the measures adopted to facilitate waste segregation at source?

_____

_____

Q. Any recycling or reuse techniques adopted onsite or offsite?

_____

_____

Q. How occupational health and safety of workers is ensured while handling waste?

_____

Q. Number of waste recycling units in Lahore (formal/informal)?

_____

Q. What measures have been adopted to stop illegal dumping, burning and collection of waste by informal units (scavengers)?

_____

_____

Q. Total number of waste management companies working in Lahore? _____

Q. What are the waste management components followed by this company?

1. _____

2. _____

3. _____

III). WASTE DISPOSAL OR LANDFILL SITE

Q. How and where the waste was disposed previously?

_____

_____

Q. What are the current practices of solid waste disposal?

_____

Q. Name and Location of landfill site?

_____

Q. Status of landfill site?

a) Open dump b) sanitary landfill c) dumping with sand cover

Q. What was the method adopted for selection of landfill site?

_____

_____

Q. Year of establishment: _____

Q. Total area: _____

Q. Capacity: _____

Q. No. of workers: _____

Q. Major components of landfill site and their functions?

Component	Function

Q. Distance from collection area to the site (km)? _____

Q. Estimated life span of landfill? _____

Q. Amount of solid waste disposed per day (tonne/day)? _____

Q. Type of solid waste brought at landfill: _____

Q. Is waste segregated before disposal and how?

_____

_____

Q. Disposal method for organic waste: _____

_____

Q. Disposal method for inorganic waste: _____

_____

Q. Disposal method for hazardous waste? _____

_____

Q. Any environmental sensitive site present near the landfill?

_____

Q. Distance of nearby community from landfill site? _____

Q. How workers and surrounding community health and safety is ensured?

_____

Q. Existence of waste pickers or scavengers on site?

a) Yes b) No

Q. Practice of open burning onsite?

a) Yes b) No

Q. Any waste to energy technique installed at site?

a) Yes b) No

Q. If yes, type and quantity of waste treated by the technology?

_____

Q. Any environment-friendly practices adopted?

_____

Q. Most common issues and problems encountered on-site?

_____

_____

Q. Any monitoring measures adopted onsite?

_____

_____

Q. Do you have an emergency preparedness plan?

_____

_____

IV). AWARENESS AND HEALTH & SAFETY

Q. Any awareness and training programmes for employers?

a) Yes b) No

Q. If yes, type and frequency of programmes?

_____

Q. Any awareness and training programmes for locals/public?

_____

Q. What is the most common mode adopted for awareness dissemination?

a) Lectures b) Presentation c) Discussions d) Conference e) Any other

Q. Define the types of health impacts mostly faced by workers dealing with waste?

_____

_____

Q. Types of Personal Protective Equipment (PPE) use by employees dealing with waste?

_____

_____

Q. According to your knowledge, based on current solid waste composition and quantity which type of energy recovery technology is most beneficial and suitable for Lahore?

_____

_____

Q. What hurdles are faced by you in implementing municipal waste management system?

_____

_____

_____

Q. What are your suggestions about the improvement of solid waste management system?

_____

_____

Q. Any future plans for improvements in waste management?

_____

_____

Q. In your opinion what could be expected barriers in achieving the desire targets?

_____

_____

Q. List of ongoing projects on waste on waste management in Lahore?

_____

_____

Q. Any plans for private waste collector or informal sectors?

_____

_____

Q. Any other remarks or suggestions?

_____

_____

THANKS FOR YOUR TIME AND COOPERATION

Appendix C (II)

QUESTIONNAIRE FOR UC 226 MANAGER OPERATION AND SUPERVISOR

Date: _____

Q. Name and designation: _____

Q. Total number of workers in the area? _____

Q. Out of total the number of male and females workers? _____

Q. Total quantity of waste generation per day (kg)? _____

Q. Composition of waste of the study area?

Waste type	Amount	Percentage
Biodegradable/organic		
Paper		
Iron and metals		
Construction		
Medical		
Garden waste and leaves		
Wood		
Aluminum		
Hazardous		
Flammable		
Glass and ceramic		
Textile		
Radioactive		
Plastic and rubber		
Other		

Q. Percentage of organic and inorganic waste? _____

Q. Type of equipment use by the workers for waste collection? _____

Q. Do you offer door to door waste collection?

a) Yes b) No

Q. If No, what are the reasons?

_____

_____

Q. Number of waste bin/containers present in the study area? _____

Q. Capacity of waste bins/ containers? _____

Q. Locations of all near-by points where these bins are placed?

_____

_____

Q. How often these containers are emptied? _____

Q. Which vehicles takes the waste from these containers? _____

Q. Capacity of that vehicle? _____

Q. What is general waste flow process from collection till disposal of the study area?

_____

_____

Q. Any kind of waste segregation being adopted before its disposal into containers or landfill by the company?

_____

_____

Q. what kind of limitation are being faced by the workers during their working hours?

_____

_____

Q. What kind or barriers and hurdles are mostly faced in good waste management?

_____

_____

Q. Any data available on number of private informal waste collector working in the area?

_____

_____

Q. Does their presence is affecting the overall waste collection efficiency of the area?

_____

_____

Q. Is there any connection or contract between private waste collectors and company?

_____

_____

Q. Where does private waste collector ultimately dispose their waste and how?

_____

_____

Q. Overall organogram of management dealing with the waste of UC 226:

_____

_____

THANKS FOR YOUR TIME AND COOPERATION

Appendix D

Pictorial Presentation of Interviews and Focus Group Discussions with locals of BC

Plate 1: A view of residents of the Bahar Colony filling questionnaire.

Plate 2: A view of interviews with resident of the Bahar Colony.

Plate 3: A view of interviews with resident of the Bahar Colony.

Plate 4: A view of interviews with resident of the Bahar Colony.

Plate 5: A view of interviews with resident of the Bahar Colony.

Plate 6: A view of interviews with resident of the Bahar Colony.

Plate 1: A view of interviews with resident f the Bahar Colony.

Plate 2: A view of interviews with resident of the Bahar Colony.

Plate 3: A view of interviews with resident of the Bahar Colony.

Plate 4: A view of interviews with resident of the Bahar Colony.

Plate 5: A view of focus group discussion with residents of the Bahar Colony.

Plate 6: A view of focus group discussion with residents of the Bahar Colony.

Plate 1: A view of focus group discussion with residents of the Bahar Colony.

Plate 2: A view of focus group discussion with residents of the Bahar Colony.

Plate 3: A view of focus group discussion with residents of the Bahar Colony.

Plate 4: A view of focus group discussion with residents of the Bahar Colony.

Plate 5: A view of focus group discussion with residents of the Bahar Colony.

Plate 6: A view of focus group discussion with residents of the Bahar Colony.

Appendix E

Pictorial Presentation of Interview with informal Private Waste Collector of BC

Plate 1: A view of consultation with private waste collector of the Bahar Colony.

Plate 2: A view of private waste collector working in the area.

Plate 3: A view of different allocated bags attached to the waste collector vehicle in the Bahar Colony.

Plate 4: A view of waste collector vehicles in the Bahar Colony.

Plate 5: A view of waste segregation at source by the private waste collector.

Plate 6: A view of segregated recyclable material by private waste collector.

Appendix F

Pictorial Presentation of Meetings with LWMC Officials

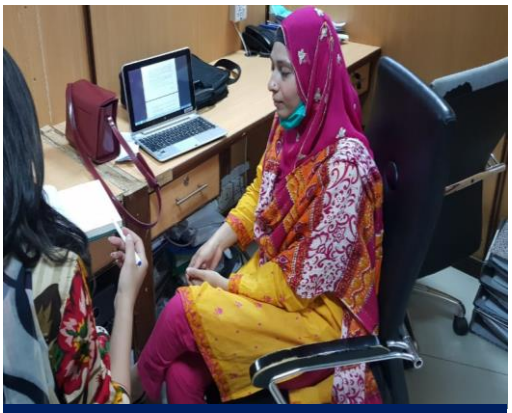

Plate 1: A view of consultative meeting with Manager Operation of UC 226.

Plate 2: A view of data collection meeting with Manager Project and Planning department.

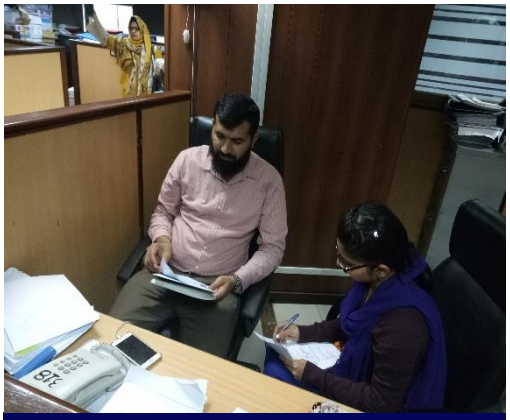

Plate 3: A view of data collection meeting with Manager Operation.

Plate 4: A view of data collection meeting with Research Associate (Project and Planning).

Plate 5: A view of meeting with Supervisor of UC 226 in the Bahar Colony.

Plate 6: A view of discussion with sanitary staff of LWMC in the Bahar Colony.

Appendix G

Timeline of the study

Name	**Samira Nazir**
Programme:	**Master of Urban Climate and Sustainability (MUrCS)**
Project title:	**Developing a Conceptual Framework for a Bio-Based Circular Economy Approach to Waste Management in Bahar Colony, Lahore-Pakistan**
Supervisor:	**Caroline Gallagher and Paul Carroll**

Activity	**2020**							
	Jan	Feb	March	April	May	June	July	Aug
I. Literature Review								
II. Questionnaire Development								
III. Field Surveys and consultations with locals and officials								
IV. Data analysis								
V. Results and Discussion								
VI. Conclusion and Recommendation								
VII. Thesis submission								