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A COMPARATIVE STUDY OF WASTE MANAGEMENT SYSTEMS IN DEVELOPING COUNTRIES AND WESTERN WORLD

Observations from Pakistan, Finland, Sweden and Germany

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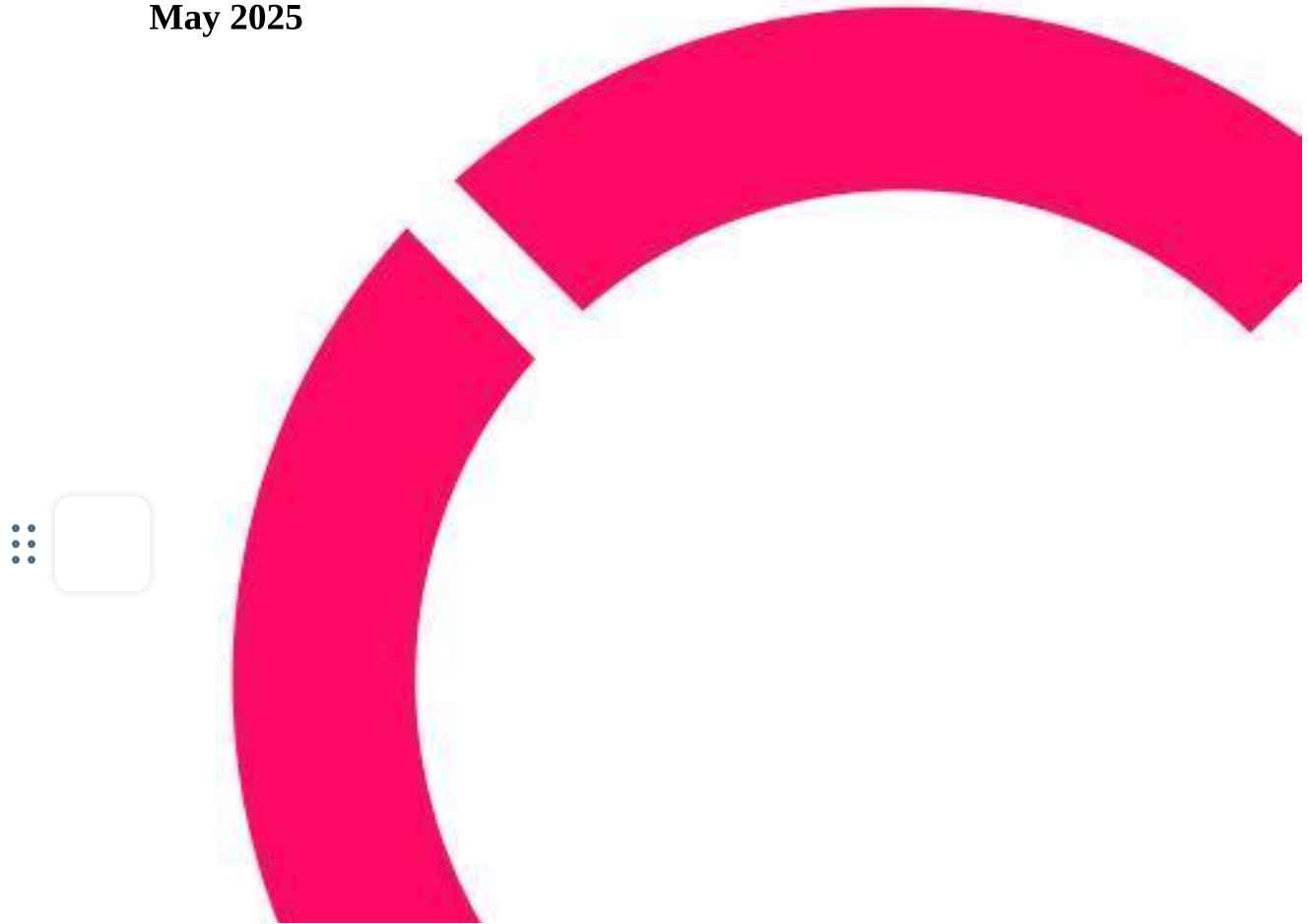

ABSTRACT

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In the recent past, there has been increased global attention on sustainable development, particularly in terms of waste management. This study is primarily focused on the comparison of the waste management systems in developing countries and developed western world countries with observations from Pakistan, Finland, Sweden and Germany respectively. The study was carried out in partnership with Pakistan-based entrepreneur Zahid Brother to gain insights about Pakistan's waste management system.

The purpose of the thesis is to analyse waste management policies in Western world and how effectively they can be implemented in Pakistan to meet sustainability requirements. To answer the objective of the thesis, the research questions raised were about the key differences and similarities between developed Western countries and Pakistan’s waste management policies, levels of public participation, and issues faced by local businesses. A quantitative research method was utilised, and semi-structured interviews were used to interview the management of small and medium sized companies participating in waste management in Pakistan.

This study indicated that most business owners were positive and hopeful since steps, such as the plastic bags ban, have been adopted at private businesses in Pakistan, which shows a growing commitment to sustainable waste management reform. Some key issues, including weak regulatory enforcement, insufficient infrastructure, limited technological collaboration, and low public awareness, all contribute to Pakistan's waste management challenges. It was found that effective waste management in Pakistan required strong policy framework, strict rules, and financial incentives for business owners. One suggestion is that the government should promote public-private partnership with tax incentives in building efficient waste management infrastructure and recycling mechanisms in developing countries like Pakistan.

Key words
Policy frameworks, Recycling, Sustainable development, Waste management

SUSTAINABLE DEVELOPMENT

Sustainable development has been defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development, 1987). Sustainable development calls for concerted efforts towards building an inclusive, sustainable and resilient future for people and planet (United Nations, 2015).

SOLID WASTE

Solid wastes, as defined by the United Nations, include all domestic refuse and non-hazardous wastes such as commercial and institutional wastes, street sweepings, and construction debris (United Nations, 2018).

SOLID WASTE MANAGEMENT

Integrated solid waste management is an approach which includes safe and proper handling of all sources and features of solid waste. This includes generation, segregation, transfer, sorting, treatment, recovery, and disposal, with an emphasis on maximizing resource use efficiency. (UNEP, 2016)

RECYCLING

Recycling is defined as the reprocessing of waste materials in a manufacturing process to redirect them from the waste stream while excluding their use as fuel. Reprocessing materials might result in either the same or different products (U.S. Environmental Protection Agency, 2025).

1 INTRODUCTION

Solid waste management (SWM) plays an important role in enabling sustainable urban development by collecting, transporting, recycling, and finally disposing waste of different nature produced in households, households as well as in industries and commercial establishments. SWM that is effective results in mitigation environmental degradation, public health risks and conservation of limited natural resources (Patil et al., 2024, 48). Waste mismanagement is a big ecological threat globally. It contaminates the soil, pollutes the water and emits greenhouse gases. For example, global methane emissions from landfills represent 11 per cent of global methane emissions from 28 to 36 times the warming potential of CO_2 (IPCC, 2023, 9). SWM pillar, recycling, divert waste to landfill, and reduce the extraction of raw materials. Recycling one tonne of aluminium reduces energy consumption of 14000 kWh (about one year), or the equivalent of using 14000 kWh of energy (U.S. Environmental Protection Agency, 1995, 91).

The difference between the system of SWM in developed and developing nations signifies the influence of economy, governance and technological advancement. Policies like extended producer responsibility (EPR) and advanced waste-to-energy (WtE) infrastructure as well as recycling rates above 60% are what Germany, Sweden and Japan have succeeded in doing in conducting circular economy models (OECD, 2022, 8). For example, Sweden ramps household waste from neighbouring countries into its WtE plants that provide service to 1,2 million Swedish homes (Avfall Sverige, 2023, 15). However, countries such as Pakistan have systematic problems like lack of funding, old infrastructure and using informal labor. 60% of the 12,000 tonnes of daily waste in Karachi, Pakistan’s largest city, is collected formally, the rest gathers in open dumps or water bodies and contributes to flooding, disease outbreaks (UN-Habitat, 2022, 12).

This thesis targets to evaluate viability of enhancing solid waste management (SWM) practices in Pakistan by highlighting significant obstacles, assessing global best practices, and proposing locally appropriate remedies. Rapid population expansion, urbanisation, consumerism, and law enforcement of trash reduction policies have all contributed to Pakistan's notable increase in garbage creation. Even though above 30 million tonnes of municipal solid trash are generated every year, inadequate infrastructure and disjointed policy implementation have prevented this waste from being handled effectively. (World Bank, 2022, 10). According to Pakistan Institute of Development Economics (PIDE, 2022, 11), major urban centres in Pakistan, including Lahore and Islamabad, is claimed to

create thousands of tonnes of waste per day, yet the infrastructure required to handle it remains underdeveloped. While discussing waste collection, around half of the waste is not gathered properly, and less than five percent of it is recycled. Due to the absence of an established policy, recyclables are wrongly handled by informal workers who do not follow adequate measures or safety equipment. Meanwhile, the open dumping and burning of toxic waste continue to pose significant environmental and health risks. (International Labour Organization, ILO, 2022, 14)

Even though national and provincial SWM regulations have been implemented, policy enforcement is still restricted due to bureaucratic inefficiencies and lack of resources. In contrast, Western world nations like Germany and Sweden have enacted stringent laws based on the circular economy concept, which has led to high recycling rates and accountability through judicial enforcement. These differences between Pakistan and Western countries reflect policy and implementation deficiencies that must be filled. (BMUV, 2023, 8)

This study will analyse Pakistan's waste management system by comparing it to the strict enforcement procedures seen in Western countries such as Finland, Sweden and Germany. Transferable techniques like public awareness, behavioural patterns, and the role of informal sectors are also evaluated, which can be suitable in the socioeconomic and cultural context of Pakistan. This study seeks to address SWM problems in Pakistan with the goal of meeting specific research objectives, such as comparing policy frameworks, assessing technological and infrastructural limits, and evaluating socio-cultural dynamics with western countries. This study is intended to inform policymakers, NGOs, and international funders about how to strengthen Pakistan's solid waste management system by providing practical recommendations based on theoretical findings.
The following research questions can be initiated to address the objective of thesis.
What are the main policy differences between Pakistan and Western countries in terms of regulation, finance, and enforcement? How do infrastructure and cultural factors limit Pakistan's SWM efficiency?How can Pakistan incorporate Western innovations such as AI sorting, biogas, and circular economy models into its SW?

2 THEORETICAL BACKGROUND AND LITERATURE REVIEW

2.1 Global Trends in Solid Waste Management

The global generation of solid trash has increased due to population growth, urbanisation, and consumption. As per report from (World Bank 2022,12) it states that the world generates 2,24 billion tonnes of municipal solid waste (MSW) per year and presumably will increase to 3,88 billion tonnes in 2050. Although living in developed nations, we are in fact more responsible for per capita waste generation than less developed nations. For example, per person, the United States produces 4,9 pounds of garbage every day (EPA, 2023), while Pakistan produces 0,6 pounds (World Bank, 2022, 18). In fact, most low- income countries have inadequate infrastructure (93% of waste in developing countries is unprocessed and left openly or burned) (Kaza, Yao, Bhada-Tata, & Van Woerden, 2018).

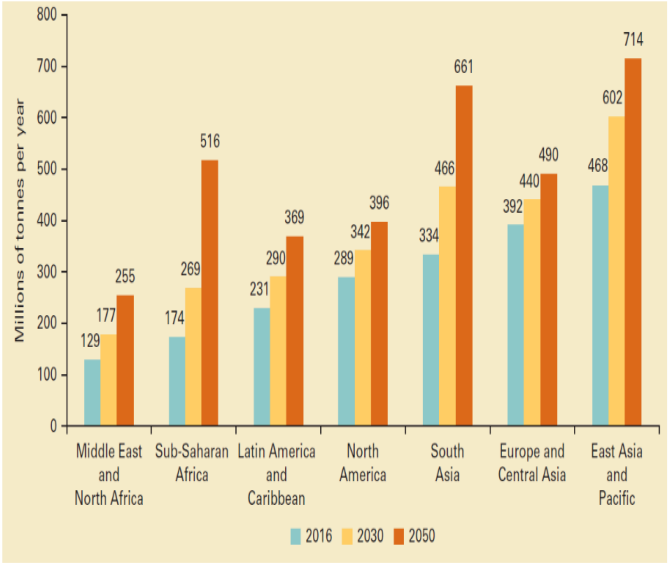

FIGURE 1: Projected waste generation by region

(What a Waste 2.0, 2018)

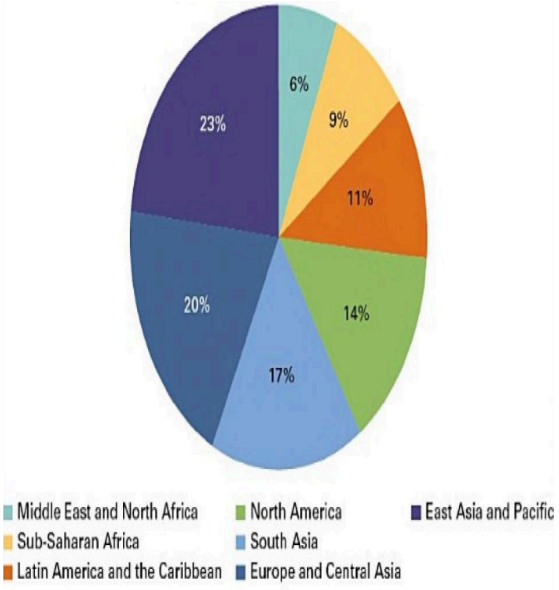

FIGURE 2: Share of waste generated by region

The vast difference in SWM efficiency between the western world and developing countries, however, has also to do with unequal economic capacity, governance and technological adoptio. Circular economy models are the developed nations' priority, in which 45%–60% of the waste is recycled or composted (Eurostat, 2025, 2). For instance, Germany's Grüne Punkt system recovers 68% of the

packaging waste by extended producer responsibility (BMUV, 2023, 5). However, Pakistan recycles only 5% of its waste formally, of which the waste is left to informal kabari networks on which there are no safety protocols (Ministry of Climate Change Pakistan, MoCC, 2022, 2). About 70% of India's urban waste is not collected and remains open dumped (Chaudhary et al., 2021, 15). Such disparities point to the demand of context specific solutions which are applicable to socioeconomic situations.

2.2 Policy Frameworks in Global Perspectives and Regional Adaptation

SWM policies are stringently implemented by the countries in the West which have a rigorous legislative basis, coupled with financial incentives. In anticipation of the European Union's Landfill Directive (1999/31/EC), requiring an action of reducing biodegradable waste landfill by 65% till year 2035, composting ventures and WtE technologies have gained investments (FAO, 1999, 3). Just like Japan's Home Appliance Recycling Law (2001), which obligates manufacturers to recycle 50%–60% of discarded electronics, Japan's 78% refrigerator recovery rate (METI and MOE, 2022). Penalties for not complying with these frameworks are also enforced, such as, for example, SB 1383, in California, fine municipalities that do not cap organic waste disposal to 75% by 2025 at $10,000/day (CalRecycle, 2025).

Pakistan's policies on SWM lack adequate funding and enforcement. However, the National Environment Policy (2005) does not stipulate any binding targets for reduction of waste, and provincial laws such as Punjab SWM Act (2014) are not enforced because of political inertia (Environment Protection and Climate Change Department, 2014, 2). And corruption compounds this further as in 2022, 35% of the SWM budget of Karachi, went into corruption that ceased the purchase of waste compactors. Whereas Turkey's Zero Waste Project through public awareness campaigns and PPPs has doubled recycling rates to 25 within 6 years (Coskun, 2022, 9). The focus of these examples is on the role of political will and accountability in SWM governance.

2.3 Technological Innovations and Infrastructure

In developed nations, SWM has been revolutionized due to technological advancements. Robot arms and optical sensors are used in Netherlands' Recycling Avenue with a capacity of 40,000 waste items per hour with 99% accuracy (TNO, 2023, 10). Sweden's WtE plants produce 50% of waste into

electricity powering 1,2 million homes per year (Avfall Sveriges, 2023, 14). Chemical recycling innovations such as France's Carbios can take part of polymer (PET plastics) and break it down into reusable monomers, allowing infinite recyclability (Carbios, 2020, 8). The technologies help achieving circular economy principles and reducing reliance on landfill. The EU's total landfill rate decreased from 23% to 17% between 2010 and 2022, and the amount of waste dumped in landfills per person fell to 306 kilogrammes per year. Despite this, total waste creation continues to climb, and the amount of sorting residues transported to landfill has doubled since 2010. There has been more progress in diverting domestic and similar waste from landfills (Eurostat, 2023).

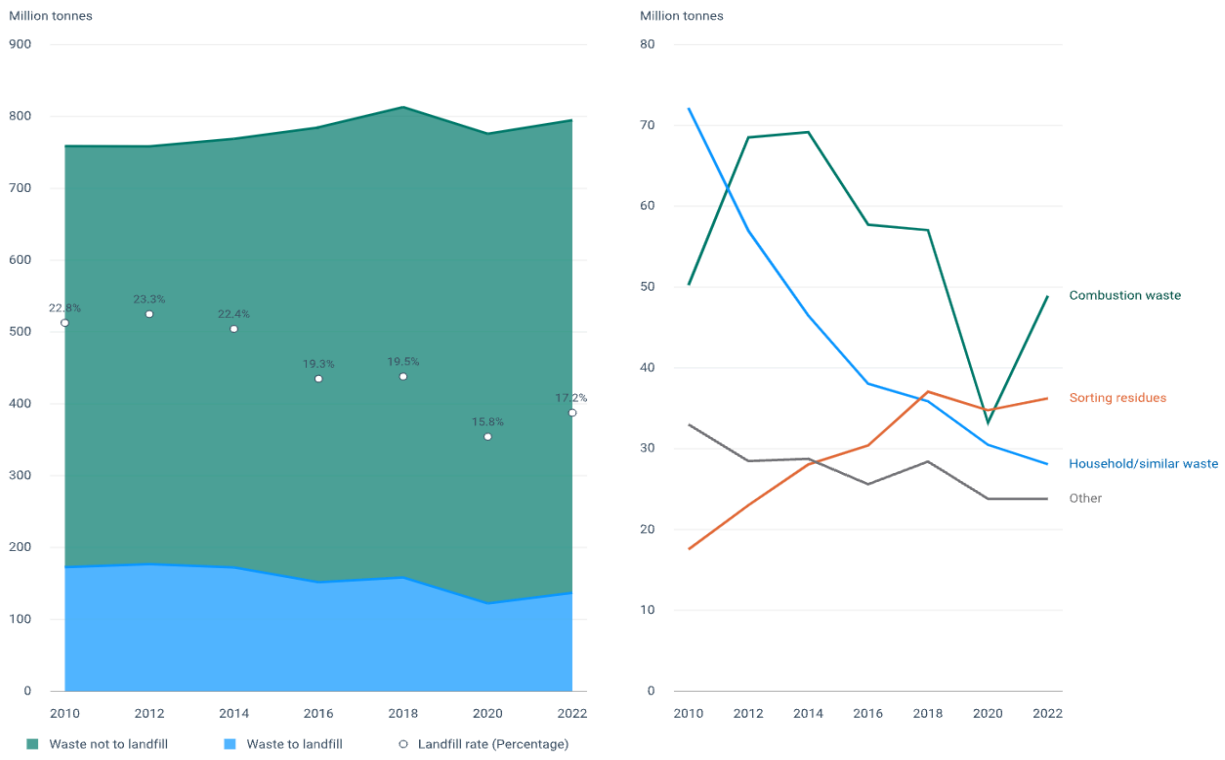

FIGURE 3: EU Percentage and share of deposited waste in landfills, by waste category type, EU-27 (European Environment Agency EEA, 2024)

Pakistan's SWM infrastructure according to SMM is outdated and fragmented. Most municipalities rely on donkey carts for collection (Asian Development Bank, 2024, 18), and only 30% of municipalities operate fleet vehicles. Only 10% of the city's waste is processed by Lahore's sole composting plant, where just 500 tonnes/day are processed, or <1% of Karachi's plastic waste (PIDE, 2022, 11).

Methane capture systems, which are absent in Pakistan's 1,200 open dumps, only add to climate impacts since they yield 14 million tonnes CO_2 equivalent of methane annually (UNEP, 2024, 9). If there is a gap between technology and local budgets, bridging that gap necessitates the financings of institutionalized solutions like Biogas plants or mobile waste tracking apps designed for local budgets.

2.4 Socioeconomic and Cultural Dimensions

SWM needs public engagement. South Korea's Volume-Based Waste Fee System (1995) reduced household waste by 18% by charging residents fees for excess disposal (Lee, Shurson, Oh and Jang, 2024,15). Unlike, Pakistan's 59% literacy rate and cultural apathy makes it fail in awareness campaigns (UNESCO, 2024, 18). Eid-ul-Adha sacrifices create 5,000 tonnes of daily animal waste which overwhelms municipal services (NDMA, 2023, 7). Saudi Arabia's centralized rendering plant model offers a potential model of converting sacrificial waste into biofuels (Ashraf, Ullah, Khan, Tremel, Ahmad and Tahir, 2023, 4458).

The informal sector has an important but little understood role in the development of countries. In Pakistan, informal waste pickers who earned $2–3 daily without protections, collect more than 70–80% of recyclables, and are 1,5 million strong (ILO, 2022, 7). According to the Brazil's Public policy for solid waste, this formalized 600,000 workers into cooperatives, increasing the rates of recycling by 30% (Da Silva, C.L. and Bolson, 2018). Some of the similar initiatives in Pakistan can further promote equity and efficiency while translating the goals of SDG 8 (Decent Work, 2024).

2.5 Case Studies and Comparative Analyses of West and Pakistan

Considering the case studies from western countries like Germany where Duales System Deutschland extracts 95% of material with mandatory segregation within the household (BMUV, 2023, 5). In Sweden**,** Bioreactor technology is used in Högbytorp Landfill to increase the decomposition rate and capture methane, enough to offset 50,000 tonnes of CO_2 per year (Avfall Sverige, 2023, 13). While in Canada**,** approximately 60% of organic waste through curbside composting is diverted from landfills within Toronto's Green Bin Program (City of Toronto, 2024, 15). There are also examples in large urban cities in Pakistan. For instance, Karachi, which is Pakistan's largest city, produces 12,000 tonnes/day but only collects 60 while having to depend on informal kabari networks (UN-Habitat,

2022, 8). While in Lahore, groundwater at the Lakhodair landfill is contaminated with heavy metals (EPA, 2023, 7). Additionally, in Islamabad waste collection rates in the Clean Green Pakistan initiative were raised to 80%, an achievement that is, however, not supported by recycling infrastructure (MoCC, 2022, 5).

2.6 Sustainable Development and SWM

Effective SWM can support in achieving sustainable development goals. Some of relevant sustainable goals include sustainable Cities SDG 11, along with Responsible usage SDG 12 and Climate Action SDG 13. As an example, objectives of SDG 11 (Sustainable Cities) are being achieved in most aspects by Singapore. The goal of Singapore's Zero Waste Masterplan is to reach 70% landfill diversion by 2030 (NEA, 2022, 11). Also, for fulfilling targets of SDG 12, around 68% of paper is recycled in the U.S. and 4 billion trees/year are saved (EPA, 2023, 6). In addition to that, to cope up with Climate Action (SDG 13), WtE plants from Sweden substitute 8/100 for fossil fuels (Avfall Sverige, 2023, 12). Pakistan's organic waste could generate 1500 MW of energy through biogas energy to power 3 million homes, but only 10 plants work nationally (UNDP, 2023, 12). India's National Biogas Programme, though only replicable on a 5 million household units level currently, is deforestation reducing (MNRE, 2023, 8).

2.7 Economic Implications and Funding Mechanisms

The cost of mismanaged waste in Pakistan is 1,3 billion annually towards health care and flood damage (World Bank, 2022, 23). On the contrary, the global recycling industry is expected to grow with revenue to 530 billion by 2025 (World Bank, 2022, 21). Compared to Pakistan's SWM budget <1%, developed nations allocate 3–5% of their municipal budgets to SWM (PIDE, 2022, 12). Turkey's Zero Waste Project is an example of PPPs which can bridge funding gaps with collaborations with SMEs and international donors.

2.8 Literature Review

Theoretical section of this thesis examines current stage of waste management in Pakistan and key determinants for new entrepreneurs in the industry. Comparison will be done between the solid waste management systems of Pakistan to the western countries like Finland, focusing on Policies, infrastructure and public participation. Theoretical insights are offered into the potential hurdles and constraints that entrepreneurs confront in Pakistan's waste management business. Analysis of regulatory framework, current practices, key hurdles, risk factors, and public participation is done using data collected from five companies including public and private SMEs who are part of waste-related business. This literature review emphasizes the need to reform Pakistan’s SWM systems by policy enforcement, technological adoption, and social inclusion. By formalizing that existing **kabari** network and investing in biogas plants, Pakistan can overcome environmental degradation while simultaneously pushing forward with sustainable development.

2.8.1 Sustainable Development Theory

The Brundtland Commission’s report (World Commission on Environment and Development, 1987,15) gave prominence to the concept of sustainable development based on the notion that ‘' humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs World Bank (World Commission on Environment and Development, 1987)’’. Essentially, the philosophy emphasises the importance of balance in three pillars, economic growth, social equity, and environmental protection. These three domains are harmonized when they guide societies to long- term progress that does not deplete natural resources and is not dependent on vulnerable communities. With evolution, the theory of sustainable development has expanded to incorporate governance, technology and even cultural factors that show that it is useful in fighting challenges across the globe.

In relation to solid waste management (SWM), basis of sustainable development theory relies on the requirement of waste strategies encompassing more than green cleaning and is often referred to as 'greening' of current systems (Wilson, Velis and Cheeseman, 2012).
As Pakistan is a developing country with a growing urbanization and high incremental consumption, the approach is signalling that real progress is linked to combine new technologies with social equity measures like better working conditions for informal waste pickers (ILO, 2022, 9). For instance, the

development of enhanced waste-to-energy (WtE) plants, can not only diversify Pakistan's energy mix but also simultaneously increase landfill use. Yet, mere installation of modern infrastructure cannot by itself make this a reality if local communities are not involved in proper disposal practices and informal workers are not empowered. Despite this, funding allocations also must be balanced, such that economic feasibility does not matter more than environmental and social goals (PIDE, 2022, 6).

At the same time, Western nations, particularly developed Western nations, have universally adopted and put into actions sustainable development through circular economy models and appreciative regulatory frameworks, while non-Western nations have yet to realize it. An example of circular economy model for waste recycling includes Japan, which has established strong waste management policies for Waste Electrical and Electronic Equipment (WEEE). These regulations require consumers to pay recycling fees, retailers to take back used products, and manufacturers involved to finish the recycling process. It has improved Japan's recycling rates of 70% for air conditioners, 65% for washing machines, 60% for refrigerators, and 55% for TVs (Ministry of Environment Japan, 2023). Germany's high proven recycling rates, Sweden's successful WtE projects, and Japan's disposing of Waste Electrical and Electronic Equipment (WEEE) (BMUV, 2023, 13; Ministry of Environment Japan, 2023) show that high levels of sustainable systems can also be defined and applied appropriately as action. The illustrations are these examples of high levels of political will and ready financial mechanisms to overcome systemic barriers which otherwise fuel inert change.

Referring to this study, we explore a theory of sustainable development in its normative capacity for us to compare Pakistan's SWM system with developed Western countries. The message stresses that integrated SWM policy achieves multi-level benefits from reducing greenhouse gas production, improving public health to enhancing social inclusiveness. To put it simply, if Pakistan were to embrace a holistic, sustainability-based approach, it would go a long way to turning Pakistan's SWM service from a reactive, under resourced scrap, into an enabler of development, conservation and wellbeing of its society and its environment. Therefore, the theory serves as a guidepost of sorts and a performance measurement, showing whether policy reforms and technological advances are indeed net benefits for current and future generations (IPCC, 2023, 4).

2.8.2 Circular Economy Theory

The circular economy theory works on basic principle of designing all products, extracting raw materials for the purpose of using them for longer, prolonging the life of goods and resources and reviving natural processes (Ellen MacArthur Foundation, 2019). Circular economy is different from traditional ‘linear’ model in such a way that production cycles are closed loop and resources flow back into the system throughout. It leads to less virgin materials extraction, environmental impact minimization and favorable product design and end of life management. The notion was caught up in Western policy circles but came from industrial ecology, cradle-to-cradle design, and an array of local exercises in waste minimization.

The circular economy theory is a transformative lens for Pakistan. At present, most of the country’s waste is dumped in open dumps or informally recycled by marginalised workers (UN-Habitat, 2022, 12). Circular approaches that Pakistani municipalities and private actors can adopt to redesign product, extend producer responsibility and establish local recycling cooperatives are discussed. Such interventions to smaller scales – composting organic waste and using it for biogas generation – can slash the landfill volume by a factor of 1–2 and work towards addressing the energy deficits (UNDP, 2023, 17). Yet, in order truly to operationalize the circular economy principles in Pakistan, there would be a need for robust policy frameworks supported by enforceable rules as well as financial incentives for industries to redesign new products and invest in recycling infrastructures (OECD, 2022, 22).

FIGURE 4: Waste Management Hierarchy

When it comes to solid waste management, a circular economy approach requires thinking about all the solid waste's liabilities, from residential trash to commercial and industrial byproducts. This has translated in the literature in many Western countries (Germany, Sweden and the Netherlands) into advanced recycling methods, product take back schemes and strong consumer education campaigns

(Avfall Sverige, 2023, 9; BMUV, 2023, 11). The model is exemplified by how Sweden sits on over a million residences that are powered by waste-to-energy on top of efforts to reclaim valuable materials from the electronic or household waste streams. These initiatives encapsulate circular economy thinking in creating economic value from discarded resources that goes to landfill.

Comparing Pakistan's realities to Western success, the significance of circular economy model in scaling up is highlighted that the scaling up is not the matter of only importing the foreign solutions. Given the local socio-cultural dynamics, extensive unlawful waste economic sector and regional economic constraints, strategies should be tailored. But useful as a way of thinking, circular economy thinking finds itself still a powerful guide where waste is not considered a nuisance to be managed but is seen as a resource that can generate economic, ecological and social gains. It all ends up being embedded wisely, and if embedded wisely it paves the path to a sustainable resource use, a lower impact on climate, and an inclusive economic growth.

2.8.3 Stakeholder Theory

As described by R. Edward Freeman (Freeman, R.E., Wicks and Parmar, 2004, pp. 365–367), stake holder theory is based upon consideration of the interests of all parties (and people) that might be affected or affect your organization, this includes something more than shareholders, traditional business interests. Thus, in policy and governance this communication means that decision makers should search for and include a broad range of interests in governments, citizens, private firms, informal workers and environmental advocacy firms to create a policy with generally accepted support and look legit. Applied to solid waste management, stakeholder theory is particularly powerful in economic development, public health, environmental protection, labour markets and even culture norms.

The engagement of stakeholders in SWM in developed Western countries is more often formalised through structures of formal consultations, public hearings, and partnerships with non-government organizations. Municipal authorities in several parts of Europe and North America work with environmental NGOs and local community groups to support recycling drives or to influence legislation (CalRecycle, 2025, 14). It provides an inclusive approach to help policymakers anticipate the challenges – technical, financial or social, and include the voices of all segments of the society to enhance compliance and cooperation from the parties. In addition, it helps with innovation since one

can foster multiple perspectives and think creatively about smart bin technology, community composting or even community running composting.

Yet, Pakistan's stakeholder landscape is more complex. The coordination between government bodies is lacking, with a result that mandates overlap each other and waste is generated (NEP, 2005, 5). The informal sector, including waste pickers, participates in recycling, but they rarely informally participate in discussions and decisions that would benefit them (ILO, 2022, 6). Informational actors can be incorporated through stakeholder engagement to extend legal protections, safe working conditions and fair compensation for social equity purposes. So, besides the religious and cultural aspects involved, like ways of handling waste during Eid celebrations, those involve instructions from the local religious authorities and community leaders to strike the right chord so that these are culturally sensitive (NDMA, 2023, 4).

Stakeholder theory emphasises that there are similarities as well as conflicts among the various groups. One example here would be bridging the formal and informal systems, so that they formed collaborative facilities for sorting, in which the informal sector was recognized as being more knowledgeable about local materials flow. In short, overall, stakeholder theory argues that effective sustainable SWM does not just emanate from top-down demands, but from transparent interaction, collaborative governance, and recognition of the legitimacy of each stakeholder's claims to outcomes as well as to the decision making itself (PIDE, 2022, 14).

2.9 Gaps in Existing Literature

Replicating Western models has been most advocated by studies without discussing Pakistan's specific challenges like informal sector integration, religious waste practice. In Pakistan, there are still unseen areas of waste management which are still not fully explored with lot of potential e.g. Rural solid waste management dynamics due to limited data on agricultural waste management. Also, gender roles are not properly established. While formally, women make 60% of the informal workforce, they are unable to participate in the policy dialogue (ILO, 2022, 5).

3 Methodology

This chapter elaborates the methodological underpinning for the various ways used to compare SWM systems in Pakistan with some advanced western developed nations like Finland. Given the enormous constraints that collecting primary data is supposed to have, and with a plethora of published work on SWM policies, indicators of performance and socio-economic factors one should decide to stick with just the secondary data sources.

3.1 Research Methods

This chapter explains the methodological basis for several ways of comparing solid waste management (SWM) systems in Pakistan with selected evolved Western countries, particularly Finland. The fact that the feasibility constraints of collecting primary data is so great and the abundant presence of published information on the policies of SWM, performance metrics and socio-economic factors lead one to choose to rely solely on the secondary data sources. The main objective of this chapter is to assist the reader in understanding how published reports, peer reviewed article, governmental databases and international agency documents were identified, reviewed and interpreted for this research. In doing so, this chapter follows the theoretical underpinnings of that which the authors refer to as Sustainable Development Theory, Circular Economy Theory, and Stakeholder Theory.

The study employs a comparative descriptive design, observing the differences between the respective major urban centres of Pakistan (Karachi, Lahore, etc.), with some of the Western context represented by countries mainly Finland and in support Germany and Sweden. As an approach, it uses a few documented evidence to build a solid visual picture of the SWM systems in different socioeconomic and governance backgrounds. Taking a descriptive design, the system variations in the waste treatment technologies, the policy enforcement tools, and allocations found are emphasized, as well as driving systems proximate such as the governance structures and the socio-cultural factors that make up the system (Cvetković,Sudar, Ivanov, Lukić & Grozdanić, 2024).

The study was focussed to generate multiple factors that affect the adaption of various successful western waste management policies in Pakistan, effective collaboration between private and public partnership and social awareness for residents. Interviews will be conducted in semi-structured ways,

through online meetings, or via telephone, according to convenience and preferences by participants. Furthermore, interviews can be additionally strengthened with open-ended questions for in detail discussions and to gather opinion of SMEs. Ethical principles will be strictly followed including formal consent and confidentiality shall be maintained. After the interviews are done, the responses will be further evaluated based on research data available regarding Finland in the same field. No interviews will be conducted in Finland due to limited scope of my study. The date from Pakistan will review impact of current regulations in Pakistan and Finland, key differences between the two countries waste management system, the effectiveness of good environmental practices in Finland and areas of improvement in Pakistan. This approach will give us more detailed insights about the way SMEs work in both countries Finland and Pakistan and what can be done to handle environmental challenges and effective implementation of government regulations.

The second part of data collection from Finland for this study is based on published and publicly available rather than on direct fieldwork or stakeholder interview. I consult relevant government and intergovernmental reports, including the Pakistan's Ministry of Climate Change, provincial Solid Wastes Management authorities, the Pakistan Environmental Protection Agency, and governments of comparable developed nations. Numerical indicators such as waste generation rates, landfill diversion percentages, recycling volumes, were particularly provided by reports from international organizations including the World Bank, OECD, and multiple working bodies from United Nations for application to evaluation of the contexts of thesis objectives. Qualitative depth was supplied by exploring governance issues, dynamics of informal sector and its local environmental impacts from the academic journals, peer reviewed articles and policy papers. Relevant materials of this research were selected based on the main themes of this research, namely sustainability, circularity approaches to waste, and stakeholder participation. Credibility of the source was assessed as whether it was peer reviewed, published by a relevant source or well-known institution or frequently cited in SWM literature. Data published in the last decade were emphasized, although the eminent older works were included when they had a considerable impact on current practices or became seminal references within SWM discourse.

3.2 Data analysis

The purpose of the study was to understand and learn more about the waste management issues that small and medium-sized businesses (SMEs) in Pakistan are currently facing as well as possible solutions. An organised qualitative research method was used in this scenario. Five SMEs were first

approached, representing both the public and private sectors in Pakistan. Two public organisations, the Lahore Waste Management Authority and the Sadiqabad Municipal Authority, as well as two private enterprises, MYZ Waste Management and Hygienic Waste Management, consented to participate. The commissioning company's point of view, handled by Mr. Ameer Khan, was also considered. The qualitative method provided more in-depth assessment of participants' thoughts on regulatory laws, sustainable practices, infrastructure restrictions, public participation, economic constraints, and climate change effects.

Semi-structured interviews were conducted to accommodate both planned questions and further follow-up questions. The research questions were distributed to participants ahead of time (APPENDIX 1). The duration of the interviews ranged from 25 to 40 minutes. Three interviews were recorded with consent, while two were performed over the phone while writing on my own since individuals desired not to be recorded. Recordings made later transcription and further analysis easier without interrupting the interview flow.

The recordings were transcribed on the same day as the interviews. After then, the responses were methodically arranged in accordance with the research questions. An identification number (such as Manager (1–4) was given to each participant to maintain confidentiality and do comparative analysis. The results are organised into subject categories and will be presented in Chapter 4.

3.3 Interviewees

Five SME representatives took part in the study, giving insights from both the public and private sectors involved in waste management in Pakistan.

Companies 1 and 2 are from the public sector in Pakistan. The responses provided important insights into the regulatory issues and infrastructure limits faced by municipalities. Also, it was mentioned that regulatory policies are not consistent due to political issues which result in poor waste management procedures, such as outdated regulations and law enforcement. Infrastructure limits, such as inadequate dumping sites and recycling facilities, worsen the situation, needing significant changes and investments in the area.

Company 3 is private company MYZ Waste Management which has established itself as waste handling company that mainly serves other companies and private homes. Their strategy is focused on providing customised waste management solutions to business customers, which they believe to be more sustainable and feasible. During the interview, they outlined several major operational issues related to household waste, such as unwillingness by homeowners to pay for services, restricted access to available recycling facilities, and financial constraints such as less funding by government which reduces their ability to expand their customers and provide more services to end users.

Company 4 is an interesting organization which specialises in creative, environmentally friendly garbage solutions. During the interview, they highlighted the difficulties in increasing public awareness, the limited number of recycling facilities, and the necessity of closer cooperation with local government. Broader sector-wide challenges, such as insufficient tax incentives and climate change, were also raised. It was mentioned that private public partnerships with tax incentives by government can lead to increased efficiency of waste management in Pakistan. In addition to that, government should involve all stakeholders including business owners, government officials and public speakers to increase public awareness and reflect such environment friendly practices at both residential and commercial places.

3.4 Data Interpretation

In this study, policy papers were thoroughly examined to determine how well they matched the primary themes from the theories employed, such as sustainability, stakeholder involvement, and circular economy. Important sections of the study were emphasised, particularly those pertaining to the management of resources like waste handling, the involvement of various groups, and the enforcement of rules. Common themes such as producer responsibility, recycling objectives, public awareness, and local corruption issues were used to categorise the received information from interviews. Simple statistics, such as trends in waste generation and budget allocation, were utilised to back up the findings, but no detailed calculations were performed. The idea was to compare solid waste management between the Western world and Pakistan, rather than identifying cause and effect links. The findings were analysed using Sustainable Development Theory, Circular Economy Theory, and Stakeholder Theory. The findings were then compared to these theories to determine if present waste management methods support or fall short of broader sustainability goals, as well as which groups are included or excluded from these processes.

3.5 Ethical consideration

However, ethical things were low since this project relies solely on secondary data. The responsibility of chief lies in the fact that the data sources used were correctly noted and data collected remained intact. Potential governmental or institutional biases were recognized as potential biases, and every effort was made to multi-reference findings whenever possible. Because there was no personal data or sensitive information from human participants involved, informed consent or protocols for confidentiality did not need to be implemented (Di Minin, Fink, Hausmann, Kremer, & Kulkarni, 2021, p. 442). However, there has been transparency in terms of limitation for each source even if the official records involve underestimation or overestimation.

3.6 Limitations of methodology

This research has several limitations that should be acknowledged. First, it relies primarily on secondary data and published reports for comparing Finland and Pakistan, which may lead to inconsistencies due to differing data collection methods and years. The accuracy and completeness of available data (e.g., waste generation rates, recycling statistics) vary by country, for instance, informal recycling in Pakistan is not well documented, potentially understating Pakistan's recycling figures. Second, the scope was limited to comparing a few countries – Finland as the main case, with Sweden and Germany as supporting examples. This detailed comparison may not be able to grasp the whole diversity of waste management practices in other developed or developing countries. Third, the analysis is largely qualitative, which identifies differences in policies, technologies, and outcomes. Furthermore, it does not provide a quantitative model of how implementing Finland's practices would statistically impact Pakistan.

But the biggest drawback of partially relying on secondary data is that it does not allow for capturing real time operations practices, communities' perceptions on what works and the informal labour conditions of the industry in as much detail as possible. As interviews from Finland are not conducted, but it can be focus of another study in future. Understandably, there are official published statistics, that often omit or generalize underlying complexities when the context involves widespread informal waste management. Despite these constraints, the wealth of reliable, peer reviewed, and institutionally verified documents have permitted a thorough review of policy frameworks and measured results, which are sufficient for the aims of the study.

4 Discussion

4.1 Policy and regulatory frameworks

A strong policy and a legal framework are already in practice for solid waste management (SWM) in Finland, which is consistent with sustainable development principles. The implementation of the EU Waste Framework Directive hierarchy is ensured through Finnish Waste Act (646/2011) and the Environmental Protection Act (Ministry of the Environment, 2023) where main aim of waste prevention, reuse, recycling and recovery over disposal is already explained (Sahimaa 2021). It is local municipalities who are mainly responsible for household waste services, while industrial waste is dealt with by private firms under close and strict regulation. All of this coupled with EU directives such as the Landfill Directive aimed to minimize dumping has led Finland to recycle over 40% of municipal waste and less that 1% to landfills by 2020 (Halkos & Petrou 2019). Similarly, other high-income countries have such stringent frameworks, especially, Germany's Circular Economy Act aimed to have 65% recycling rate (greater than the EU's 50% by 2020) which aids Germany to achieve a municipal recycling rate of approximately 67% in 2019 (Domenech & Bahn-Walkowiak 2019).

Given that Sweden also enforces progressive waste laws, including bans of landfilling of organic waste, it sends less than 1% of its garbage to landfills and about 50% of its garbage gets recycled, with the rest converted to energy (Matheson, 2022). They illustrate how a strong commitment to policy is possible, clear goals may be set, and enforcement of them made, and can result in advanced waste outcomes, a point key to Sustainable Development Theory in finding a balance between environmental protection, economic and social needs, through governance. Systemic barriers to handle waste effectively in the case of Finland have been latterly superseded by high level political will and stable financing. These countries ensured that the waste not only comes across as a nuisance instead, but it is also managed as a resource by including circular economy goals as part of national policy sine Finland was one of the first to do so in 2016 (Sitra, 2016).

In contrast, Pakistan's policy framework for waste management has historically been fragmented and weakly enforced, undermining sustainable waste governance. Numerous laws and regulations, including the Pakistan Environmental Protection Act (1997), which prohibits releasing of certain kinds of garbage, the Hospital garbage Management Rules (1998, 2005), and municipal bylaws, which

regulate waste management in Pakistan. However, while discussing about developing countries, these regulations were formulated in a data and information vacuum and have not translated into effective implementation. There is no singular, rigorously enforced national solid waste policy where responsibilities are split between federal, provincial, and local authorities, often with overlapping mandates and gaps in coordination. The result is a regulatory framework strong on paper but weak in practice. Until recently, policy emphasis on sustainable waste management in Pakistan was minimal – for example, open dumping and burning have persisted largely unchecked, indicating enforcement failures.

The government has begun to recognize these shortcomings and respond in 2025, Pakistan announced development of a national Circular Economy Policy to integrate waste sustainability into strategy (Zahid, Hayat, Rahman, & Ali, 2024). Initiatives like bans on single-use plastics (e.g. plastic bags) have been introduced, reportedly cutting plastic bag usage from 80% to 58% in some areas. Yet, officials admit enforcement challenges due to limited capacity. Overall, Pakistan's policy regime is at an initial stage compared to Finland's policy framework since it lacks consistent application of the waste hierarchy and suffers from inadequate institutional support. This gap underlines the relevance of stakeholder theory, where inclusive decision-making and clear accountability are missing. Unlike Finland – where policymakers engage municipalities, industries, and citizens in crafting waste rules – Pakistan's waste governance has often excluded key stakeholders such as local communities and the informal sector. Improving laws on paper will require parallel efforts to incorporate stakeholder voices and ensure compliance on the ground.

4.2 Technological Approaches and Infrastructure

Finland have heavily invested in modern waste management infrastructure and technologies, enabling efficient, environmentally sound handling of waste. In Finland, state-of-the-art automated sorting facilities equipped with robotics and now recently AI are used to separate recyclables with high precision, boosting recycling rates by recovering plastics, metals, paper and glass from mixed waste Lubongo, Daej and Alexandridis, 2024). Waste that cannot be recycled is diverted to waste-to-energy (WtE) plants (Silva et al. 2022), which incinerate waste to produce electricity and district heating while operating under strict EU emissions standards. These WtE facilities significantly reduce volume of waste to be landfilled and replace some fossil fuel use, aligning with Circular Economy Theory by treating waste as a resource. Finland also leads in biogas technology by using organic waste from

households and is processed in anaerobic digesters to produce biogas (used as renewable fuel) and nutrient-rich digestive that serves as fertilize (Winquist et al. 2021). Such innovations close the loop for organic waste, exemplifying circular principles in action. Additionally, Finnish cities use subterranean garbage container systems and sophisticated sensors to enhance waste collection routes, lowering operational costs and environmental emissions. (Kumar & Verma 2022).

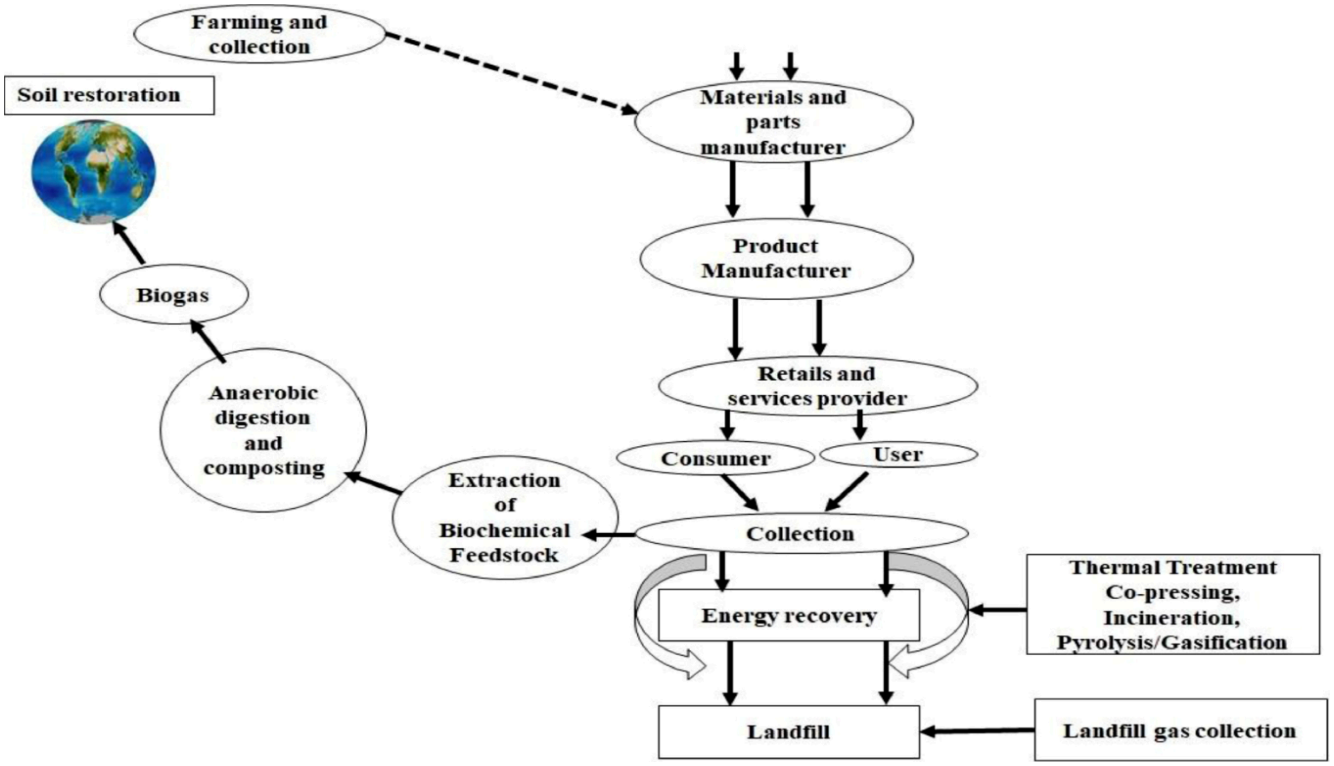

FIGURE 5: Visual Representation Waste-to-Energy Technologies – Methane Capture, Combustion, and Anaerobic Digestion

Similarly, Sweden and Germany utilize advanced infrastructures – Sweden operates 32 WtE plants (even importing garbage to fuel them) with sophisticated pollution controls (Bagheri, Gómez-Sanabria and Höglund-Isaksson, 2024), and Germany has an extensive network of recycling facilities supported by technology for sorting and reprocessing (Blömeke, Rickert, Mennenga, Thiede, Spengler and Herrmann, 2020). These technological solutions result from decades of public and private investment, and they depend on steady funding and technical expertise. They have enabled near-universal waste collection coverage and treatment in those countries. For instance, nearly 100% of Finland's urban waste is collected and processed through formal systems, ensuring little is left in the environment.

Pakistan faces a major technological and infrastructure gap in its solid waste management, contributing to inefficiencies and environmental harm. Currently, much of Pakistan's waste handling relies on low-tech, labour-intensive methods. Collection is often done with open trucks and manual labour, without systematic sorting or compaction. There are few sanitary landfills or engineered dump sites nationwide – instead, most cities dispose of waste in open dumping grounds or crude landfills with no liners or leachate treatment (Roy et al. 2022). These dumps lack gas collection, so landfill methane and leachate freely escape to the environment. Recycling technology is also limited since there are no large-scale automated sorting plants or modern recycling centres in major cities since recycling occurs mainly via the informal sector picking through trash.

Waste-to-energy infrastructure is virtually absent in Pakistan because there are no active mass-burn incineration units for municipal waste, due to high capital costs and technological requirements. Some pilot projects have been proposed in which foreign companies from Germany, Norway, and Thailand have signed memoranda of understanding to establish WtE plants in Lahore, aiming to use 1,000+ tonnes of waste daily to generate electricity (Yana et al. 2025). However, as of this study, these projects remain at the planning stage. The lack of waste treatment facilities means that an estimated 90% of Pakistan's collected solid waste is simply dumped or burned without treatment (Ameen, Anwar-Ul-Haq, Sohail, Akmal, & Siddiqui, 2023). Even basic infrastructure like transfer stations and mechanical workshops for waste vehicle maintenance are inadequate in many municipalities, leading to frequent breakdowns in collection service.

This technological lag is compounded by financial constraints – advanced facilities (recycling plants, WtE) require investments and operational expertise that cash-strapped local governments struggle to muster. The result is that Pakistan's waste system remains stuck in a linear "collect-transport-dump" model with minimal resource recovery, whereas Finland is moving toward a high-tech circular model. Bridging this gap will require not only capital and technology transfer but also capacity building. Encouragingly, circular economy theory is gaining traction in Pakistan's policy circles, which may spur adoption of technologies like composting for organic waste or small-scale biogas units in the nearer term as stepping stones. Until infrastructure catches up, Pakistan will continue to face an uphill battle in managing waste safely and efficiently.

4.3 Public Participation and Stakeholder Engagement

The responsibilities and contribution of the public and stakeholders in context to solid waste management differs sharply between Finland and Pakistan, reflecting broader social and cultural contrasts as well as the application of Stakeholder Theory in practice. In Finland, public participation is a cornerstone of the waste system's success. Household compliance with waste separation is very high (Reijonen et al. 2021) – Finnish residents routinely sort recyclables (paper, glass, metals, plastics) and organics into designated bins due to both legal requirements and environmental awareness. National and local campaigns continuously reinforce these behaviours. For example, community programs like "Waste Week" and the Green Flag environmental education in schools promote recycling habits from an early age. As a result, Finnish society exhibits a culture of recycling and responsible waste disposal. Public hearings and consultations are held when developing waste plans, and NGOs often partner with municipalities on waste reduction initiatives. The private sector is also a key stakeholder part of extended producer responsibility rules, companies must take back or fund the recycling of packaging and products, aligning business incentives with public waste goals.

The Finnish public's high engagement (with an estimated 99% overall "recycling" rate when including energy recovery) is supported by deposit-refund schemes for bottles, eco-labelling, and a general social norm that views wasting as irresponsible. Likewise, Sweden provides a similar example – households separate their waste into numerous categories and have convenient recycling stations within 300 meters of residential areas (Wilhelmsson 2022). In these countries, the public is not a passive recipient of waste services but an active participant, and their cooperation greatly increases the efficiency of the system – a virtuous cycle of stakeholder engagement leading to better performance, which in turn reinforces public trust.

In Pakistan, public participation in waste management is generally low, hampering efforts to improve the system. Waste is often viewed purely as the government's (or municipal cleaners') responsibility. There is little practice of source segregation in households or businesses where typically, all types of waste are mixed and put outside, or even just thrown in the street or empty lots. Awareness of proper waste practices is limited since many citizens are not aware of the benefits of recycling and negative impacts of untreated landfill disposal causing environmental and health complications (Ali et al. 2019).

The education system until recently paid strong attention to waste or environmental ownership, and public campaigns have been sporadic. This lack of awareness translates into behaviours like littering, open dumping, and resistance to measures such as household sorting or fee payments for waste services.

From a stakeholder engagement perspective, Pakistan's waste management has historically been top-down with minimal inclusion of community voices. Government plans have rarely involved residents in decision-making or feedback. Furthermore, an important set of stakeholders – the informal waste pickers (scavengers who collect recyclables from trash) – have been largely excluded from formal processes. These informal workers significantly contribute to whatever recycling does occur (they salvage plastics, metals, paper from dumps and bins to sell to recycling markets), yet they operate without recognition, often in unsafe conditions. Under Stakeholder Theory, their exclusion is a missed opportunity where integrating informal recyclers into the formal system (for instance, in door-to-door collection of recyclables or at sorting facilities) could improve efficiency and social equity.

Pakistani cities have seen some community-based cleanliness drives and NGO-led initiatives (e.g. volunteer cleanup campaigns in Islamabad and beach cleanups in Karachi), indicating growing public interest, but these remain small scale. Cultural factors also play a role – for example, during religious festivals like Eid, local customs dictate specific waste practices (such as proper burial of animal waste) which require engagement with religious and community leaders to manage effectively (Ali et al. 2019). However, systematic inclusion of stakeholders is still lacking. The net effect is that Pakistan's populace is not fully enlisted in the effort to manage waste, in contrast to Finland where broad stakeholder involvement amplifies the system's reach. To move forward, Pakistan will need to invest in public education on waste and create channels for citizen participation (like community recycling programs, school curricula on waste, and complaint/reporting systems for cleanup). The recent emphasis on circular economy by Pakistani officials explicitly calls for private sector and citizen involvement, which if followed through, could start to shift the public's role from passive to active. Engaging the public and all stakeholders is crucial, as effective SWM ultimately requires changes in everyday behaviour and collective action, not just government effort.

4.4 Environmental Outcomes

The differing outcomes of waste management in Finland and Pakistan are most evident in their environmental impacts, highlighting why an effective SWM system is vital for sustainable development. Finland's advanced waste system has led to significantly better environmental performance across multiple indicators. Most notably, landfill minimization in Finland has reduced the classic environmental harms associated with dumpsites. With under 1% of municipal waste now landfilled in Finland and Sweden, both countries have nearly eliminated the production of landfill leachate that can lead to unhealthy groundwater, in parallel to increased production of landfill methane gas. This is a significant accomplishment of reducing methane production since methane, a greenhouse gas 28–36 times more powerful than CO_2 during a 100-year period (Komendantova, 2021). Also, Methane's chemical composition holds more heat in the atmosphere than carbon dioxide (CO_2), making it up to 80 times more potent during a 20-year period after discharge. Reducing methane emissions by 45% by 2030 could help achieve the Paris Agreement's goal of limiting global temperature rise to 1,5°C (UNEP, 2021). Below picture reflects the drastic reduction in landfill in Sweden from the year 1994 till 2023.

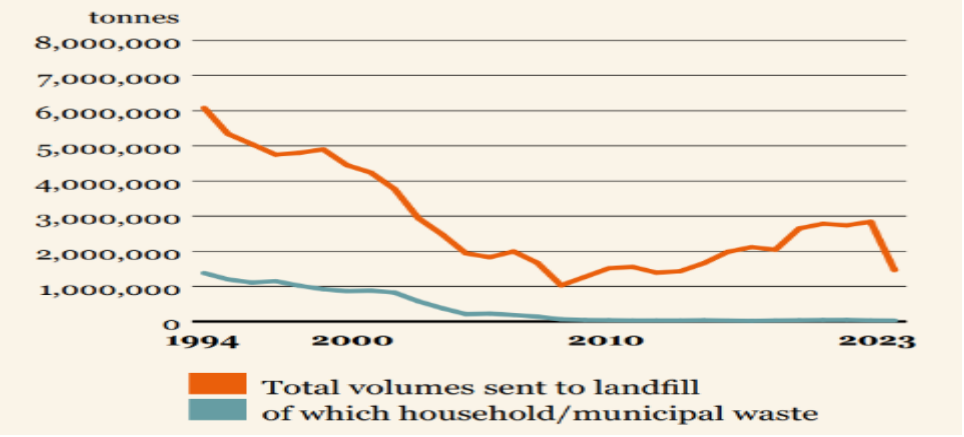

FIGURE 6 – Reduction of landfill waste in Sweden

By diverting waste to recycling and energy recovery, Finland and its peers (like Sweden, which also landfills <1%) have drastically cut these methane emissions, contributing to climate change mitigation. Instead, controlled incineration in WtE plants, while producing CO_2, generates energy that offsets fossil fuel use, and is coupled with air pollution control technology that captures toxins (e.g. dioxins, particulate matter) before they are released. Consequently, air and water pollution from Finland's waste sector is minimal compared to countries with open dumping. High recycling rates also yield positive environmental outcomes by reducing the need for virgin resource extraction – for example, recycling metals and paper saves energy and forests. Finland's push toward a circular economy means

more materials are kept in use or benignly returned to nature (as compost or bio-fertilizer) rather than becoming pollution. Moreover, the cleanliness of Finnish cities, aided by effective waste services, translates to healthier local environments – there is little litter on streets or plastic debris in rivers.

In summary, developed countries' SWM models show that sound waste management directly supports environmental protection – a key tenet of Sustainable Development Theory, which stresses that economic and social progress should not come at the cost of environmental degradation. Pakistan's poor waste management, on the other hand, results in severe environmental and public health consequences. With a large portion of waste not collected or treated properly, the country faces widespread pollution. Open dumpsites, common on the outskirts of cities and even within neighbourhoods, leach contaminants into the soil and groundwater (BMUV, 2023). These dumps often contain mixtures of rotting organic matter, plastics, medical waste, and industrial refuse, creating toxic run-off. During rains, polluted leachate can wash into waterways and many Pakistani cities have noted garbage clogging drains and causing urban flooding, as well as contamination of rivers and nullahs with plastics and other debris. The air quality is also affected because there are no enforced controls, it is routine for waste to be openly burned, either by individuals trying to reduce trash volume or by cleanup crews at dumps.

Open burning emits particulate matter, black carbon, and hazardous gases, contributing to urban smog and respiratory problems for residents. It also releases greenhouse gases without energy recovery, a lose-lose outcome. The environmental toll is evident in statistics which shows that around 60–70% of municipal waste in only gathered in Pakistani cities (Nadeem et al. 2023), while the rest is left in the environment from where the waste is collected, almost all is eventually dumped or burned untreated. As a result, soil and water contamination is on the rise, and one can observe heaps of refuse providing breeding grounds for disease vectors. Studies note that open dumps in Pakistan serve as breeding grounds for flies and mosquitoes, directly linking mismanaged waste to public health issues like malaria, dengue fever, and other vector-borne diseases. Indeed, uncollected garbage and blocked drains were contributing factors to recent urban dengue outbreaks and flooding in Karachi.

The public health burden of this pollution is substantial since different diseases like frequent gastrointestinal illnesses, skin infections, and respiratory ailments in densely populated poor areas are exacerbated by the presence of decomposing waste nearby. The link between the environment and health emphasises the importance of sustainable development practices. Pakistan's existing method of

handling solid waste is slowing progress on critical goals like good health (SDG 3), clean water (SDG 6), and sustainable cities (SDG 11). Furthermore, the greenhouse gas emissions from Pakistan's waste sector, primarily methane from open dumps, are a growing concern as the country urbanizes. Pakistan's Nationally Determined Contributions (climate commitments) recognize waste as a source of emissions to be addressed, but without concrete improvements in waste management, those climate goals remain out of reach. In essence, the comparison is stark where Finland's model yields cleaner air, land, and water – turning waste into an input for energy and recycling – whereas Pakistan's failing system turns waste into an expanding source of pollution and risk.

Addressing this is not just an environmental necessity but also a social justice issue, as the poorest communities in Pakistan often suffer the worst exposure to waste pollution. It reinforces the need for Pakistan to move toward a more sustainable, circular approach to waste, as environmental harm from the status quo is unsustainable.

4.5 Economic and Financial Aspects

Solid waste management also has important economic dimensions, and here again Finland and similar countries derive economic benefits from efficient systems, whereas Pakistan incurs costs and missed opportunities under its struggling system. Finland's waste management is characterized by substantial upfront expenditures that result in long-term economic advantages (Lubongo et al. 2024). The country spends significantly on waste infrastructure and operations – costs are covered through a combination of municipal budgets, waste fees paid by households, and producer responsibility contributions. This ensures the system's financial sustainability. While managing waste properly is not cheap, Finland avoids many hidden costs of poor waste management (such as healthcare costs from pollution-related diseases, environmental cleanup costs, and lost tourism or property value due to filthy environments).

In economic terms, Finland's approach turns waste into value addition in which the recycling industry and waste-to-energy sector contribute to the economy by creating green jobs and energy outputs. Recycling companies, compost facilities, biogas plants, and incinerators employ engineers, technicians, and workers – a sector of the economy that wouldn't exist without an emphasis on waste recovery (Blömeke et al. 2020). For example, waste-to-energy process can be effective in lot of ways as it reduces waste disposal expenditures in parallel to production of electricity and heating that have

market value and further contributing to Finland's energy mix and energy security (IEA, 2023). Similarly, materials recovered via recycling (metals, paper pulp, plastics granules) become feedstock for manufacturing, reducing the need for imports of raw materials. Below figure reflects step by step procedure for Waste management and utilizing it as means of recovering the raw materials as explained earlier.

Germany's experience is telling that its circular economy sector (waste management and recycling) has become a multi-billion-euro industry and an exporter of technology, illustrating the economic payoff of investing in waste systems. Moreover, extended producer responsibility in Europe shifts some financial burden off municipalities – producers internalize the cost of end-of-life product management, which economically incentivizes them to manufacture products that are easier to recycle and produce less waste (OECD, 2025).

Finland and its peers also typically impose landfill taxes and incineration fees that encourage waste diversion while generating revenue that can be reinvested in the system (Lubongo et al. 2024). Western countries with high landfill taxes tends to have low landfill rates. As an example, Sweden and Finland Lanfill tax rates are quite high and it reduces landfill rates percentage to near 1% in Sweden and near 20% in Finland. Below graph is an illustration of these statistics.

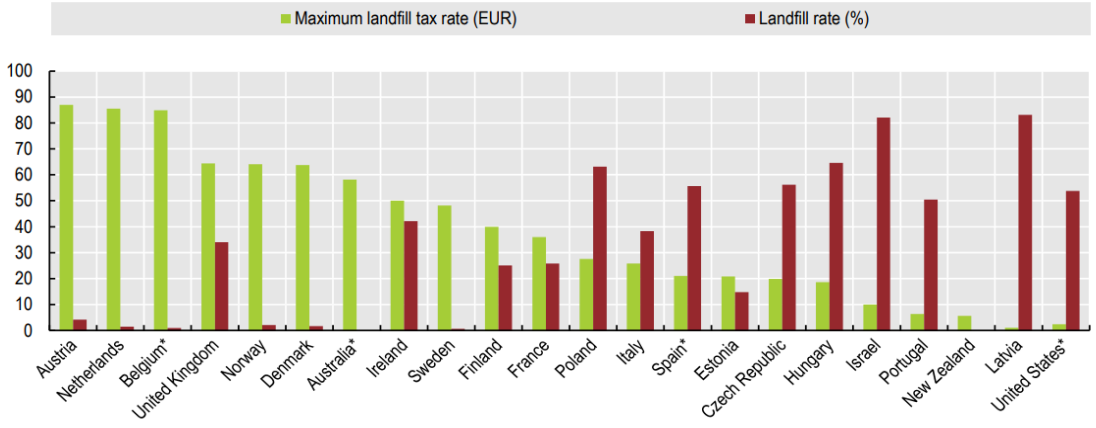

FIGURE 7 – Landfill taxes and rates by country (OECD, 2017)

In sum, the "circular economy" model in Finland is not only an environmental concept but also an economic strategy since it aims to decouple economic growth from waste generation, create new business opportunities in recycling and remanufacturing, and save costs associated with resource extraction and environmental damage. This aligns well with Circular Economy Theory, which posits that keeping resources in use and designing out waste can drive innovation and economic efficiency.

Pakistan’s waste management, by contrast, imposes a net economic burden on society, and the country has yet to tap into the potential economic value of its waste. The direct costs of SWM in Pakistan – collection, transport, and disposal – are primarily borne by municipal governments. However, most municipal bodies are severely under-resourced while waste management often consumes a large portion of their budget yet remains underfunded relative to need. It is common for Pakistani cities to allocate funds for waste collection contracts or municipal staff salaries, but little for investing in better infrastructure. Consequently, the system remains stuck in a costly and inefficient mode. For instance, hauling uncompressed waste to distant dumps is fuel-inefficient, and lack of recycling means more volume to manage.

The financial constraints lead to situations like unpaid garbage workers, broken-down trucks, and overflowing dumpsites, which in turn necessitate emergency clean-ups or public health interventions that cost additional money. Meanwhile, the external costs – health care for populations affected by waste pollution, environmental remediation, and loss of productive urban land taken up by expanding dumps – are not accounted for in budgets but are very real economic drags (Ali et al. 2019). On the other hand, there is significant untapped economic opportunity in Pakistan’s waste. Everyday millions of tons of recyclables (plastics, metals, paper, glass) are disposed of that could be raw material for industries. A relatively small informal recycling trade does exist tens of thousands of informal workers recover and sell recyclables, creating a downstream economy of scrap trading and small-scale recycling. However, because this is not formally supported, it remains limited in scope and the value addition is low (e.g., waste pickers earn very little for the materials they collect due to middlemen and lack of processing facilities).

If Pakistan invested in sorting and recycling facilities, those materials could yield much higher economic returns and jobs, essentially creating a recycling industry on par with those in Europe or China (Ali et al. 2019). Similarly, organic waste (which makes up about 30% of Pakistan’s waste stream) is mostly wasted as it could be composted or digested to produce fertilizer and biogas, which would support and energy needs. A World Bank assessment noted that turning waste into energy or compost in developing countries like Pakistan could create value and reduce climate emissions simultaneously (World Bank, 2022). To illustrate the opportunity cost, Karachi’s ~16,000 tonnes of waste per day, if efficiently managed, could generate significant electricity (through WtE) or organic composite for farming. Instead, money is spent simply pushing this waste into dumps.

There have been some moves towards realizing economic benefits – for example, the Pakistani government, with foreign partners, has been exploring waste-to-energy which could attract investment and create power (as indicated by MoUs in Lahore). Additionally, efforts to involve the private sector in waste services (like contracting international waste management firms in cities) show recognition that efficiency and expertise can save costs in the long run. Yet challenges remain since the cost of advanced technology is high (incineration plants can cost hundreds of millions of dollars), and without subsidies or external funding, municipalities alone cannot afford them (Ali et al. 2019). Moreover, low willingness-to-pay among the public for waste services means revenue generation is difficult – many Pakistani residents pay no garbage fee, making the system entirely tax-funded. In economic terms, Pakistan is stuck in a vicious cycle where insufficient funding leads to poor service, which leads to low public trust and willingness to pay, which in turn perpetuates insufficient funding.

Breaking this cycle might involve demonstrating the economic value of a better system (e.g. pilot projects where waste collection fees fund recycling that creates local jobs, etc.). It is increasingly acknowledged by policymakers in Pakistan that moving toward a circular economy could bring substantial economic gains. Adopting resource recovery by Pakistan would help reduce such losses due to resource wastage and environmental degradation. To conclude, the economic contrast is evident where Finland views this as an investment in upstream sustainability, where its fiscal and development dividends come due to its resources and energy recovered, whereas Pakistan unfortunately considers it a sunk municipal cost. Over time, Pakistan’s economic outcomes in the waste sector could be improved through adopting key elements of Finland’s model such as EPR schemes to shift costs to producers or public private partnerships for waste facilities.

5 CONCLUSION

The comparative study of solid waste management systems in Finland and Pakistan, supported by interviews with key stakeholders in Pakistan's waste sector, reveals significant differences in practices, outputs, and governance. Finland's approach is based on long-term planning, consistent policies, public participation, and a strong commitment to sustainability through the circular economy. Waste is viewed as a resource, and good stakeholder collaboration, investment in technology, and regulatory enforcement have resulted in high recycling rates, low landfill use, and active waste-to-energy systems.

On the other hand, Pakistan's current system continues to struggle with issues related to public behaviour, governance, and infrastructure. Interviews with five SME representatives highlighted that both public and private sector players face considerable operational and systemic challenges. Policy inconsistencies, obsolete legislation, and significant infrastructure deficiencies, such as inadequate waste disposal sites and a lack of recycling facilities, were also mentioned by public sector officials. Political unpredictability and low law enforcement intensify these problems, making even detailed programs less effective.

Private sector insights also noted a lack of government support, low public awareness, and financial barriers. One private company in Pakistan mentioned about difficulties in extending their customer base due to customers' unwillingness to pay for waste handling and limited availability of recycling facilities. Another entrepreneur emphasised the importance of improved coordination with local authorities and noted a lack of tax incentives as a barrier to SWM innovation. It has been observed that involving all stakeholders including government, corporations, and communities is critical to driving systemic change.

Finland's approach offers important insights for dealing with these issues. A robust national policy framework with defined responsibilities, recycling targets, and accountability is essential. Pakistan's recent efforts like improved waste recycling rate (21%) in Lahore shows willingness to establish a circular economy policy, but stronger implementation and enforcement tools are desperately needed. Finland's extended producer responsibility (EPR) rules, which hold manufacturers accountable for post-consumer waste, can be applied in Pakistan to stimulate innovation from the start.

In parallel, although Pakistan cannot immediately duplicate Finland's advanced technological infrastructure, it can start with solutions that are appropriate for the given environment. Investing in controlled landfills, composting facilities, and small-scale biogas digesters for organic waste can produce rapid results. International partnership with countries such as Finland could help with technology transfer and capacity building. Local business interviews reveal a willingness to collaborate with international investors and innovate Solid waste management system in Pakistan.

One of most crucial aspect includes public awareness and participation which are essential. Recycling of solid waste has become widespread in Finland because of outreach and demonstrating initiatives. To foster an atmosphere regarding waste management, Pakistan can launch educational environmental programs, national campaigns, and community engagement that involve local influencers. Stakeholders in Pakistan emphasised that incorporating both the public and informal waste sectors, notably through formalised partnerships with local entrepreneurs and informal waste collectors, might greatly improve collection and recycling results.

It is worth mentioning that Pakistan must regard waste management as an investment in public health, climate mitigation, and job creation, rather than an economic burden. Finland's mixed funding strategy, which includes user fees, taxes, and private investment for waste handling, serves as a model. The gradual implementation of user fees in metropolitan areas, combined with enhanced services, has the potential to increase cost recovery and public acceptance. Interviewees agreed that private-public partnerships may improve service delivery, particularly if supported by financial and tax incentives.

Furthermore, Pakistan should develop data systems to monitor generated waste and treatment, as Finland has successfully done. Accurate data helps evidence-based policy and increases openness. Stakeholders in Pakistan have identified a lack of reliable information as an obstacle to successful planning and evaluation. Most importantly, Finland's experience demonstrates that sustained work, policy consistency, and stakeholder participation can result in significant gains. Sweden and Germany are two examples of nations that show that waste systems may be transformed from subpar to highly effective within decades. The objective for Pakistan should be to phase out open dumping gradually and implement organised recycling targets. For example, deposit-return schemes for plastic bottles or funding for reuse and repair firms might both cut trash and create green jobs.

While the gap between Pakistan and Finland is still huge, the ideas of sustainable and inclusive waste management are universal. The combination of Sustainable Development Theory, Circular Economy Theory, and Stakeholder Theory into this analysis emphasises that success necessitates not only on technical solutions but also governance reforms, stakeholder inclusion, and public support. Speaking with sector representatives in Pakistan reveals a mixture of dissatisfaction with the limitations that now exist and hope for change if policies are supported by institutional accountability, financial support, and political will.

Finally, Pakistan has begun to recognise the necessity of sustainable waste management through recent policy developments and pilot efforts. Using the lessons learnt from nations such as Finland offers a path forward for development. With strategic investments, stakeholder collaboration, and public involvement, Pakistan can overhaul its waste management system to promote environmental protection, public health, and economic growth, resulting in not only cleaner cities, but also a healthier and more resilient future.

5.1 Limitations and Future Study

This research has several limitations that should be considered and detailed further. First, it relies primarily on secondary data and published reports for comparing Finland and Pakistan, which may lead to inconsistencies due to differing data collection methods and years. The accuracy and completeness of available data (e.g., waste generation rates, recycling statistics) vary by country. For instance, informal recycling in Pakistan is not well documented, potentially understating Pakistan’s recycling figures. Second, the scope was limited to comparing a few countries – Finland as the main case, with Sweden and Germany as supporting examples. This focused comparison may not provide the full spectrum of waste management practices in other developed or developing countries. Third, the analysis is largely qualitative, while it identifies differences in policies, technologies, and outcomes, it does not provide a quantitative model of how implementing Finland’s practices would statistically impact Pakistan.

Contextual factors (cultural, economic, political) limit direct transferability of solutions, and this study does not account for all such factors. Additionally, no primary field research (such as interviews with Pakistani waste officials or community surveys) was conducted, which means the study might

overlook on-the-ground nuances or recent unreported developments in Pakistan. Future research could address these gaps by conducting field studies in Pakistani cities to gather primary data on waste practices and stakeholder perspectives. Comparative studies involving a broader set of countries – including emerging economies that have improved their waste management (such as Malaysia or Turkey) – would also provide a richer basis to formulate recommendations for Pakistan. Finally, a more detailed economic analysis (cost-benefit or feasibility studies of specific interventions) would be a valuable next step to build on the strategic insights of this chapter.

5.2 Conflict of Interest

The author confirms that there is no conflict of interest in the execution of this research. This comparative study was conducted impartially, without any financial, professional, or personal stake that could have influenced the analysis or conclusions. No funding was received from organizations or agencies in Finland, Pakistan, or elsewhere that might benefit from portrayals of waste management systems. The research was undertaken as an academic exercise, and the author’s aim was to present an objective comparison grounded in evidence and theory. To avoid bias, data were gathered from a balanced mix of sources, including international reports, peer-reviewed articles, government documents, and independent case studies. The inclusion of multiple countries (Finland, Pakistan, Sweden, Germany) was designed to provide a well-rounded perspective rather than advocate for one country’s approach in isolation.

The author has not been employed by or contracted with any waste management companies, government waste departments, or advocacy groups during the period of this research. Additionally, efforts were made to maintain neutrality in language. For example, describing both the strengths and weaknesses of each country’s system to ensure that the analysis does not favour one side due to any preconceived allegiance. While the author is academically interested in sustainable development and may personally support improved waste management globally, this normative stance is informed by widely accepted scientific and policy consensus, not by any undue influence from external parties. All collaborators or advisors on this thesis (such as academic supervisors) similarly have no vested interests in the outcomes.

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APPENDIX 1

Questions about policy framework & infrastructure.

1. What kind of waste management policy rules do you follow in your company?
2. What do you think about the policy framework given by the government in your area and what kind of challenges does a company face because of them?
3. Are there any regulatory gaps in your opinion which do have a negative influence on waste management operations? If yes, what changes would you recommend?
4. In your opinion, how effective is the National waste management framework at national and municipal levels? What is missing from a company point of view?
5. What makes it challenging for your company to adhere to laws governing waste management?
6. What is the main infrastructure-related issues to be addressed for effective waste management?
7. In your opinion, can new technological advancement in western world could improve the way that waste is collected, recycled, or disposed of in Pakistan?
8. What is lacking in Pakistan when we address systems for waste collection such as recycling centers or garbage collection networks?

Questions about economic limitations & public engagement and awareness.

9. What are the economic resources of your company? From where do they come?
10. In your opinion, if government provides any financial incentives or subsidies to private sector companies, can that help to improve waste management situation in Pakistan?
11. What kind of limitations a company faces in Pakistan when it comes to promote appropriate garbage disposal among the public?
12. What initiatives, collaborations or campaigns has your organization implemented to promote waste disposal practices among the public?
13. Does your company collaborate with schools or local media to spread awareness?