Ministry of Climate Change
and Environmental Coordination
Government of Pakistan

SPAR6C
Supporting Preparedness for
Article 6 Cooperation

Sectoral Study

Decarbonization of Pakistan's Waste Sector: Technologies, Policy Options and Carbon Market Opportunities

GGGI
UN environment programme
copenhagen climate centre
GFA
The Federal Government
IKI INTERNATIONAL CLIMATE INITIATIVE

Acknowledgements

This report is a publication from the Pakistan work package of the Supporting Preparedness for Article 6 Cooperation (SPAR6C) Program. SPAR6C program is a five-year initiative funded by the German Federal Government, formerly by the Federal Ministry for Economic Affairs and Climate Action (BMWK), through the International Climate Initiative (IKI). The program covers Colombia, Pakistan, Thailand and Zambia and provides decision support to government counterparts on Article 6 strategy and governance frameworks, capacity building for private sector and technical assistance to identify and prepare mitigation activities which could serve as the basis for Article 6 transactions under the Paris Agreement. The government counterpart for SPAR6C Pakistan is the Ministry of Climate Change and Environmental Coordination. The support in Pakistan is led by the UNCEP-Copenhagen Climate Centre (UNEP-CCC) and supported by GFA Consulting Group; Global Green Growth Institute (GGGI) is the Consortium lead and provides overall coordination and administrative support.

Author

Dr. Karima Hamouda, GFA Consulting Group

Dr. Nasir Javed, Senior Consultant

Reviewers

Xianli Zhu, UNEP Copenhagen Climate Centre

Urwah Khan, UNEP Copenhagen Climate Centre

Denis Machnik, UNEP Copenhagen Climate Centre

Ministry of Climate Change and Environmental Coordination, Pakistan

Design and layout contribution

Mavra Bari

Maham Shahzadi

Photo Credits

Cover © Alison Teal from Alison's Adventures / Caters News
Page 24: © Author's own image
Page 46: © Hafsa Yasin and Muhammad Usman (2017), ESP
Page 47: © Usman et al. (2017), ESP

Table of content

List of figures

List of tables

List of abbreviations

ADB	Asian Development Bank
CDKN	Climate and Development Knowledge Network
CDM	Clean Development Mechanism
DBOT	Design-Build-Operate and Transfer
ETF	Enhanced Transparency Framework
GCCS	Gas Collection and Control Systems
GDP	Gross Domestic Product
GHG	Greenhouse gases
HCWM	Healthcare waste management
IPCC	Intergovernmental Panel on Climate Change
KP	Khyber Pakhtunkhwa
LFG	Landfill Gas
MBT	Mechanical-Biological Treatment
MoCC& EC	Ministry of Climate Change and Environmental Coordination
MRV	*Monitoring, Reporting and Verification*
NAP	National Adaptation Plans
NDC	Nationally Determined Contributions
OMGE	Overall Mitigation of Global Emissions
PHED	Public Health Engineering Department
SBSTA	Subsidiary Body for Scientific and Technological Advice
SDGs	Sustainable Development Goals
SSO	Source-Separated Organics
SSWMB	Sindh Solid Waste Management Board
SWDS	Solid waste disposal sites
SWEEP	Sindh Waste Efficiency and Environmental Improvement Project
TNA	Technical Needs Assessment
UNFCCC	United Nations Framework Convention on Climate Change
WACS	Waste Characterization Studies
WSSCs	water supply and sanitation companies

Executive Summary

Global waste management faces enormous challenges. Projections for the coming decades indicate a sharp increase in the volume of municipal solid waste, which today is still largely uncontrolled or ends up in landfills. The rise in population, economic growth and high rates of urbanization are just some of the reasons for increasing rates of waste and its associated GHG emissions. Current approaches to materials recovery and thermal treatment are not scaling fast enough with the growing amounts of waste generated. Adding to the difficulty is the fact that data on the amount of waste produced as well as its methods of treatment, and thus its GHG emissions, are often unavailable or incomplete.

Estimates suggest that a majority of Greenhouse Gas (GHG) emissions from the waste sector come from the anaerobic decomposition of organic waste in landfills, where methane is produced - a very potent GHG. The incineration of waste further contributes to emissions of carbon dioxide and other noxious gases. Other sources of GHG emissions in this sector include wastewater treatment and industrial waste processing. Although proper waste management practices and technology can offset some GHG emissions, their implementation is too slow, and funding is often lacking.

The urgency to account for and mitigate global GHG emissions lies at the heart of the Paris Agreement. Under the Paris Agreement, signatory states have committed to limiting the increase in average global temperature compared to pre-industrial levels to well below 2°C and preferably to 1.5°C by the middle of the century. To achieve this, countries are tasked to define and submit ambitious mitigation goals as their Nationally Determined Contributions (NDCs). Due to the lack of data and its associated challenges to implement changes, the waste sector often is only covered insufficiently or without specific mitigationgoals in NDCs. The 2021 updated NDC by Pakistan reflects a more determined commitment to reduction of GHG emissions and improvements in waste management practices than its prior NDC. The country has set more ambitious targets for waste reduction, recycling, and implementation of sustainable waste management technologies. Thus, a major aspect of the updated NDC focuses on promoting principles of circular economy, emphasizing zero waste generation and maximum resource recovery. Additionally, the government of Pakistan aims at increasing investments in waste-to-energy projects and enhance the efficiency of waste collection and disposal.

This sectoral study on the Decarbonization of Pakistan's Waste Sector, focusing on Technologies, Policy Options and Carbon Market Opportunities, is part of the Supporting Preparedness for Article 6 Cooperation (SPAR6C), a project funded by the International Climate Initiative (IKI). The report provides an assessment of the waste management sector in Pakistan, its GHG emissions, future scenarios, decarbonization technologies, carbon market opportunities, and policy recommendations. It pinpoints that methane emissions from landfills are an immense source, largely due to the inadequacy of waste management infrastructure. While there are decarbonization technologies available, such as methane capture and composting, adoption has been too slow. Under a business-as-usual scenario and with no additional interventions, GHG emissions in Pakistan will increase by 2040. The report further shows the potential of carbon market approaches in financing decarbonization efforts by providing new incentives for emission-reductions. But obstacles remain, particularly the complexities of the carbon market and its regulatory frameworks. To utilize carbon finance instruments, meaningful policies and regulations can give planning security, support investments in infrastructure and contribute to emission reductions and therefore a more sustainable waste management sector in Pakistan.

1. Background

1.1 Importance of addressing GHG emissions in waste management

In 2019, biogenic methane accounted for 94% of waste emissions, primarily produced by the decomposition of organic materials such as food, garden, wood, and paper waste[1]. Although waste makes up a small portion of the global GHG emissions, biogenic methane's warming effect is 25 times potent as that of carbon dioxide[2]. In developing countries, the waste sector's greenhouse gas (GHG) emissions have seen significant increases over the past decade. For instance, the World Bank (2018) estimates that waste-related GHG emissions in low- and middle-income countries grew by approximately 15% between 2010 and 2020[3], reflecting the challenges posed by rapid urbanization and insufficient waste management infrastructure. Specifically, methane emissions from waste—primarily due to the decomposition of organic material in unmanaged landfills—account for a substantial portion of these emissions. In Bangladesh, for example, methane emissions from landfills have increased by about 20% in the past decade, contributing significantly to the country's overall GHG emissions[4]. Similarly, in sub-Saharan Africa, waste-related emissions have risen by over 12% during the same period, driven by a lack of formal waste management systems and the prevalence of open dumping[5]. These numbers highlight the growing contribution of the waste sector to GHG emissions in developing regions and underscore the need for targeted interventions to curb this trend.

Implementing measures to reduce, recycle, and recover larger amounts of organic waste, alongside enhancing services and infrastructure, will present multiple benefits. These actions will facilitate the transition to a circular economy, create new jobs and business opportunities, enhance responsible waste disposal practices, and offer cost savings for both households and businesses.

While waste accounts for a relatively small share of Pakistan's national greenhouse gas emissions, the country's efforts to move toward a low-emissions future will drive broader transformations and bring multiple benefits, including emissions reductions in other sectors. The country is aiming to build a society where waste is kept to a minimum. focuses on preventing waste generation and reusing discarded organic materials like food, garden waste, paper, cardboard, and timber within a circular economy framework. In this envisioned future, waste emissions will be reduced, captured, and repurposed for beneficial uses wherever feasible—for example, by harnessing biogenic methane from landfills to produce electricity. Shifting the country's perception of waste, coupled with improvements in services and waste infrastructure, will empower communities and businesses to strengthen their resilience.

Effective waste management practices, such as recycling, composting, and waste-to-energy processes, can substantially reduce GHG emissions. For instance, recycling can lead to significant reductions in emissions by replacing the need for energy-intensive virgin material production. Similarly, waste prevention, particularly in food waste, can also lower emissions substantially[6].

Additionally, the adoption of comprehensive waste management strategies, such as the transition to a circular economy, not only mitigates GHG emissions but also offers significant economic benefits. For example, the Global Waste Management Outlook highlights that moving

[1] https://environment.govt.nz/publications/aotearoa-new-zealands-first-emissions-reduction-plan/waste/

[2] Retrieved from https://www.ipcc.ch/assessment-report/ar5/.

[3] World Bank. (2018). What a waste 2.0: A global snapshot of solid waste management to 2050.

[4] Climate & Clean Air Coalition. (2020). Waste sector: Mitigating methane emissions in Bangladesh.

[5] United Nations Environment Programme. (2021). Waste management in developing countries: Trends and challenges

[6] https://www.epa.gov/homeland-security-waste/waste-management-planning-mitigate-impact-climate-change

towards zero waste and circular economy models could lead to a net economic gain globally, as well as reduce the hidden costs associated with pollution, health impacts, and climate change (UNEP- UN Environment Program, 2024)[7].

Efforts to reduce waste emissions must prioritize organic waste. This includes all materials containing degradable organic carbon, such as food scraps, garden clippings, paper, cardboard, and timber. Those efforts should include wastewater in the future.

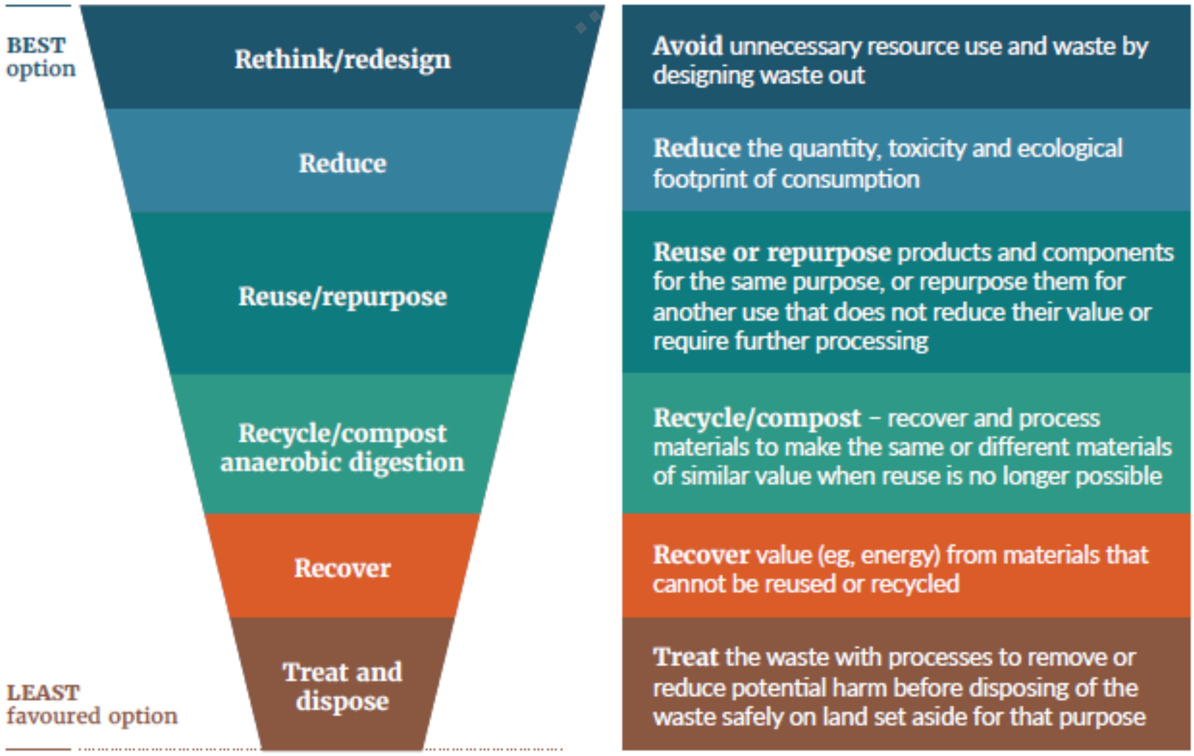
Plans to reduce emissions are categorized according to the waste hierarchy:

► Avoid and Reduce: Minimize the production of organic waste.

► Recycle: Divert organic waste for beneficial uses, preventing it from reaching landfills.

► Recover: Mitigate emissions from organic waste in landfills by capturing biogenic methane for energy production.

Figure 1: Waste hierarchy (Source: Government of New Zealand, 2022 [8])



Proper waste management is directly linked to several SDGs, including those related to clean water and sanitation (SDG 6), sustainable cities (SDG 11), responsible consumption and production (SDG 12), and life below water (SDG 14). These goals emphasize the importance of minimizing waste generation and ensuring sustainable practices to protect ecosystems and improve public health[9].

Effective waste management practices can reduce emissions and play a vital role in achieving climate goals. In this context, Article 6 of the Paris Agreement provides a framework for countries to cooperate in reducing emissions through market and non-market mechanisms. By linking efforts in the waste sector with the opportunities presented by Article 6, countries can enhance their climate action and achieve more sustainable and effective outcomes.

---

7 https://www.unep.org/resources/global-waste-management-outlook-2024
8 https://environment.govt.nz/publications/aotearoa-new-zealands-first-emissions-reduction-plan/waste/
9 https://link.springer.com/article/10.1007/s00506-024-01034-7

1.2 Overview of the Paris Agreement and its Relevance to the Waste Sector

Article 6 of the Paris Agreement facilitates voluntary international cooperation to achieve the emission reduction goals outlined in Nationally Determined Contributions (NDCs). This provision enables countries to transfer carbon credits, which are earned from reducing greenhouse gas (GHG) emissions, to assist other nations in meeting their climate objectives[10]. Specifically, Article 6.2 provides a framework for trading GHG emission reductions, known as "mitigation outcomes" between countries. Article 6.4, akin to the Clean Development Mechanism (CDM) of the Kyoto Protocol, sets up a system for trading these emission reductions under the oversight of the Conference of Parties, the main decision-making body of the UN Framework Convention on Climate Change. Additionally, Article 6.8 addresses non-market approaches to mitigation and adaptation, fostering cooperation through financial support, technology transfer, and capacity building without involving the trading of emission reductions[11].

Understanding Article 6 of the Paris Agreement in the context of the waste sector involves exploring how international cooperation mechanisms can help reduce greenhouse gas (GHG) emissions from waste management activities.

Article 6 of the Paris Agreement facilitates international cooperation to meet climate goals through two primary mechanisms:

1. **Article 6.2**: Allows countries to trade Internationally Transferred Mitigation Outcomes (ITMOs) to achieve their Nationally Determined Contributions (NDCs).
2. **Article 6.4**: Establishes a centralized mechanism to promote sustainable development and support emissions reduction projects.
3. **Article 6.8**: This cooperation aims to reinforce the Parties' nationally determined contributions in relation to both mitigation and adaptation strategies. There is equitable access and allocation of financial and technical resources to developing countries within the provisions of Article 6.8, which is key to developing a co-operative architecture that enhances climate ambition under the Paris Agreement[12].

What is Article 6 readiness?

Article 6 readiness can be broadly understood as the steps which any given nation needs to undertake or the institutional frameworks it is required to create in order to gain the maximum from international market-based engagement envisaged under Article 6 of the Paris Agreement, although there is no common understanding. It is also awareness and readiness to explore non-market options provided by Article 6.8.

1.3 Introduction to Article 6 and its Implications for Waste Management in Pakistan

The mandate of the Paris Agreement and the COP21 Decision requires Parties to: (a) establish guidance for cooperative approaches as outlined in Article 6.2; and (b) formulate the rules, modalities, and procedures for the new mechanism specified in Article 6.4. These negotiations

[10] https://www.worldbank.org/en/news/feature/2022/05/17/what-you-need-to-know-about-article-6-of-the-paris-agreement
[11] https://www.worldbank.org/en/news/feature/2022/05/17/what-you-need-to-know-about-article-6-of-the-paris-agreement
[12] Operationalise Article 6.8 for Non-Market Approach to Real Solutions & Real Zero: www.demandclimatejustice.org

are being conducted under the Subsidiary Body for Scientific and Technological Advice (SBSTA)[13].

Under Article 6.2, cooperative approaches allow countries to take a decentralized path to achieving their Nationally Determined Contributions (NDCs). This system permits Parties to transfer and use Internationally Transferred Mitigation Outcomes (ITMOs) based on international guidelines currently being formulated by the Conference of the Parties serving as the Meeting of the Parties to the Paris Agreement (CMA). In contrast, the Article 6.4 Mechanism provides a centralized crediting tool that all Parties can use to help meet their NDCs and support sustainable development[14].

Several critical issues are currently being discussed regarding both international routes in Article 6. For Article 6.2 and Article 6.4, key aspects include environmental integrity, ITMO accounting, ambition, and corresponding adjustments, particularly if units under the Article 6.4 Mechanism are also considered ITMOs. Additionally, in the context of Article 6.4, Parties are negotiating the treatment of additionality and baselines, the application of the overall mitigation of global emissions (OMGE) concept[15], and a potential transition from the Clean Development Mechanism (CDM).

Article 6 of the Paris Agreement provides opportunities for Pakistan's waste management sector to enhance its practices and contribute to national and global climate goals.

Financial Incentives and Investment: Article 6 facilitates international cooperation and carbon credit trading, which can attract foreign investment into Pakistan's waste management sector. Projects that effectively reduce GHG emissions, such as improving landfill operations, implementing recycling programs, and developing waste-to-energy plants, can generate carbon credits[16]. These credits can then be sold to other countries, providing a new revenue stream and financial support for further advancements in waste management[17]. The absence of a structured carbon market in Pakistan hinders the economic viability of waste treatment projects, as there is insufficient revenue flow to support them. A carbon market could provide financial incentives by allowing waste management initiatives to monetize the reduction of greenhouse gas emissions through carbon credits. According to the Asian Development Bank (ADB)[18],[19], improved waste management, coupled with the development of carbon pricing mechanisms, could not only enhance sustainability but also help Pakistan meet its climate goals under the Paris Agreement. Integrating the waste sector into carbon markets would create a much-needed revenue stream for these projects, addressing both financial and environmental challenges.

Technology Transfer and Capacity Building: Under Article 6.8, there are provisions for non-market approaches, including finance, technology transfer, and capacity building. Pakistan can benefit from international partnerships that provide access to advanced waste management technologies and technical expertise[11]. This will help in modernizing waste processing facilities and improving efficiency, which is crucial for managing the growing waste problem in urban areas like Karachi and Lahore.[20]

---

13 Opportunities for the Implementation of Article 6 of the Paris Agreement in the Solid Waste Sector in Peru

14 Howard, A., et al. Features and Implications of NDCs for Carbon Markets, in: Swedish Energy Agency (2017). Reports on international cooperation for climate change mitigation.

15 The concept of OMGE: https://www.goldstandard.org/publications/how-could-the-concept-omge-be-operationalised

16 https://www.weforum.org/agenda/2023/05/article-6-of-the-paris-agreement-how-it-can-accelerate-the-transition-to-net-zero/

17 https://www.worldbank.org/en/news/feature/2022/05/17/what-you-need-to-know-about-article-6-of-the-paris-agreement

18 https://www.adb.org/publications/waste-sector-inclusion-revised-ndcs-pakistan

19 https://www.adb.org/publications/solid-waste-management-pakistan-road-map

20 https://climatefocus.com/publications/opportunities-implementation-article-6-paris-agreement-solid-waste-sector-peru/

Enhanced Mitigation Efforts: Article 6 can help Pakistan enhance its mitigation efforts by providing financial and technical resources. For instance, projects aimed at reducing methane emissions from landfills or converting waste into renewable energy can significantly lower GHG emissions. These projects can also contribute to Pakistan's commitments under its Nationally Determined Contributions (NDCs).

2. Overview of the waste sector and its GHG emissions - current status

2.1 Overview of the Municipal Solid waste management sector in Pakistan Introduction

Efficient waste management is necessary for public health, environmental sustainability and socioeconomic development in the society. The country is undergo-ing a persistent process of urbanisation, industrialisation and population growth which does not map with the development in its solid waste management (SWM) systems and practices functionality rendering SWM as a better primary concern for Pakistan. The failures of many local, provincial and nati onal initiatives, reforms and policies have been well documented over the decades yet a resolution to achieve sustainable waste management has proven elusive. The sector grapples w ith lack of adequate infrastructure, weak institutional capacities and regula-tory compliance issues. The Municipalities face significant challenges in effectively managingsolid waste in c-ities, largely due to constraints such as limited funding, the absence of comprehensive rules, regulations, and standards, insufficient knowledge and expertise on the subject, as well as a shortage of collection vehicles and equipment21.

To help reduce the risks of potential acute crises and long-term environmental impacts on groundwater and public health, it is important for the government to consider prioritizing waste management and showing strong political commitment in this area.

Effective waste management is expensive, often comprising 20%–50% of municipal budgets. Operating this essential municipal service requires integrated systems that are efficient, sustainable, and socially supported[22].

NDCs and Paris Agreement: Waste sector contributes less than 5% emissions at the national level, Waste sector contributes less than 5% emissions at the national level, but this is likely to increase with growing waste generations and if the current practices in waste management continue. The GHG emission estimate as of 2018 for waste sector is 21.72 MT of CO_2,compared to estimated 12.29 MT in 201523. The challenge for mitigation measures has been further enhanced in the updated NDCs (2021). To achieve these ambitious targets, Pakistanneeds a firm strategy, action plan and resources.24 As per Pakistan's revised Nationally Determined Contributions (NDC), the greenhouse gas (GHG) emissions from the waste sector are projected to reach 29.7 million tons of CO2 equivalent by 2030. This increase reflects the challenges posed by rapid urbanization and inadequate waste management practices in the country25. Through the Ministry of Climate Change and Environmental Coordination (MoCC& EC), the Federal Government is responsible for devising the national environmental policies that include the subject of the SWM. The Federal Government has established

[21] Brief on Solid waste management in Pakistan; Pakistan Environment Protection Agency. https://environment.gov.pk/SiteImage/Misc/files/Downloads/interventions/environmentalissues/BriefSWMPak.pdf

[22] https://www.worldbank.org/en/topic/urbandevelopment/brief/solid-waste-management

[23] Government of Pakistan. Pakistan's Updated Nationally Determined Contribution (NDC). United Nations Framework Convention on Climate Change, 2021. Available at UNFCCC.

[24] Emission profile of waste sector in Pakistan; Ijaz, Muhammad, Journal of Material Cycles and Waste Management; 2023. Vol 26-

[25] ADB: solid waste road map for policy makers. 2021

Sustainable Development Goals (SDGs) support units at the provincial level that coordinate and help the provincial planning and development departments to integrate their development plans in accordance with the national SDGs framework.

2.1.1 Main Governing Authorities

In Pakistan, the waste sector is primarily governed by a mix of federal, provincial, and local authorities.

Post the 18th constitutional amendment in 2010, waste management is the responsibility of provincial governments. Through the Local Government and Community Development Departments (LG&CDD) at the provincial level, municipalities are mandated the essential function of waste management at the local level. The LG&CDD is primarily a regulatory department of the Provincial government, with no technical capacity in the subject of waste management. The Public Health Engineering Department (PHED) handles wastewater management in Punjab, while the LG& CDD oversees this sector in Sindh, Khyber Pakhtunkhwa (KP), and Balochistan. Key governing bodies include:

Ministry of Climate Change (MoCC): The federal Ministry is responsible for developing national policies on environmental protection, waste management, and climate change. The MoCC plays a crucial role in setting the national agenda for decarbonization and aligning it with international commitments, such as the Paris Agreement.

Provincial Environmental Protection Agencies (EPAs): These agencies are responsible for implementing national policies at the provincial level, monitoring compliance, and enforcing environmental regulations. Each province has its EPA, which adapts national policies to local contexts.

Provincial Departments of Local Government: According to the Constitution of Pakistan, waste management is a provincial subject. As such, the Departments of Local Government at the provincial level act as provincial regulators for municipalities and waste management companies, thereby playing a crucial role in the overall waste management sector.

Local Governments (Municipalities) & Waste Management Companies: Local bodies are tasked with the collection, transportation, and disposal of municipal solid waste. They are pivotal in the implementation of waste management practices and policies at the grassroots level.

National Electric Power Regulatory Authority (NEPRA): Oversees the regulation of the electricity sector, including waste-to-energy projects that are part of the decarbonization strategy.

2.1.2 Existing Policies and Regulations

Pakistan's waste management sector is governed by several policies and regulations, which include:

Pakistan Climate Change Policy & Implementation Framework: The NCCP emphasizes the importance of reducing greenhouse gas (GHG) emissions from waste management practices. This includes promoting waste-to-energy projects, enhancing recycling and composting, and improving waste segregation at the source[26].

National Environmental Policy (2005)[27]: Provides a framework for environmental protection, including guidelines on waste management, but lacks specific mandates for decarbonization. Being almost twenty years old, needs a major revision.

---

26 https://mocc.gov.pk › Site Image › Policy
27 https://pbit.punjab.gov.pk/system/files/National%20Environmental%20Policy%202005.pdf

National Sanitation Policy (2006)[28] and National Drinking Water Policy (2009)[29]: Focus on improving water and sanitation infrastructure, indirectly affecting waste management by promoting hygienic waste disposal practices.

Provincial Waste Management Policies: Various provinces have their own waste management policies and strategies, such as the Punjab Environmental Quality Standards (PEQS), which include specific guidelines for waste disposal and emissions.

Pakistan Hazardous Waste Management Policy 2022[30]: The Policy emphasizes the need to reduce GHG emissions in the waste sector, like adaptation of best available techniques (BAT) and best environmental practices (BEP) in the hazardous waste treatment and disposal sector.

Alternative and Renewable Energy Policy (2019)[31]: Encourages waste-to-energy projects, promoting the use of municipal solid waste as a resource for renewable energy generation.

National Clean Air Policy[32,33,34]: Pakistan's National Clean Air Policy (NCAP), introduced in 2023, focuses on mitigating air pollution and greenhouse gas (GHG) emissions across key sectors, including waste management. The policy aims to reduce emissions from major polluting sources such as households, industry, and waste, which contributes approximately 24% to the nation's primary particulate matter (PM 2.5) emissions. A key strategy within the waste sector is to improve waste handling practices and promote recycling to minimize emissions from landfills and uncontrolled burning. Additionally, the NCAP sets ambitious goals to reduce air pollution by as much as 81% by 2040 through targeted interventions. These measures not only aim to address the health impacts of air pollution, which caused over 235,000 premature deaths in 2019, but also align with Pakistan's climate change goals, contributing to a reduction in GHG emissions.

- **Institutional Arrangements: Provincial Context**

The institutional design for solid waste management in all the provinces is similar, while at the local service delivery level, there are province specific variations.

a. Provincial Government

- At the provincial level, the respective Environmental Protection Agencies are the primary regulatory bodies responsible for enforcing environmental regulations, including those related to waste management.
- The Provincial Environmental Protection Acts in all four provinces are post 18th amendment adaptation of the Pakistan Environmental Protection Act 1997, so all have same provisions relating to waste. The key sections of the Act, relating to waste regulation are:

b. Local Governments (Municipal and District Councils)

Municipal Committees/Town Committees: These local bodies are responsible for waste collection, transportation, and disposal within their respective jurisdictions. They manage day-to-day operations, including waste collection schedules, maintenance of equipment, and oversight of waste disposal sites. The Punjab Local Government Act 2013 mandates all municipal committees to provide this service.

---

28 https://pbit.punjab.gov.pk/system/files/National%20Sanitation%20Policy%202012.pdf
29 https://mocc.gov.pk/SiteImage/Policy/DrinkingWaterPolicy.doc
30 https://mocc.gov.pk/SiteImage/Misc/files/National Hazardous Waste Management Policy 202022.pdf
31 https://nepra.org.pk/Policies/ARE_Policy_2019_-_Gazette_Notified.pdf
32 https://energyandcleanair.org/publication/air-quality-governance-in-pakistan-a-review/
33 https://www.sei.org/publications/air-pollutant-emissions-pakistan-clean-air-policy/
34 https://epaper.dawn.com/DetailImage.php?StoryImage=11_03_2023_004_003

The institutional structures and modalities vary across the four provinces. An overview is provided below.

1. Punjab

Dedicated waste management companies with relatively better capacities and resources have established themselves in all eight divisional headquarters cities in Punjab. The average solid waste collection efficiency in Punjab is only around 50%, some of the collected waste is dumped in open areas along the roadside, canal bank and low-lying areas. Illegal dumping of uncollected waste on sidewalks, open spaces, sewer lines, and even canals result in blockages of wastewater flow in the sewers, posing additional challenges for the local government. The existing situation of municipal waste management in large urban centers is comparatively better as compared to most of the intermediate/small cities and rural areas. Soil contamination is affecting the quality of groundwater at shallow depths.

Municipal corporations and committees have mandated responsibility for solid waste management services in most intermediate cities. However, almost all cities are facing challenges to comply with the required daily waste collection targets. In rural areas, the district councils and union councils are tasked with fulfilling the mandate, but their limited resources often force local residents to rely on self-help to maintain litter-free streets. In almost all cases, the waste is dumped in local low-lying areas and even sewerage ponds.

Sanitary landfill sites are limited in most cities, both large and small. However, many larger cities, as well as several smaller ones, have designated dumping areas located on the outskirts of settlements. While these sites provide a place for waste disposal, the existing dumpsites across urban centers still pose significant environmental challenges.

A few projects launched in the last decade and half, bring some ray of hope towards overall improvement. Recently, almost all provinces have launched a number of major projects that, if successfully implemented and replicated in other areas, could lead to a significant improvement.

- **Projects:**

ADB Financed Intermediate Cities Project: The Government of Punjab signed a loan agreement with the Asian Development Bank (ADB), which became effective in 2017, and covers 7 cities of the province, with major investments and plans for integrated waste management projects. These are at various stages of implementation in different cities.

Punjab Cities Program[35]: This is a 200 million USD WB financed program, that includes provision of waste collection machinery in 16 small cities of the province. However, the program focuses only collection and does not cover landfill site development

New Landfill Site (LFS) in Lahore: The two old dumping sites (Mahmood Booti and Lakhodair) are being closed and rehabilitated, while a new LFS is being developed for future use. The new facility is being designed as a sanitary LFS.

Outsourcing: Post 2024 elections, the provincial government has expanded the jurisdiction of waste management companies to regional (divisional) level and has invited bids from the private sector for collection and transport of waste in 27 districts and tehsils (sub-districts). In the next phase, landfill sites shall be developed across all areas.

2. Sindh

Before 2021, waste management was primarily a responsibility of local governments. However, due to limited capacity and resources, the performance in this area did not always meet the

[35] http://pcp-pmdfc.punjab.gov.pk

desired levels. Additionally, many municipalities faced challenges in outsourcing these services effectively.

Sindh Solid Waste Management Board: In 2021, the Sindh Government created the Sindh Solid Waste Management Board (SSWMB) as a provincial agency to oversee waste management in key cities. Since then, the collection and transport has been outsourced to the private operators in 8 districts. In the next phase, the tenders for design and construction of transfer stations (with segregation facilities) and landfill sites have been floated.

SWEEP: The World Bank sponsors the Sindh Waste Efficiency and Environmental Improvement Project (SWEEP), which aims to improve waste management and environmental sustainability in Pakistan's Sindh province.

The SSWMB has undertaken several key projects in Karachi under the SWEEP Program:

- Upgrading and expanding the waste collection infrastructure in Karachi.
- Establishing and upgrading sanitary landfill sites to handle solid waste more effectively and reduce environmental hazards, including development of waste-to-energy facilities.
- Building and upgrading transfer stations where waste can be temporarily stored and sorted before being transported to landfill sites.
- Proper closure and remediation of dumpsites to prevent further environmental degradation.
- Implementing campaigns and programs to raise public awareness about the importance of proper waste disposal and recycling.
- Enhancing the capacity of SSWMB and other local authorities through training and institutional reforms.

3. Khyber Pakhtunkhwa (KP)

In the KP province, the overall waste management system is governed by the KP Local Government Act. However, the municipal councils (municipal corporations, committees, and town municipal authorities) are responsible for implementing the system on the ground, while district councils and union councils are in charge in rural areas.

In 2014-16, considering the need for improved governance and capacities, the provincial government implemented a major institutional reform, whereby water and sanitation companies (WSSCs) were established in the seven largest cities of the province.

KP Cities Improvement Program: The KP Government in 2019 initiated the KP Cities Improvement Project, with support from ADB and AIIB, totaling around 680m USD, for project on waste management, water supply, waste water and green and urban spaces, in five large cities of the province. The Project includes the establishment of Integrated Solid Waste Management systems in the five largest cities, covering the elements of door-to-door collection, segregation, anaerobic digestion, composting and engineered landfill sites. Private operators are implementing the project under the Design-Build-Operate and Transfer (DBOT) modality. The project is likely to lead to significant GHG emission reductions and is a good case for claiming carbon credits.

4. Balochistan

PPP Contract: The provincial capital, Quetta, is home to more than three million residents, almost the entire urban population of the province, generates around 1000 tons of waste per day. The Quetta municipal government has signed an agreement with the *Provincial Public Private Partnership (PPP) Authority* for outsourcing the entire integrated system, including door to door collection, treatment, and disposal. This is at the negotiation stage and is a potential candidate for carbon credits under the SPAR6C program.

The present situation in the waste sector in the above-mentioned provinces is a result of various challenges encountered by local governments and waste management companies.

1. **Limited Political Commitment:** Over years, the national and provincial governments have not consistently prioritized the waste sector. While waste management has recently gained more visibility in political manifestos and agendas, there are still challenges in aligning investments and developing a strong framework.
2. **Insufficient Policy and Regulatory Framework:** Despite the introduction of various policies, laws, acts, rules, and regulations across all levels of government, the overall framework still faces challenges due to gaps, overlaps, and inconsistencies.
3. **Challenges in Enforcement**: While laws and regulations are in place, the enforcement mechanisms could be strengthened to ensure better compliance by industries, municipalities, and citizens. Enhancing these mechanisms would improve the overall effectiveness of waste management efforts.
4. **Infrastructure Limitations**: Many municipalities, particularly in smaller cities and rural areas, face challenges due to limited infrastructure, including outdated vehicles, insufficient landfill sites, and a lack of trained personnel. These limitations contribute to suboptimal waste management practices, such as open dumping and burning, which in turn increase environmental pollution and health risks.
5. **Need for Increased Public Awareness**: There is an opportunity to enhance public understanding of proper waste disposal, recycling, and the broader importance of waste management for environmental conservation. Greater awareness would likely lead to improved cooperation and reduce issues like littering and random dumping.
6. **Role of the Informal Sector**: The informal sector plays a significant role in waste collection and recycling, especially where the formal sector faces challenges. However, these activities are often unregulated, posing health and safety risks for workers and contributing to environmental pollution. Integrating the informal sector into the formal system could present a valuable opportunity.

2.2 Quantification of total waste generated in the country and Breakdown of waste composition

2.2.1 Municipal Solid Waste

It is estimated that around 36 million metric tons[36] of municipal solid waste[37] (MSW) are generated every year in Pakistan. The amount of waste produced is predicted to increase substantially in the coming years due to rapid population growth and urbanization. Considering the capacity and resources of the waste management entities, it is assessed, that overall, about 50% of generated waste is collected. The rate however varies from 80 % in larger cities to hardly any in most of the rural areas.[38] As for disposal, there are few properly managed landfill sites in the country. Most of the generated urban waste is either left un-collected or dumped in open grounds.
As per various studies conducted in the last ten years, the estimated waste generation and collection data is as follows:

36 Estimates from Waste Analysis and Characterization Studies (WACS) done during the last 10 years in around 20 cities in Pakistan. (Author's compilation)

37 The term "municipal" means mixed waste and separately collected waste from households, including paper and cardboard, glass, metals, plastics, bio-waste, wood, textiles, packaging, waste electrical and electronic equipment, waste batteries and accumulators, and bulky waste, including mattresses and furniture. In addition, it includes mixed waste and separately collected waste from other sources, where such waste is similar in nature and composition to waste from households.

38 Mihai, F.C. and A. Grozavu. 2019. Role of Waste Collection Efficiency in Providing a Cleaner Rural Environment. Sustainability. Vol. 11(23). p.6855.

Table 1: Estimated waste generation in Pakistan (2024)

Human Settlements	Population million	Waste Generation (kg/c/d)	Annual Waste Generation (m Tons/yr.)	%Collected of waste generated	Transported	Treated (Reuse, recycling, recovery) *
11 large cities[39,40]	62.5	0.55	12.55	80	80	20%
Medium and Small cities	37.5	0.42	5.75	50-70	50-70	10%
Rural areas	150	0.33	18.07	20	20	20%
Total	**250**		**36.36**			

**This recovery, reuse and recycling is almost entirely in the private / informal sector.*

Since 2010, several waste volume, composition and characterization studies (WACS) have been conducted in different large and small urban centers. The results have been varying within a broad range. However, all these study results find that the organic waste is the major component, often up to 60%. A comparative analysis of the study results in given below.

Table 2: waste composition analysis, urban (source: ADB compilation)

Item (%)	Mirpur	Muzaffarabad	Mardan	Gujranwala	Peshawar	Islamabad	Kohat	Sahiwal	Mingora
Kitchen Green Waste	62,33	68,24	62,96	62,50	53,74	59,95	55,82	56,90	49,21
Paper	4,46	4,95	3,91	15,30	7,32	7,26	8,2	5,219	13,1
Textile	3,05	2,71	3,71	3,87	2,35	1,81	2,75	3,71	3,53
Dray Grass and wood	1,43	1,32	1,05	1,63	10,29	0,00	0,15	1,70	4,66
Plastic	10,51	10,22	7,36	7,70	9,34	7,49	21,7	9,54	14,69
Leather and rubber	0,84	1,09	0,61	0,77	0,63	0,00	0,723	0,88	0,33
Metal	0,31	0,26	0,20	0,23	0,72	0,68	0,025	0,375	0,46
Bottle and Glass	1,03	1,31	0,87	1,16	2,32	2,79	0,0325	0,75	0,74
Ceramic Stone and Soil etc	0,59	0,24	3,09	1,10	12,32	0,00	0,9	2,514	1,3
Domestic Hazardous Wastes	0,37	0,47	0,45	0,60	0,00	0,82	0,4	1,03	0,50
Sieve Remaining > 6mm	1,61	0,78	0,00	3,23	0,00	0,00	0,76	3,06	2,86
Miscellaneous	13,47	8,41	15,79	1,91	0,97	19,20	8,540	14,3314	8,62

39 Karahi, Lahore, Peshawar, Quetta, Hyderabad, Faisalabad, Multan, Gujranwala, Rawalpndi, Sialkot, & Bahwalpur.
40 *https://www.adb.org/publications/solid-waste-management-pakistan-road-map. However, the data has been updated by authors for 2024.*

2.2.2 Industrial waste

Industrial waste, including all wastes generated by activities such as demolition and construction, manufacturing, agricultural operations, wholesale trade, and mining, are mostly collected and treated as part of the municipal waste, as majority of industries are in cities and not in dedicated industrial estates. This situation is due to several factors:

- Many industries were established in urban areas during the early stages of industrialization when city boundaries were less defined and over time, cities have expanded, and industries that were once on the outskirts became part of the urban landscape.
- Being located within or near city limits allows industries to be closer to their markets, suppliers, and workforce, reducing transportation and manufacturing cost.
- In many instances, urban planning has faced challenges, and the enforcement of zoning laws could be improved.

Although the government has worked to develop dedicated industrial parks and areas, there have been some challenges with land acquisition, infrastructure development, and providing the necessary amenities, which have made these areas less appealing to industries compared to urban locations.

However, this trend has led to several issues, including environmental pollution, traffic congestion, and strain on urban infrastructure.
With reference to waste management and environmental pollution, this trend has serious implications, including:

- Increased Strain on Municipal Waste Management Systems, which are typically designed to handle residential and commercial waste, not industrial waste.
- Inadequate Facilities: the waste management companies (and Board) usually lack the necessary specialized facilities to properly treat or dispose of industrial waste, which in any case gets mixed up with municipal waste, posing serious health and environmental challenges.
- Air and Water Contamination: Industries often produce hazardous waste, including chemicals and heavy metals, which can contaminate air, water, and soil if not properly managed, directly affecting the health of urban populations. Many cases of polluted ground water have been reported.
- Higher Waste Management Costs: Managing industrial waste within municipal systems often requires additional resources, such as specialized equipment and trained personnel, leading to increased operational costs for municipalities, while there being almost no direct user charges for these services, causes unfair burden on waste management budgets.
- Difficulty in Monitoring: Monitoring and enforcing waste management regulations in urban areas with mixed industrial and residential zones can be challenging. This can lead to non-compliance with environmental regulations by industries, further exacerbating waste management issues.
- Fragmented Responsibility: The division of responsibility between municipal authorities and environmental agencies and the industries regulators can lead to gaps in waste management oversight, making it difficult to ensure that industrial waste is managed appropriately.

a. Hazardous waste

In Pakistan, hazardous waste is defined under the framework of the National Hazardous Waste Management Policy, 2022[41]. This policy defines hazardous waste as any material that, because of its amount, concentration, or physical, chemical, or infectious properties, could pose a potential threat to human health or the environment. This waste can be in solid, liquid, or gaseous

[41] https://www.dra.gov.pk/news_updates/press_releases/national-hazardous-waste-management-policy-2022/

form and typically includes toxic, reactive, flammable, corrosive, or infectious substances. The policy also aligns with international conventions like the Basel Convention, emphasizing the need for proper management, treatment, and disposal of such waste to prevent environmental contamination and health hazards.

E-waste or more comprehensively called waste electrical and electronic equipment (WEEE) is any "*electrical or electronic equipment, which is waste, including all components, subassemblies and consumables, which are part of the equipment at the time the equipment becomes waste*" (Basel Convention 2019)

Current regulations in Pakistan, at both provincial and federal levels, do not include specific guidelines for managing e-waste. However, the National Hazardous Waste Management Policy 2022 recognizes e-waste as a waste category that should be addressed in a forthcoming regulatory framework after the policy's approval. The same is yet to be developed. This situation has led to environmental and health concerns due to the improper handling and disposal of such waste.

In 2022, Pakistan's domestic e-waste production was estimated at 556 million kilograms, with an average rate of 2.4 kilograms per capita[42]. Pakistan is also a major recipient of imported e-waste from other countries. According to *Global E-waste Monitor study*, approximately 95.4 million kilograms of e-waste are imported into Pakistan annually[43], with 89 percent of it entering through Karachi. Although Pakistan is a party to the Basel Convention, it faces major challenges in regulating the import of e-waste from developed countries, much of which is falsely labeled as used goods.

Pakistan imports a large volume of e-waste in various forms, making it a significant contributor to health and environmental problems. This is because less than 2% of the material received is reusable[44], which are mostly expensive metals like gold, silver, platinum, cobalt, copper, aluminum and iron. It is estimated that only ten out of sixty chemical elements present in e-waste are recyclables[45]. Some key challenges that remain include urging electronic producers and manufacturers to design products that are more suitable for recycling, as well as conducting further research on the mechanical processing needed to recycle the other chemical elements.

In Pakistan, the recycling sector is largely controlled by informal operators. Karachi serves as the primary center for e-waste dismantling and recycling, with additional markets now established in Lahore, Faisalabad, Gujranwala, and Peshawar.

Healthcare waste: On average, the rate of hospital waste generated in the country is estimated to be 0.667 kg per hospital bed per day.[46] It is estimated that around 10%–25% of this waste is infectious and hence hazardous[47]. Due to inadequate sanitation practices, hazardous waste frequently ends up mixed with general waste, worsening waste management challenges. Effective Health Care Waste Management (HCWM) begins with proper segregation at the source.

The current practices of HCWM in Pakistan is a critical public health and environmental concern. Pakistan Environmental Protection Act (PEPA) 1997 is the foundational law that addresses hospital waste management. Subsequently, Hospital Waste Management Rules

42 Global E-waste Monitor 2024; https://ewastemonitor.info/the-global-e-waste-monitor-2024/

43 ibid

44 Hasmi, Muhammad Zafar et al. 2019. Electronic Waste Pollution. Springer; Switzerland.

45 https://earth.org/what-is-e-waste-recycling/

46 Ali, Mustafa et al. 2016; Management of Wastes from Hospitals: A Case Study in Pakistan; Waste Management and Research. Vol. 34 (1) pp. 87–90.

47 Ali, Mustafa et al. 2016; Management of Wastes from Hospitals: A Case Study in Pakistan; Waste Management and Research. Vol. 34 (1) pp. 87–90.

2005, promulgated under the PEPA 1997 provide detailed guidelines on the segregation, collection, transportation, and disposal of hospital waste. They also outline responsibilities for healthcare institutions to ensure proper waste management. The key step in HCWM is the segregation at source, since once mixed with municipal waste, it is no longer possible to segregate. Management of the 15-20% infectious / hazardous healthcare waste generated at such facilities is the responsibility of these facilities and provincial health department, being a specialized function. The remaining 80-85 % waste generated here, which is normal municipal waste is to be managed by the municipalities and waste management companies.

In Pakistan, several challenges impact the effective management of healthcare waste. These include a general lack of awareness and training regarding proper waste handling practices, as well as insufficient infrastructure for the segregation, storage, transport, and disposal of waste through methods like incineration, autoclaving, and landfilling. Financial limitations also play a significant role, as comprehensive waste management can be costly. Additionally, enforcement mechanisms are often weak, particularly in cases where the plastic components of this waste are in high demand within the recycling market, despite the associated health risks.

b. Wastewater situation in Pakistan

In Pakistan, domestic wastewater is either discharged directly to a sewer system, a natural drain, water body, a nearby field, or an internal septic tank. An estimated 32,500 hectares mostly used to grow vegetables—are irrigated with wastewater, most of it untreated (Jiménez et al., 2010). It is estimated that only some 3-8%[48] of urban wastewater is treated in municipal treatment plants. Treated wastewater is usually discharged into open drains, and there are no established systems for reusing it in agriculture or other municipal applications. In many cases, the treated/untreated wastewater mixes with commercial and industrial solid waste, thus further complicating the issue.

- **Punjab**

By and large, there is very little wastewater treatment in the province. Only in Faisalabad city,there are functional wastewater treatment plants, that treat around 20 million gallons per day (MGD).[49]

Lahore is the largest city of the province, generating around 540 MGD of wastewater, of which almost all is directly discharged into river Ravi. There is a proposedproject for the construction of a WWTP of 100 MGD capacity,[50] at Mahmood Booti. The project is being undertaken by the Ravi Urban Development Authority (RUDA). Another WWTP at Katar band of 44MGD capacity is at feasibility study stage, under DANIDA support.[51]

Total sewage generated in WASA, Faisalabad jurisdiction, is 280 MGD, out of which 200 MGD is discharged into Chenab River through Paharang Drain on western side and the remaining is discharged into Ravi River through Madhuana Drain on eastern side.

In addition to the existing two plants, on the eastern side, a 44 MGD WWTP funded by DANIDA is under execution. The feasibility study & Reference design was carried out by the consuting firm M/s SWECO Denmark. There is also a proposal for construction of a 66 MGD WWTP at dow-stream of Satiana Drain, for which talks are in process with Asian Development Bank (ADB) to provide financial assistance.

48 The figures vary in different studies and also on the definition / level of treatment in different cities and facilities.
49 WASA Faisalabad website, accessed on 11th Aug 2024. https://wasafaisalabad.gop.pk/Home
50 https://tribune.com.pk/story/110233/city%E2%80%99s-first-waste-water-plant-on-its-way
51 https://www.sweco.dk/nyheder/nyheder-og-events/sweco-wins-major-watertech-project-in-lahore-pakista

- **Islamabad**

The Pakistan Water Situational Analysis reports that Islamabad has three wastewater treatment plants, but only one is operational, and even that is running at less than half of its full capacity.

- **Sindh**

According to Water Policy in Pakistan report" Karachi generates more than 450 million gallons per day (MGD) of sewage from homes, businesses, hospitals, and industrial facilities 52 This wastewater flows through drainage systems and eventually empties into the Lyari and Malir rivers before reaching the ocean. Although Karachi technically has three wastewater treatment plants with a combined capacity to handle about 150 MGD (around 33% of the total sewage), these plants are currently not operational[53, 54]

Karachi is home to 70% of Pakistan's industry; and six industrial estates. Only a portion of the generated industrial effluent from this zone goes to a treatment plant (TP1), which is itself operating at half capacity because of the inadequate sewage piping.
The Karachi Water and Sewerage Board (KWSB) has suggested setting up additional treatment plants, but those projects are in a state of limbo as well.

- **Khyber Pakhtunkhwa (KPK)**

In KPK, the operational sewer systems reach less than 5% of the urban areas[55]; the few networks are mostly neglected and frequently overflow. Since there is no functional treatment plant in the region, the wastewater flows mainly through open drains. At Hayatabad, Peshawar, an extremely small facility provides treatment to a handful of industrial sources. The untreated wastewater and sewage is otherwise directly discharged to surface drains or used on farmland for irrigation purposes, inflicting severe environmental damage and creating health risks to farmers and nearby communities [56].

KPCIP Wastewater Treatment Plants: There are two municipal wastewater treatment plants being established under ADB assistance, one at Mardan of 5.8 million gallons per day (MGD) and another at Kohat of 3 MGD capacity. Both are using the activated sludge technology, solar power for operations and the sludge shall be treated through anaerobic digestion[57]. These projects are under construction and likely to be operational by 2027.

- **Balochistan**

Quetta is the capital and largest urban center of province, generating around 60MGD of waste water. However, presently one wastewater treatment plant exists in Quetta city at Sabzal road.[58] The plant is operated by Quetta WASA with the capacity of 1.8 MGD waste water treatment. It has been rehabilitated recently and is designed to supply treated waste water to the nearby agricultural lands.[59]

---

52 Mahmood ¬Ahmad, Water Policy in Pakistan: Issues and Options: https://doi.org/10.1007/978-3-031-36131-9
53 Sindh Water Commission report: https://scp.gov.pk/files/newspr/Enquiry_final_Report_06_03_2017.pdf
54 Dawn 6th jan, 2021: https://www.dawn.com/news/1599905
55 Asian Development Bank - Project Overview for KP Cities Improvement Project
56 ADB: Khyber Pakhtunkhwa Cities Improvement Program, Sector Assessment. 2019
57 https://kpcip.gov.pk/
58 https://dailyindependent.com.pk/sardar-ejaz-jaffar-stresses-need-to-take-steps-on-war-footing-ground-to-tackle-issue-of-clean-drinking-water-in-quetta-city/
59 WASA Quetta Report

2.3 Overview of current waste management practices in Pakistan

In all four provinces, the waste management situation is generally similar, with partial collection, limited recovery and treatment, and few proper landfill sites. As a result, much of the waste ends up being disposed of in open areas.

Collection: The default practice of waste collection in most of the urban areas and almost all rural areas is street sweeping. Under this system, the citizens collect the waste of the household and dump it in the streets, and the sanitary workers are deployed by the municipalities[60], who sweep the streets, collect the waste in wheelbarrows and then dump at communal collection points. Most of these collection points are open dumps, while in many cities, around fifty percent of these have been replaced with containers of varying capacity.

In almost 15-25 %[61] of the urban areas in large cities, the practice of door-to-door collection has been introduced, mostly by the private sector and informal waste collectors. During the collection phase, much of the recyclables are recovered by the collection personnel.

Secondary Collection and Transport: The open communal dumps are serviced by tractor-towed trollies in rural areas and most of the small towns and cities. In large cities, a variety of vehicles, ranging from tractor towed trollies, open trucks, dump trucks, roll-on- roll-off vehicles and in some cases, compactors are deployed. In most cases, these secondary collection vehicles are unloaded directly at disposal sites due to the absence of transfer stations.

Due to overall shortage of required manpower, and machinery, much of the waste, especially in rural areas is left uncollected, or dumped locally in low lying grounds and open plots.

Segregation: The segregation and recovery of recyclables begin at the household level, where household members and domestic workers often collect reusable and easily saleable metal and plastic items. Following this initial stage, the collection and sweeping staff conduct a quick inspection to recover any remaining valuable materials. Then the communal collection points serve as the prime segregation facilities for the informal scavengers, who work in thousands and almost round the clock, to ensure that not much goes waste. Many of the scavengers include children and undocumented refugees from neighboring Afghanistan. Last but not the least, there are scavengers at all the landfill sites / dumpsites, who take the last chance and recover whatever is left. Sometimes, they put the dry dumps on fire and then use large magnet rods to recover the minor pieces of iron.

All the recovered recyclables from these stages find their way through a well-developed network of intermediate buyers and then back to the industry. In terms of numbers, probably the recovery / recycling rate is not bad in Pakistan, however, it is not integrated or documented. Moreover, the recovery at the communal points lead to littering around the bins (to prevent them from mixing), and thus causing aesthetic problems. Often the scavengers work in collusion with the formal workers, sharing the income. While there are small-scale pilot projects in some cities, primarily funded by NGOs, that focus on formal segregation and composting, these initiatives are still limited in scope.

Treatment: Inorganic recyclables that are commercially viable are effectively recovered and re-enter the market. However, certain components that lack commercial viability—such as polythene bags, non-recyclable plastics, and contaminated paper—are often discarded, leading to environmental degradation. These materials, when mixed with the organic fraction,

---

60 The word municipalities is used to include all other entities working on behalf of local governments like Waste Management companies, Board etc.

61 Compendium of Good Practices in Urban Solid Waste Management: Involving waste pickers to improve door to door collection

significantly compromise the quality of compost, rendering it unsuitable for agricultural use. Even trace amounts of plastics, glass, or heavy metals can adversely affect compost quality.

A number of attempts have been made in the past by the public and private sector to set up recovery and composting facilities, but due to lack of cooperation from the municipalities and weak enforcement of regulations, they have not been successful. Recently, a city-wide segregation and composting facility has been set up by the Government in Sahiwal city, with a capacity of 100 tons / day. This is running in pilot phase and seems to have a promising outcome.

Some of the donor funded projects in large cities do include the elements of recovery and treatment of inorganic as well as organic components.

Disposal: The waste not collected faces the final disposal of open dumping, or is burnt by the public or workers, in the belief that this is good disposal, since the issue is apparently solved. However, some percentage finds its way into the water bodies, with plastics being accumulated in large rivers and even reaching the sea.

Figure 2: Open dumping in cities (Author's Pictures)

The collected waste is transported to the open dumpsites, usually at the periphery of the settlements. In some cities, the municipalities deploy some machinery to spread it for aesthetic and logistic reasons. The scavengers take the last chance at recovery, and the balance either takes fire or just lies as open dumps. These open dumps are comprising of mostly organic matter, which when mixed with rain and run off water become a source of leachate, causing pollution of the ground water, with serious health concerns and long-term impact on the ground water quality.

Incineration: Incineration facilities for managing infectious hospital waste are mainly available in public sector institutions and several private sector hospitals. However, some of these incinerators are old and may not consistently operate at the recommended temperatures, which can potentially lead to the release of harmful emissions. Although hospital waste management regulations have been established, their implementation is more commonly observed in larger hospitals. In Punjab and in Khyber Pakhtunkhwa (KP), private operators have set up incinerators, who serve the smaller private hospitals and clinics. There are no incinerators for the municipal waste, though some projects of RDF (Refuse Derived Fuel) have been working in the cement factories and are being planned as part of donor funded projects

2.4 Projections of Waste Generation in Pakistan

The current estimated municipal waste generation in Pakistan is around 36 million tons per year. This is based upon a number of waste characterization and volume studies (WACS), carried out since 2012 in different cities and then extrapolating the results for other cities of similar size and characteristics. The current waste generation rate is around 0.55 kg/c/day for the eleven large cities, 0.42kg/c/ day for intermediate and small cities and around 0.33kg/c/day for rural areas.

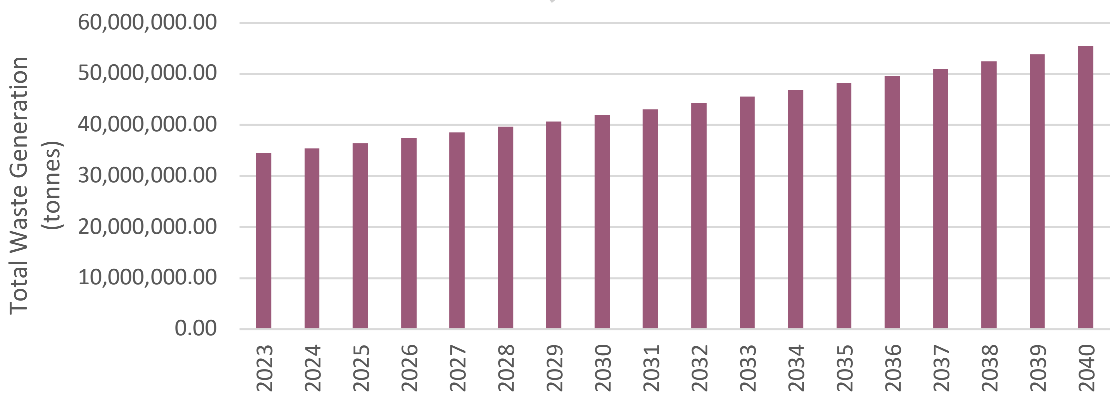
The projection of waste generation in future depends upon a number of factors:

- **Populations**: The overall population in Pakistan has been growing at around 2.13% per annum[62], as per the latest census. Thus, the total waste generation is set to increase at this.
- **Urbanization trends:** Since there is a higher waste generation in the urban areas, the urbanization trend is going to impact the overall waste generation quantities at the country level. Currently the estimated urbanization rate is more than 3.5%, compared to the general population growth rate of 2.13%. So, with increasing urbanization, the total waste generation shall be higher than the growth rate, since urban areas have a higher per capita generation.
- **Industrial development:** increased industrialization, particularly in large cities, will lead to higher industrial waste production, thus impacting overall waste quantities.
- **Socio-Economic Development:** The waste generation varies with the GDP of the country. Currently, the economic growth rate is not significant. However, if economic growth increases in the future, the waste generation rate is likely to rise accordingly.
- **Environmental Initiatives:** The net waste reaching the disposal site shall also vary with the success rate of the various environmental initiatives taken by the government and civil society targeting reduction, reuse and recycling.

The waste generation forecast for Pakistan from 2023 to 2040 was conducted by analyzing current waste generation rates for urban and rural areas, and applying population growth and urbanization trends. The waste generation rate was set at 0.55 kg/capita/day for large cities, 0.42 kg/capita/day for intermediate cities, and 0.33 kg/capita/day for rural areas. The forecast takes into account a population growth rate of 2.13% per annum and an urbanization rate of 3.5%, both of which influence the total waste generated.

The results indicate a significant increase in waste generation, with the total waste expected to rise from **34.5 million tonnes** in 2021 to approximately **53.6 million tonnes** by 2040. This increase highlights the need for robust waste management strategies, especially in urban areas where per capita waste generation is higher. The findings underscore the importance of planning for future waste management infrastructure and policies to cope with the rising demand.

Figure 3: Forecast of waste generation in Pakistan[62]



[62] Pakistan Bureau of Statistics

3. BAU scenario until 2040 in the absence of new interventions (Sector development trends and GHG emission development trends, specifying drivers behind the trends)

3.1 Calculation of GHG emissions from various waste management activities.

The waste sector contributes a very small portion to Pakistan's greenhouse gas (GHG) emissions, representing about 4 percent (21.72 MT CO_2 eq. of total GHG emissions in 2018)[63] The sector is divided into three emission sources: Solid Waste Disposal, Waste Incineration and open burning, Wastewater treatment and Discharge. These sources produce various greenhouse gases: carbon dioxide (CO_2) from burned waste and waste exposed to air, methane (CH_4) from waste digested by bacteria in the absence of air, and nitrous oxide (N_2O) emitted in substantial amounts in MSW landfills. Methane and nitrous oxide have significantly higher GHG warming potentials compared to carbon dioxide, meaning that one unit of methane or nitrous oxide has a much greater impact on global warming than one unit of carbon dioxide.

Under the IPCC 2006 Guidelines for National Greenhouse Gas Inventories, waste is categorized into several types to facilitate accurate estimation of GHG emissions. The primary categories include solid waste disposal, wastewater treatment, biological treatment of solid waste, and waste incineration. Solid waste disposal focuses on emissions from landfills, where organic waste decomposes anaerobically, producing methane (CH_4), a potent greenhouse gas. Wastewater treatment encompasses emissions from both domestic and industrial wastewater, including methane and nitrous oxide (N_2O) emissions from the treatment processes. Biological treatment of solid waste covers composting and anaerobic digestion, which primarily produce CH_4 and N_2O. Waste incineration, another key category, accounts for carbon dioxide (CO_2) and other GHGs released when waste is burned for disposal or energy recovery. These categories provide a comprehensive framework for assessing the GHG impact of waste management practices, aiding in the development of more sustainable waste management strategies.

- **Solid waste disposal:** This includes the annual amount of solid waste disposed of in various landfill sites, whether managed anaerobically or semi-aerobically, or unmanaged deep or shallow sites. It considers the waste composition and the extent of scavenging activities, including the remaining waste and its composition. GHG emission estimates should encompass both urban and rural areas, as current estimates only cover urban areas in Pakistan.
- **Biological treatment of solid waste:** This is expected to be a minimal source of GHG emissions in Pakistan, with only a few pilot projects currently in progress (In the province of Khyber Pakhtunkhwa, Punjab[64] and Karachi)[65].
- **Incineration and open burning of waste:** This cover the annual quantity and ideally the composition of waste burned openly, along with emission estimates from this source, which are not included in current inventories. Following IPCC guidelines, incineration and open burning are considered incomplete combustion processes, resulting in the emission of CO_2, CH_4, and N_2O[66],[67]. For this analysis, all solid waste compositions were deemed combustible,

63 Pakistan's updated Nationally Determined Contributions (NDC)

64 Small scale pilots and some in the private sector and one city level facility in Sahiwal. This is post 2022.

65 solid waste management sector in Pakistan, a reform road map for policy makers, march 2022

66 Zheng Xuan Hoy et al.; Curbing global solid waste emissions toward net-zero warming futures, 2023

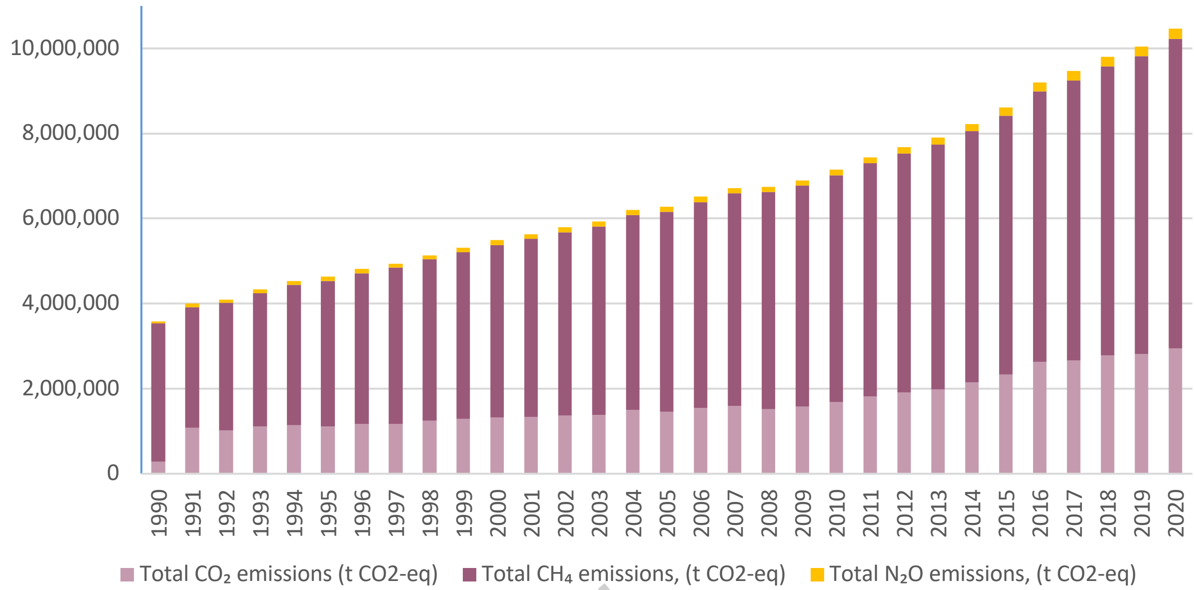
67 Pipatti, S. M. M. Vieira, "2006 IPCC guidelines for national greenhouse gas inventories" (IPCC, 2006); https://www.ipcc.ch/report/2006-ipcc-guidelines-for-national-greenhouse-gas-inventories/

excluding glass and metal waste. The IPCC's Tier 2 method was applied, using country-specific data on MSW composition alongside default values for parameters such as dry matter content, carbon content, fossil carbon fraction, and oxidation factor to estimate greenhouse gas (GHG) emissions from incineration and open burning[51.]

- **Wastewater Treatment & Discharge:** The IPCC states that methane (CH_4) emissions from industrial wastewater occur only when the wastewater has significant carbon content and is treated under anaerobic conditions, whether deliberate or not. Projections are based on expected future changes in either activity levels or emission factors. These variations in activity data may be directly related to economic and population growth, the composition of energy supply, and technological advancements.

The assumption is that economic growth will average an annual overall growth rate in Gross Domestic Product (GDP) of 7% between 2015 and 2030. Although this is lower than the 8% target set in Pakistan's Vision 2025, it balances several different projections. The sensitivity analysis examines how emissions would change at both higher and lower growth rates. Reference case projections for population and household size are based on data from the Pakistan Economic Review 2022-2023.

Figure 4: GHG emissions from Solid Waste Disposal, Incineration & Open Burning (Based on data collected from Urban Unit and [68],[69])



3.2 GHG emission from wastewater

The graph representing GHG emissions from wastewater in Pakistan from 2000 to 2024 was developed using hypothetical data to illustrate potential trends over time. The methodology involved the following steps:

1. Data Estimation: Since year-by-year emission measurements were unavailable, emissions for the years in between were estimated by interpolating values at key target years—2000, 2010, 2020, and 2024. It's important to note that these estimates broadly assume an upward trend

[68] Zheng Xuan Hoy et al.; Curbing global solid waste emissions toward net-zero warming futures, 2023

[69] Pipatti, S. M. M. Vieira, "2006 IPCC guidelines for national greenhouse gas inventories" (IPCC, 2006); https://www.ipcc.ch/report/2006-ipcc-guidelines-for-national-greenhouse-gas-inventories/

in emissions, driven by factors such as population growth, urban expansion, and industrial activity.

2. Methane (CH_4) Emissions: Thus, the trend for the production levels of methane was projected to gradually rise over the years due to an increase in the generation of domestic and industrial waste waters. This also follows the increase of organic waste volumes and the progress in building more and more wastewater treatment systems thanks to which methane emittance, if the gas is considered anaerobically, is enhanced.

3. Nitrous Oxide (N_2O) Emissions: While methane emissions tend to rise relatively steadily, it can be assumed that nitrous oxide emissions would increase at a slower rate. This is likely due to improvements in wastewater management, including the potential for more aerobic treatment methods, which tend to produce less nitrous oxide.

4. Data Presentation: We plotted the estimated emissions data from 2000 to 2024 to show trends over time. These estimates are hypothetical and meant for illustration only; they should be replaced with real data whenever possible.

➢ **Domestic Wastewater**

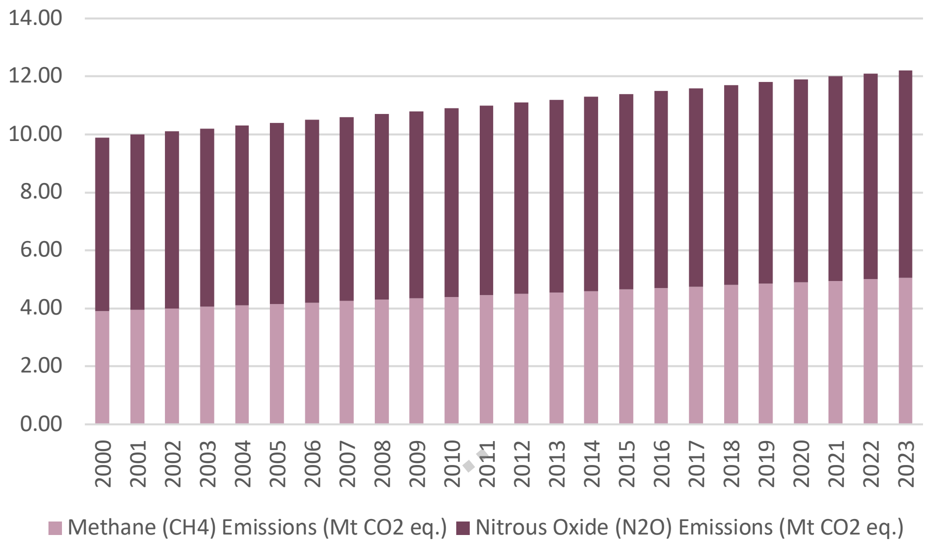
- Methane (CH_4) Emissions: In Pakistan, domestic wastewater systems like septic tanks, latrines, and open sewers lead to significant methane emissions. This happens because organic waste breaks down without oxygen, which naturally encourages methane production.
- Nitrous Oxide (N_2O) Emissions: Nitrous oxide is released from domestic wastewater treatment during processes like nitrification and denitrification, which are mostly found in centralized treatment facilities.

➢ **Industrial Wastewater**

- CH_4 Emissions from Industrial Wastewater: Industries like food processing, textiles, and paper manufacturing release methane when organic materials decompose anaerobically. This is especially the case where wastewater lacks advanced aerobic treatment systems.
- N_2O Emissions from Industrial Wastewater: Nitrous oxide is generated from the breakdown of nitrogen compounds in industrial wastewater, particularly when treatment facilities are either insufficiently advanced or poorly managed.

Emissions from both sectors are rising, in line with economic growth, industrialization, and population increase. The **Global Methane Initiative** and the **US EPA** project significant growth in methane and nitrous oxide emissions from these sectors.

Figure 5: Methane (CH4) and nitrous oxide (N2O) emissions from the wastewater sector in Pakistan (Source: [70], [71], [72])



3.3 Forecast of GHG emissions in waste and wastewater sectors

The forecast of GHG emissions in the waste sector involves assessing current waste management practices, predicting future waste generation rates, and evaluating the potential impact of mitigation measures such as improved recycling, composting, and landfill gas capture. Based on the above-mentioned assumptions, the total GHG forecast is presented as below.

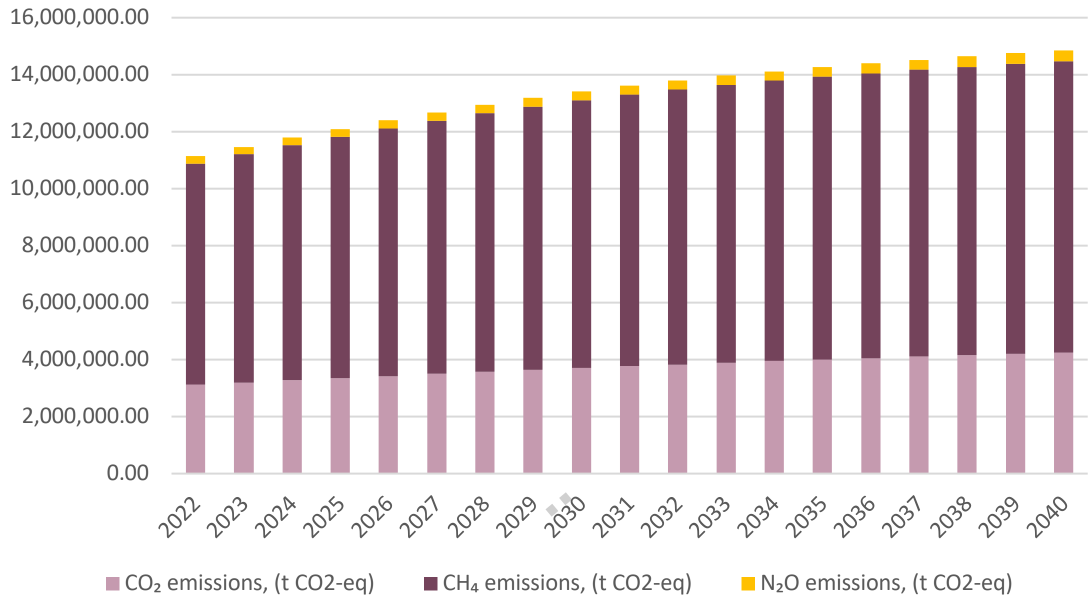
To project the GHG emissions from the waste sector in Pakistan until 2040, data was collected from various sources (68, 69), including historical emissions records, demographic trends, and waste management practices. This data served as the foundation for developing a robust forecasting model. By analyzing trends and considering factors such as population growth, urbanization, and expected changes in waste generation, a compound annual growth rate was calculated to project emissions over the next two decades.

[70] https://www.globalmethane.org/partners/detail.aspx?c=pakistan

[71] https://link.springer.com/article/10.1007/s10163-023-01827-0#:~:text=The%20estimates%20of%20waste%20sector%27s,2%20emissions%20(Table%201).

[72] UN-HABITAT Pakistan Country Report 2023 B5 final

Figure 6:GHG emissions forecast for Solid Waste Disposal, Incineration & Open Burning sector (adapted from [68])

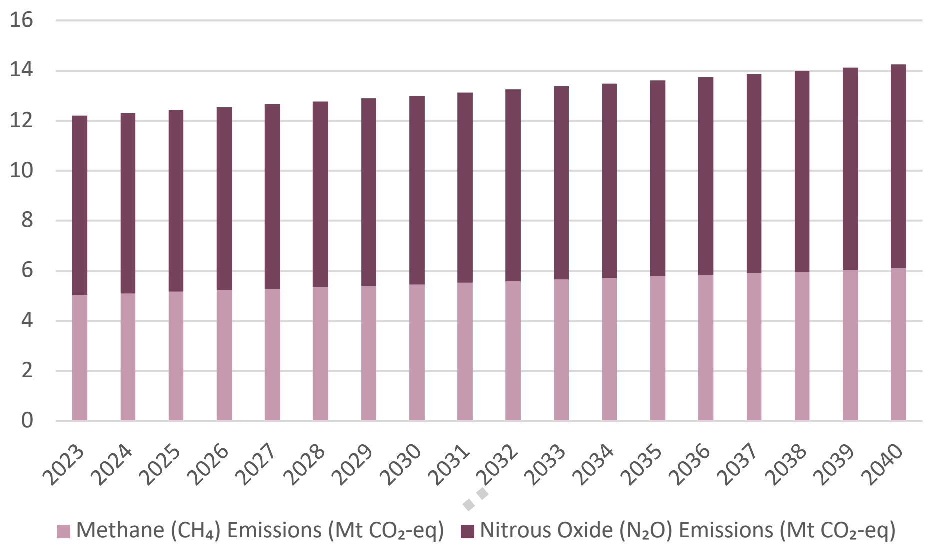


The following methodology was used to estimate the GHG emission forecast for the wastewater sector in Pakistan:

- Historical Data Analysis: Data from 2000 to 2024 on CH4 and N2O emissions from the wastewater sector in Pakistan was used, with sources listed in Figure 4.
- Calculating Growth Rates: The Compound Annual Growth Rate (CAGR) was calculated for both CH4 and N2O emissions. This shows the average yearly growth in emissions over the past 24 years.
- Forecasting Future Emissions: Using the CAGR, emissions were projected for 2025 to 2040. The forecast assumes that factors like population growth and waste management practices will continue to follow the same trends as in the past.
- Combining Historical and Forecast Data: The final dataset includes both historical emissions (2000-2024) and projections for 2025-2040, giving a clear picture of past trends and future expectations.

This approach provides a simple and reliable estimate of future emissions, assuming current trends remain unchanged.

Figure 7: GHG emission forecast from wastewater sector in Pakistan sector (adapted from [73], [74], [75])



3.4 Enhancing Data Collection and Management for GHG Inventory Development in the Waste Sector

Waste management services are administered at the sub-national level, encompassing various governmental jurisdictions such as regional, provincial, and municipal, as well as NGOs, corporations, facilities, and individual projects. As Table 3 illustrates, the participation of various actors in waste management creates a rather complicated and multi-faceted process of data production and gathering. Actually, different players are already collecting waste data for various purposes, using specific techniques at different levels of the waste management system, and reporting through different channels to different recipients.

This calls for awareness of who collects what data, where, when, and for what purpose. This would help avoid duplication and thus not overburden limited resources to ensure the collection of data is as precise, timely, and effective.

[73] https://www.globalmethane.org/partners/detail.aspx?c=pakistan

[74] https://link.springer.com/article/10.1007/s10163-023-01827-0#:~:text=The%20estimates%20of%20waste%20sector%27s,2%20emissions%20(Table%201).

[75] UN-HABITAT Pakistan Country Report 2023 B5 final

Table 3: Diversity of data on waste generation and collection (Source: GIZ/RWA [76])

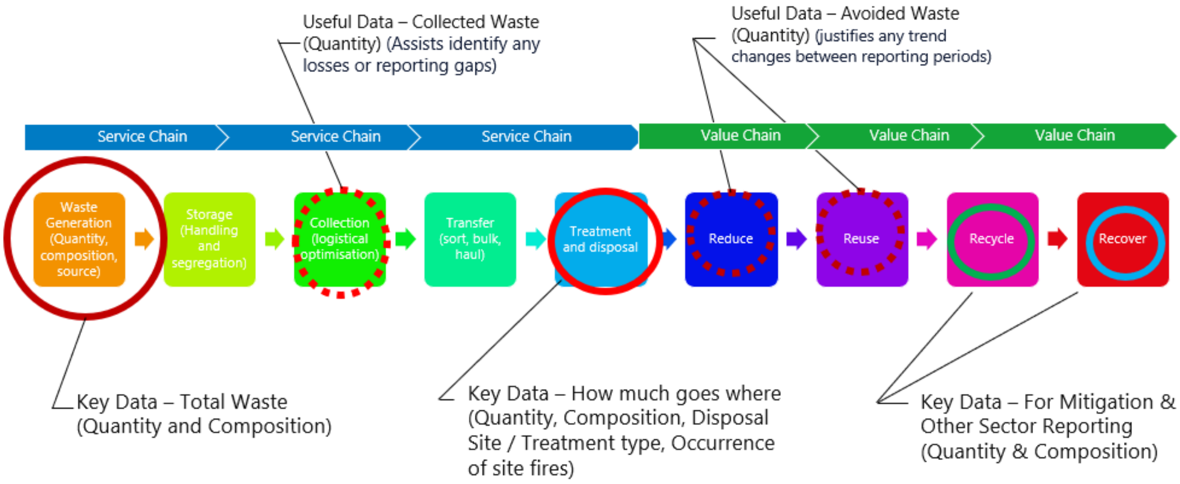
The diversity of data generation and collection	
Who (collects the data)	Landfill supervisor; Collection/fleet coordinator; Industrial operator (waste generators) Private contractors; Recyclers; Contract management team; Water and sewage department; Consulting firms; City administrator/mayor; Academic institutions; Global organizations (e.g., Eurostat, OECD, IFIs, UNSD, Basel); prospectors.
What (data is collected)	Waste amount (mass, density, volumes), population size, collection rates; transportation expenses, exports and imports, operating expenditures; Waste treatment and disposal facility scale (incoming and outgoing); composition; generation rates; income; residential categories, income brackets, energy consumption (kWh).
Where (is it collected)	Treatment/disposal facility entrance; industrial waste storage area; facility, city, municipal, national levels; on collection vehicles; ports and borders.
When (is it collected)	Each collection; monthly; quarterly; billing cycles; performance periods; annually; random sampling.
Why (is it collected)	Contract management (performance metrics); benchmarking; cost/quality oversight; supporting government decision-making; informing policies, investments, strategies, and planning; tracking progress toward goals; aiding enforcement and compliance monitoring; regulatory reporting; identifying industry trends; research.

This diversity in data collection results in varied data sets with different measurements and waste stream coverage, often leading to incompatibility. This situation creates data gaps for some stakeholders, data overload for others, and inconsistency in sector understanding, strategies, and plans.

Understanding the range of stakeholders and their specific data needs is essential to determine how to gather, interpret, and validate the necessary data correctly. Identifying and exploiting commonalities among these data sets should be prioritized to enhance consistency, accuracy, and effectiveness in waste management practices[77].

[76] Guideline on climate change mainstreaming into waste sector policies, 2021
[77] Guideline on climate change mainstreaming into waste sector policies, 2021

Figure 8: Key data needed for a typical integrated solid waste management service chain (Source: RWA Group[78])



3.5 Monitoring, Reporting, and Verification in the Pakistan Waste Sector

Having an open and transparent system that caters not only to greenhouse gas emission mitigation but also to adaptation practices is an essential step towards achieving the NDCs. However, the lack of reliable baseline data on the waste sector, as well as the absence of appropriate mechanisms for reporting and verifying local emission reductions in line with Pakistan's NDC targets, is currently a major challenge. We need to ensure that all waste related projects in the country incorporate MRV mechanisms for greater transparency and accountability. MRV data are also important in forward planning and for transparency with donors and other key stakeholders.

3.5.1 MRV Requirements of the UNFCCC

The MRV of Pakistan's NDC (2021) should comply with the requirements of the United Nations Framework Convention on Climate Change (UNFCCC) *Handbook on Measurement, Reporting and Verification for Developing Country Parties* (2014) and the Enhanced Transparency Framework (ETF) under the Paris Agreement. All countries are required, under the current international MRV framework, to submit their National Communications every 4 years and their Biennial Update Reports (BURs). They may also choose to submit National Adaptation Plans (NAPs) and Technical Needs Assessment (TNA) reports. The Enhanced Transparency Framework (ETF) under the Paris Agreement requires all countries, including Pakistan, to submit National Communications every four years and Biennial Update Reports every two years. These reports detail greenhouse gas emissions, mitigation actions, and support needed or received. For Pakistan, fulfilling these requirements is crucial for tracking progress toward its Nationally Determined Contributions (NDC), securing international support, and ensuring transparency and accountability in its climate efforts. This process strengthens domestic climate governance and builds trust in the global community.

This section proposes an institutional design for establishing an effective MRV system, based on the CDKN framework for the successful implementation of MRV from the sub-national to the national level in relation to Pakistan's NDC by vertically integrating local-government and sub-national MRV actions with national-level actions.

[78] ToT in Algeria on data needed fort he GHG estimation in waste sector, conducted by RWA Group

3.5.2 A Framework for Effective MRV System

The basic steps that need to be considered when developing an MRV system are provided in Table 4 below:

Table 4: A framework of key steps in effective monitoring, reporting, and verification at subnational and national levels Source: CDKN (2021[79]).

Key Activity	Description
Step 1 Review current MRV activities	**Review of the NDC** • Identify the type of MRV system that is required for the NDC (consider mitigation, adaptation, and climate finance). • Design the MRV system incrementally and roll out the system. • See to it that MRV is included in the updated NDC. **Evaluate current national MRV** Examine recent National Communication submissions to understand how data—such as those on mitigation, adaptation, and climate finance—were produced for these reports, including the frequency of data collection and the entities responsible (e.g., statistical offices, sectoral ministries, and related institutions).
Step 2 Set up institutional frameworks to oversee and coordinate MRV activities effectively.	**Set up an MRV steering group** • Form a group responsible for overseeing the gradual design and implementation of a national MRV system for adaptation, mitigation, and climate finance. This group could operate as a subgroup within a larger NDC implementation steering committee. • Align the group's work plan with the 5-year NDC cycle to ensure data collection that tracks progress toward NDC targets and informs policy decisions, such as the development of new policies or revisions to existing ones. **Select an overall lead institution for the MRV system** • Clearly establish a mandate that links the institution's role directly to MRV activities. • Endow the institution with the relevant competencies related to sustainability, adaptation, and mitigation. • Give the institution overall responsibility for establishing and managing the MRV system, with strategic direction from the steering group. **Develop appropriate rules and guidance** • Establish clear rules for data sharing that define what data will be shared, by whom, and the frequency of sharing among govern-ment ministries, departments, and agencies. These rules should apply to all relevant data holders, including non-governmental entities like academic institutions. They can be formalized through legislation or a memorandum of understanding (MoU) between data-sharing parties • Create and publish technical guidance related to Monitoring, Reporting, and Verification (MRV) to assist policy teams within the government and other stakeholders likely involved in the MRV

[79] https://ndc-guide.cdkn.org/book/planning-for-ndc-implementation-a-quick-start-guide/measuring-reporting-and-verification/

Key Activity	Description
	system. At minimum, this guidance should align with any internationally agreed rules and procedures. **Develop a reporting plan** • Develop a comprehensive reporting plan that considers the target audience, required data, reporting format, frequency, and assigned responsibilities. At minimum, the plan should fulfill UNFCCC requirements and any other transparency obligations outlined under the Paris Agreement. • Define a process for capturing and reporting actions from provincial governments, TMAs (Tehsil Municipal Administrations), municipalities, and other local government entities to the national level.
Step 3 Assess data gaps and needs	**Assess and prioritize data gaps** • Define the specific data needed to monitor the solid waste management (SWM) aspects of the Nationally Determined Contribution (NDC) and meet international MRV (Monitoring, Reporting, and Verification) requirements related to climate change. • After reviewing existing national processes, identify any data gaps, such as missing data, data that is unavailable or not collected in the required format or frequency, or data that does not meet quality standards. • Prioritize these data gaps in order of their relevance regarding domestic and international reporting needs. **Identify how existing MRV systems can be extended to address data gaps** • Map the current data flows, responsibilities, and processes for climate change data, and evaluate how they could be adapted to establish a system for tracking waste sector progress toward NDC implementation. • Explore additional MRV (Monitoring, Reporting, and Verification) systems that could serve both NDC and SDG goals. Consider how gender perspectives could be integrated into the MRV system, such as through gender-specific benchmarks and indicators to assess the impact of gender mainstreaming initiatives.
Step 4 Design MRV systems for mitigation, adaptation, and climate finance	**Design systems for mitigation, adaptation, and climate finance MRV** • Identify the necessary activities for developing the MRV systems. • Develop the systems by either connecting individual MRV systems or creating a single, integrated MRV system.
Step 5 Establish data management processes	**Develop systems for improving data quality** • Ensure data quality by using a variety of methods, such as verifying data independently, conducting internal audits, performing quality checks, and consulting with stakeholders. • Build data management systems that are transparent and easy to use. Decide whether to make the data accessible to everyone or restrict access through password protection for specific users. • For the time being, address any data gaps by using general estimates or international benchmarks until the data quality improves. • Create a plan to improve the data over time, outlining who will be responsible, the timeline, and what resources will be needed. This

Key Activity	Description
	plan could be part of the larger NDC implementation plan or a separate document.
Step 6 Build MRV capacity	**Determine capacity-building needs** • Identify where capacity-building is needed to design and implement each part of the MRV system. Strengthening local governments' ability to track and coordinate development plans related to the NDCs is a crucial area. • Look at where support is needed, both within the central MRV team and with other stakeholders involved in the system. Some key areas to focus on include: a. Improving the national greenhouse gas inventory and understanding the IPCC guidelines. b. Monitoring and evaluating the impact of mitigation and adaptation efforts, as well as their wider development benefits. c. Tracking climate finance through MRV. d. Ensuring proper data management, quality control, and archiving. e. Reporting to the UNFCCC and staying updated on the work of the Ad Hoc Working Group on the Paris Agreement. f. Setting up memoranda of understanding, legal frameworks, and other systems to guarantee data availability in the long term. g. Turning technical data into simple, clear messages for policymakers.
Step 7 Improve the MRV system over time	**Ensure the relevance of MRV reports** Establish a mechanism for ensuring that the output of the MRV systems can inform regular updates of the mitigation, adaptation, and climate finance planning processes, and that lessons learned can be integrated into actions taken for NDC implementation. **Consider ways to keep improving:** • Assess how well the MRV system is collecting and reporting data, and adjust the plan and systems based on what has been learned. • Gather feedback from stakeholders on how effective the MRV system is. • Collaborate with other countries to exchange lessons learned and share best practices

3.5.3 Implementing MRV Systems for the Pakistan NDCs

In centralized economies, the Monitoring, Reporting, and Verification (MRV) of a nation's Nationally Determined Contributions (NDCs) typically begins at the national level, cascading down to provinces, districts, and municipalities. However, a bottom-up approach—led by regional and municipal governments along with local organizations—can be equally effective in achieving strategic objectives, provided that these efforts align with the national NDC and its MRV requirements. This approach may be particularly well-suited for Pakistan, where provinces, municipalities, and cities exercise considerable control over their budgets and activities, and where subnational governments (SNGs) are already engaged in climate change and sustainability initiatives.

Recommendations for Implementing MRV Systems in Pakistan:

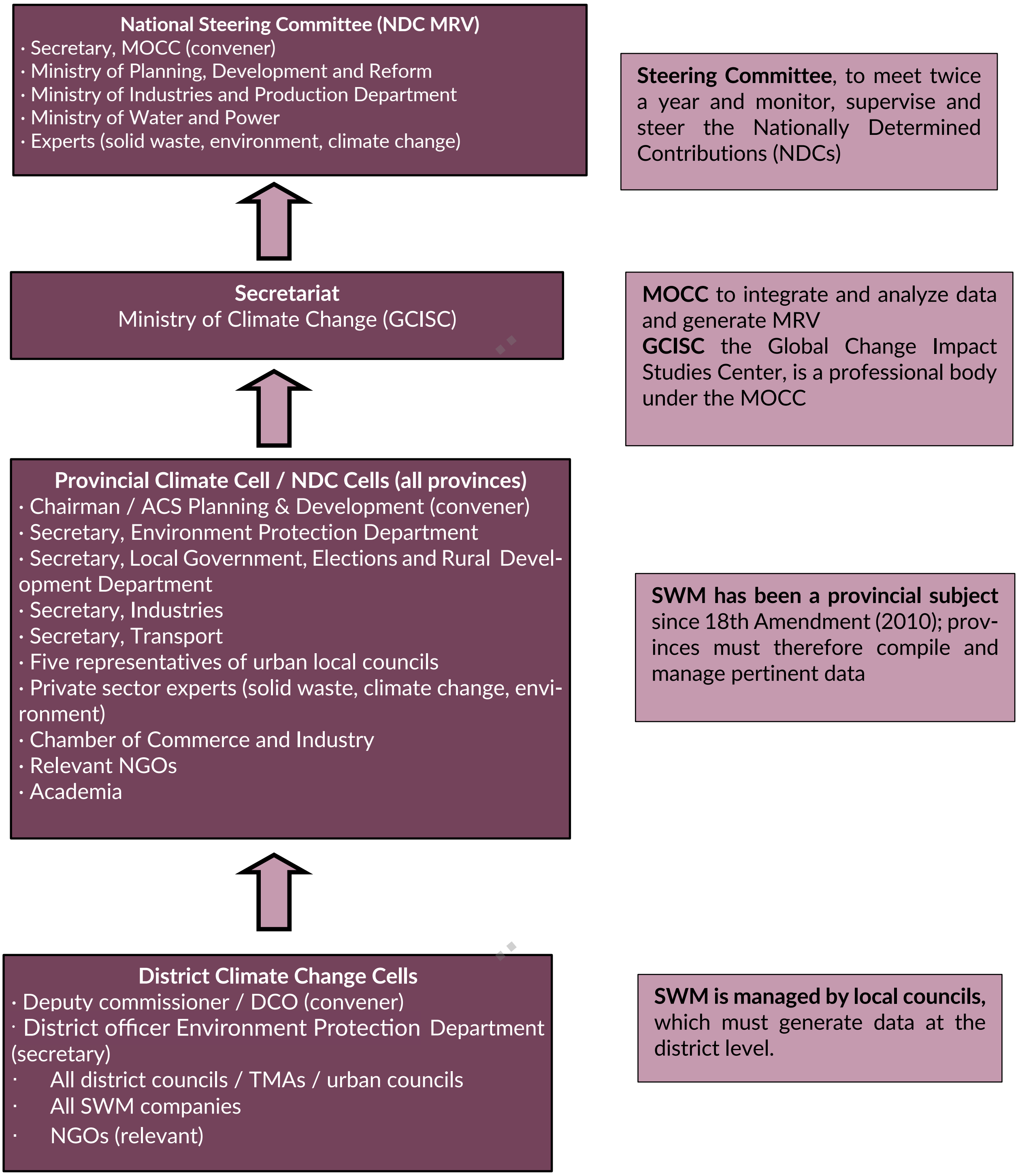
- Establish Clear Guidelines and Frameworks: Develop standardized MRV guidelines at the national level that can be adapted for use by provincial and municipal authorities. This should include clear definitions, methodologies, and reporting formats to ensure consistency and comparability across different levels of government.
- Create a centralized MRV framework that aligns national objectives with subnational priorities. This framework should facilitate data collection, reporting, and verification processes that are transparent and robust.
- Capacity Building at the Subnational Level: Invest in capacity-building programs for provincial and municipal authorities to enhance their technical skills in MRV processes. This could include training workshops, technical assistance, and the development of MRV toolkits tailored to local needs.
- Establish dedicated MRV units within provincial and municipal governments to oversee the implementation of MRV systems, ensuring that these units are adequately staffed and resourced.
- Promote Collaboration and Coordination: Foster strong collaboration between national and subnational governments, as well as with non-state actors, to ensure alignment of MRV activities with the national NDC. This could be achieved through the establishment of intergovernmental working groups or task forces.
- Encourage partnerships between subnational governments and international organizations already active in climate change mitigation and adaptation efforts. These partnerships can provide technical support, funding, and access to best practices.
- Develop a Centralized MRV Database: Create a centralized digital platform that consolidates MRV data from all levels of government. This platform should allow for easy access, sharing, and analysis of data, enabling the national government to track progress towards NDC targets more effectively.
- Ensure that the database includes tools for real-time data monitoring and validation, as well as for generating reports that can be used for both domestic and international reporting obligations.
- Pilot Programs and Scalability: Implement pilot MRV programs in selected provinces or municipalities to test the effectiveness of the proposed guidelines and frameworks. These pilots can provide valuable insights and lessons that can be used to refine the national MRV strategy.
- Identify successful subnational climate initiatives that could be scaled up to other regions, integrating them into the broader national MRV system.
- Regular Review and Adaptation: Establish a mechanism for regular review and adaptation of the MRV systems to ensure they remain relevant and effective in the face of evolving climate challenges and NDC requirements. This should include periodic stakeholder consultations and feedback loops.

By following these steps, Pakistan can implement an MRV system that is both comprehensive and adaptable, ensuring that subnational efforts contribute meaningfully to the country's overall climate goals. This approach not only strengthens the alignment between national and local climate actions but also enhances Pakistan's ability to meet its international climate commitments.

3.5.4 A Proposed Framework for Subnational to National NDCs Tracking in Pakistan

Figure 5 shows an example of how MRV for the Pakistan NDC could be organized among the various government institutions in the country.

Figure 5: Proposed Institutional Arrangements for MRV Data Flow



3.6 The potential of emission reduction in the waste sector

The waste and resource management sector are frequently overlooked despite its potential for emission reductions. This sector receives limited focus because it contributes relatively little to global GHG emissions compared to other sectors. Nevertheless, its potential merits significant attention. Currently, the sector accounts for an average of 3% of global emissions, but through measures such as recycling and recovery of material and energy from waste, it has the potential to achieve reduction rates of 15-20%[80] . Numerous studies and publications have estimated the GHG reduction potential of the waste and resource management sector.

Table 4: Emissions in the waste sector in the baseline scenario

Category	Pakistan (Mt CO_2-eq)	India (Mt CO_2-eq)	Afghanistan (Mt CO_2-eq)	China (Mt CO_2-eq)	Iran (Mt CO_2-eq)	Source
Solid Waste Disposal (Landfill)	10.23	78.00	1.20	120.00	12.50	[81] [82] [83] [84]
Wastewater Handling	11.40	62.00	0.90	89.00	9.80	
Incineration and Open Burning	0.092	3.00	0.50	11.00	1.80	
Recycling (GHG Savings)	-1.50	-5.00	-0.30	-15.00	-2.20	
Composting	0.3	0.8	0.05	1.2	0.2	

The table compares greenhouse gas (GHG) emissions from the **waste management sector** across **Pakistan**, **India**, **Afghanistan**, **China**, and **Iran**, focusing on critical categories such as **solid waste disposal (landfill), wastewater handling, incineration, recycling, and composting**. These emissions, expressed in **Mt CO_2-equivalents (CO_2-eq)**, offer insight into the environmental impact of waste management practices and identify areas for improvement in each country.

Solid Waste Disposal (Landfill): Pakistan produces **10.30 Mt CO_2-eq** from landfill emissions, which, although significant, remains well below the figures for **India** (78.00 Mt CO_2-eq) and **China** (120.00 Mt CO_2-eq). This reflects the larger waste generation capacities and higher population densities of these neighboring countries. **Afghanistan** (1.20 Mt CO_2-eq) and **Iran** (12.50 Mt CO_2-eq) have considerably lower emissions, indicative of their smaller urban populations and less developed solid waste management infrastructures. Pakistan's landfill emissions highlight the need

80 Guideline on climate change mainstreaming into waste sector policies, 2021

81 Pakistan, BUR-1, 2021

82 Emission profile of waste sector in Pakistan Volume 26, pages 283–294, (2024)

83 https://www.business-standard.com/economy/news/adb-to-give-200-mn-loan-to-india-for-solid-waste-management-in-100-cities-124073000939_1.html

84 https://www.asiapathways-adbi.org/2018/06/sustainable-funding-schemes-for-the-development-of-waste-management-projects-in-asia/

for improved landfill gas capture technologies to reduce methane emissions, which are the predominant GHG from this source[85],[86]

Wastewater Handling: In the wastewater sector, **Pakistan's** emissions stand at **11.40 Mt CO_2-eq**, reflecting its relatively advanced wastewater infrastructure compared to **Afghanistan** (0.90 Mt CO_2-eq) and **Iran** (9.80 Mt CO_2-eq). However, **India** (62.00 Mt CO_2-eq) and **China** (89.00 Mt CO_2-eq) report significantly higher emissions, primarily due to their larger urban and industrial sectors, which contribute to higher levels of methane (CH_4) and nitrous oxide (N_2O) emissions from untreated or poorly managed wastewater systems. For Pakistan, this indicates the potential to reduce emissions by improving industrial wastewater treatment facilities and adopting more effective wastewater recycling systems[87], [88]

Incineration and Open Burning: Pakistan's emissions from **incineration and open burning** stand at **0.091 Mt CO_2-eq**, similar to **Iran's** (1.80 Mt CO_2-eq) but much lower than **India** (3.00 Mt CO_2-eq) and **China** (11.00 Mt CO_2-eq). These emissions are typically associated with the open burning of waste, a common practice in countries lacking comprehensive waste management systems. Pakistan could benefit from scaling up energy recovery from waste incineration, similar to efforts seen in other countries, to reduce the overall environmental impact of open burning [89],[90]

Recycling (GHG Savings): The **GHG savings** from recycling in **Pakistan** (-1.50 Mt CO_2-eq) are modest when compared to **India** (-5.00 Mt CO_2-eq) and **China** (-15.00 Mt CO_2-eq), both of which have implemented more aggressive recycling programs. The limited recycling infrastructure in Pakistan indicates a need for greater investment in waste segregation and recycling facilities. **Afghanistan** and **Iran** demonstrate smaller savings (-0.30 Mt CO_2-eq and -2.20 Mt CO_2-eq, respectively), reflecting their nascent recycling efforts [91],[92]. Enhancing recycling rates could significantly reduce overall GHG emissions in Pakistan by diverting organic waste from landfills.

Composting: Pakistan's emissions from composting are **0.3 Mt CO_2-eq**, which is comparable to those of **Iran** (0.2 Mt CO_2-eq) and slightly below **India** (0.8 Mt CO_2-eq). **China**, with a more developed composting infrastructure, leads the region with **1.2 Mt CO_2-eq** emissions. Composting organic waste is a critical area where Pakistan could reduce methane emissions from landfills, while simultaneously enhancing soil fertility and reducing the need for chemical fertilizers[93],[94]

In comparison to its neighboring countries, **Pakistan's waste management emissions** are significant but lower than those of **India** and **China** due to its smaller population and slower industrialization. However, there are clear opportunities for Pakistan to reduce emissions, particularly through scaling up **recycling**, **composting**, and **energy recovery** from waste incineration. Learning from the more aggressive policies in India and China could enable Pakistan to enhance its waste management practices and contribute to global climate mitigation efforts.

---

85 Pakistan, BUR-1, 2021

86 Emission profile of waste sector in Pakistan Volume 26, pages 283–294, (2024)

87 Inter-governmental Panel on Climate Change (IPCC). (2007). Climate change 2007: Mitigation of climate change: Working Group III: Wastewater and human sewage CH_4 and N_2O emissions. Retrieved from archive.ipcc.ch

88 United Nations Framework Convention on Climate Change (UNFCCC). (2015). Total GHG emissions by country. Retrieved from di.unfccc.int

89 https://www.adb.org/projects/46248-001/main

90 https://www.asiapathways-adbi.org/2018/06/sustainable-funding-schemes-for-the-development-of-waste-management-projects-in-asia/

91 https://www.adb.org/projects/46248-001/main

92 https://www.asiapathways-adbi.org/2018/06/sustainable-funding-schemes-for-the-development-of-waste-management-projects-in-asia/

93 https://www.adb.org/projects/46248-001/main

94 https://www.asiapathways-adbi.org/2018/06/sustainable-funding-schemes-for-the-development-of-waste-management-projects-in-asia/

This comparison highlights the critical role that enhanced waste management strategies could play in reducing GHG emissions across the region, with Pakistan having considerable room for improvement.

Considering solutions from a circular economy perspective can greatly enhance the potential for reducing environmental impacts. This approach involves:

Reducing Dependence on Primary Raw Materials: Utilizing recycled and renewable resources to lessen the need for virgin materials.

Optimizing Production Processes: Streamlining manufacturing to increase efficiency and reduce waste.

Material Substitution: Replacing conventional materials with alternatives that require less energy to produce and emit fewer pollutants throughout their lifecycle.

Re-modelling Distribution Networks: Enhancing the efficiency of supply chains to minimize emissions and waste.

Designing for Waste Reduction: Creating products that generate less waste and are easier to dismantle and recycle.

The circular economy is a transformative concept with significant economic impact, similar to the broad effects of climate change. It is being gradually integrated across various economic sectors, fundamentally altering traditional economic practices. Europe's Green New Deal highlights the importance of circular economy solutions alongside climate change mitigation strategies. The primary strategies of the circular economy are illustrated in the accompanying figure.

4. Decarbonization technologies and their application in Pakistan

Methane is a greenhouse gas responsible for approximately 30% of global warming since preindustrial times and has about 80 times the warming impact of carbon dioxide over a 20-year period[95], [96]. As the third-largest contributor to global methane emissions, the waste sector accounts for about 20% of the global total[97]. Methane emissions from municipal solid waste (MSW) are projected to increase by 13 million tons annually over the next decade, equivalent to the GHG emissions from 278 coal-fired power plants operating for a year[98].

A study by the Netherlands Institute for Space Research revealed that methane emissions from landfills in Lahore, Pakistan, exceed 19 tons per hour[99]. This is equivalent to the GHG emissions from 1 million gasoline-powered passenger cars driven for a year[100]. The study found that methane emissions in Lahore, estimated using satellite data, are twice as high as those recorded in city inventories[101]. These findings highlight significant opportunities for both immediate and long-term methane reduction in the waste sector.

95 https://www.unep.org/news-and-stories/story/methane-emissions-are-driving-climate-change-heres-how-reduce-them

96 Ebun Ayandele, Yuchen Wu, and Tom Frankiewicz, A Playbook for Municipal Solid Waste Methane Mitigation: Recommendations Based on Global Waste Management Archetypes, RMI, 2024, https://rmi.org/insight/waste-methane-assessment-platform/

97 Global Methane Initiative, Global Methane Emissions and Mitigation Opportunities

98 US Environmental Protection Agency, "Greenhouse Gas Equivalencies Calculator,"

99 Dylan Carter, "Landfills Identified as 'Super Emitters' of Greenhouse Gases," The Brussels Times, August 11, 2022,

100 US Environmental Protection Agency, "Greenhouse Gas Equivalencies Calculator,"

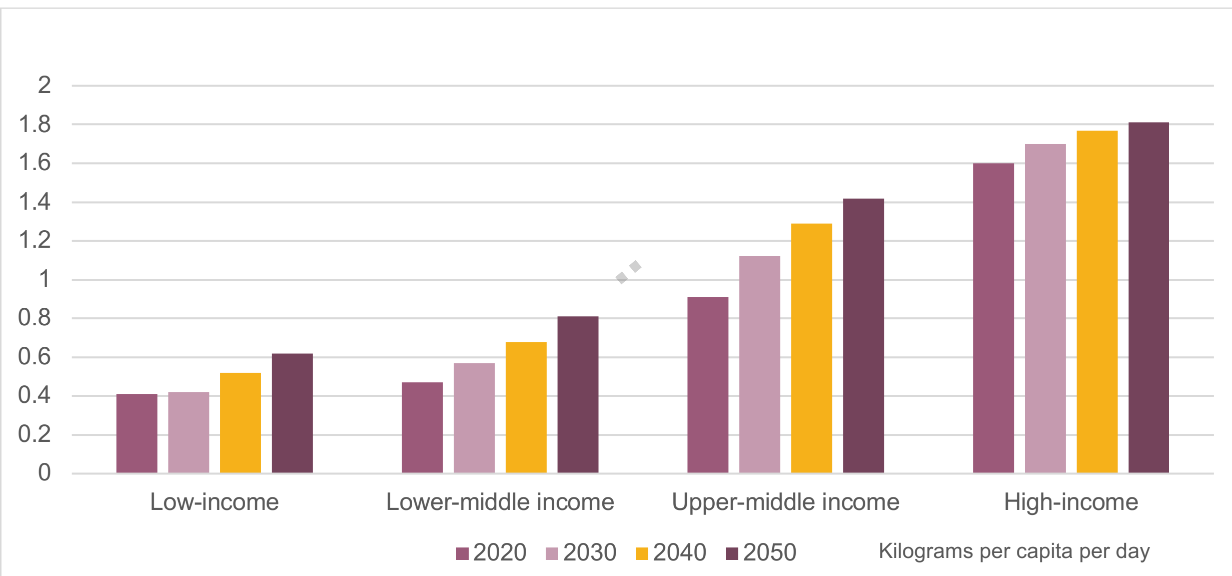
101 US Environmental Protection Agency, "Greenhouse Gas Equivalencies Calculator,"

Landfilled waste organic materials, including food scraps, yard waste, paper, and cardboard, decompose in the absence of oxygen, producing LFG through anaerobic decomposition. The composition is primarily methane and CO_2. If uncollected, the gas is released to the atmosphere. Organic material segregation at the point of generation, before land disposal, will prevent methane generation. Food and yard waste constitute the highest percent of MSW: 32% in high-income countries and as high as 56% in low-income countries.[102] The most effective way to reduce methane emissions is to stop organic waste from ending up in landfills and dumpsites. Once it's diverted, this waste can be treated and turned into useful products or resources.

Methods that will reduce the amount of organic waste disposed of in landfills and dumpsites before final disposal should be given priority. Organic waste, nonetheless, still goes to landfills and dumpsites where it undergoes decomposition and generates methane. A modern sanitary landfill may be fitted with gas collection and control systems (GCCS), which is a network of wells and blower/flare systems to extract LFG and control its migration. Although GCCS installation at a disposal site reduces methane emissions from decomposing waste, LFG collection efficiency and fugitive emissions due to decomposing waste can be significantly different among various landfills. This is because of the differences in landfill design, usage of cover over the landfill, and GCCS and flaring system efficiencies.

The adoption of waste recovery and treatment, landfill gas-to-energy, and other waste management technologies varies significantly across regions, influenced by factors such as economic development, regulatory frameworks, available financing, and geographic considerations like land availability and cultural norms. For instance, the World Bank's "More Growth, Less Garbage" report indicates that in 2020, high-income countries generated approximately four times more waste per capita than low-income countries. Furthermore, waste generation is projected to increase substantially worldwide over the next three decades[103].

Figure 9: Projected global waste generation by income group (Source: The World Bank[104])



[102] World Bank, https://blogs.worldbank.org/opendata/new-country-classifications-2016

[103] Kaza et al., More Growth, Less Garbage, 2021.

[104] MORE GROWTH, LESS GARBAGE, By Silpa Kaza, Siddarth Shrikanth, and Sarur Chaudhary

The abatement strategies are divided into four broad categories: (1) source reduction, (2) waste diversion, (3) waste disposal, and (4) crosscutting elements. Source reduction and waste diversion measures must take place before waste reaches the disposal sites, while waste disposal strategies are required once the waste reaches disposal sites. Cross-cutting solutions: These address the whole waste management process with a view to improving policy and regulatory frameworks, increasing transparency of emissions, assuring financing, and building awareness and capacity among the stakeholders. This section of the study aims to help Pakistan develop more effective solutions for methane mitigation in solid waste management.

a. Waste Prevention

The waste management hierarchy positions waste prevention at the top of the methods of managing waste, including organic waste. Waste prevention, also known as source reduction, denotes measures to be taken to minimize waste generation at source. In the context of solid waste methane mitigation, these measures focus on the reduction of biodegradable waste production and the related emissions.

One-third of the world's food production, by weight, is lost or wasted between the farm and the table[105]. As current trends continue, studies indicate that food loss and waste will double by 2050[106]. will not only contribute to reduced methane emissions but also to reduced food insecurity and malnutrition. Also, it reduces economic losses for businesses and consumers while increasing financial security for farmers[107].

According to a report by the Ministry of National Food Security & Research, Pakistan annually wastes 26% of its food production. The report revealed that this amounts to 19.6 million tonnes of food waste each year[108].

The report further revealed that most food items are wasted for not meeting the criteria of appearance, size, and color, despite efforts to ensure food security. According to the Ministry of National Food Security & Research, a significant portion of food items are excluded from the supply chain and wasted for various reasons. Additionally, the report highlighted that a substantial amount of food stored in kitchens is wasted each year after reaching its expiry date.

As the predominant part of the organic waste stream, **preventing food and organic waste is the most effective and preferred method to reduce methane emissions from municipal solid waste** (MSW). To develop robust methane abatement solutions, it is crucial to understand the factors contributing to food loss and waste, including inadequate distribution and storage infrastructure, suboptimal packaging, poor food management, and consumer behaviors. A study published by Samina Khaled et al. *"Food waste: causes and economic losses estimation at household level in Pakistan"*[109], aimed to (1) examine the food waste behavior of the respondents and (2) determine the level of monetary losses from food waste. To achieve these objectives, a questionnaire survey and a 24-hour sample of food waste were collected from 51 households in Tehsil Kahror Pakka, District

105 Kaza et al., What a Waste 2.0, 2018.

106 Liz Goodwin, "The Global Benefits of Reducing Food Loss and Waste, and How to Do It," World Resources Institute, https://www.wri.org/insights/reducing-food-loss-and-foodwaste

107 Ebun Ayandele, et al. A Playbook for Municipal Solid Waste Methane Mitigation, 2024

108 https://www.nation.com.pk/02-May-2023/pakistan-yearly-wastes-food-worth-dollar-4-billion-report

109 Khalid, S., Malik, A.U., Ullah, M.I. *et al.* Food waste: causes and economic losses estimation at household level in Pakistan. *Environ Sci Pollut Res* **30**, 99284–99297 (2023). https://doi.org/10.1007/s11356-023-28775-4

Lodhran, Punjab, Pakistan. The survey[110] focused on the levels of food waste and the respondents' knowledge and behaviors regarding food waste. An economic estimation of food waste was also conducted. In the survey, respondents from both high- and low-income households reported higher losses in fruit and vegetables (31%; 32%) and peel and scrap (53%; 48%), while egg losses were lower (4%; 4%) among various food waste categories. The main reasons for food waste included a preference for fresh food and a lack of time to save food. Monetary losses from food waste were higher in high-income households, amounting to US$ 12.8 (Rs. 3677.01) per capita per annum, compared to low-income households.

A well-publicized national strategy can raise public awareness and educate the public about sustainable consumption, providing consumers with actionable steps and increasing participation in food loss and waste (FLW) interventions. A coordinated strategy can also include reporting and monitoring requirements to enhance data collection and analysis on food waste, offering insights for better policy decision-making and progress tracking.

Key findings and recommendations for Pakistan

- Food waste research is still an embryonic field with large knowledge gaps in supply chain operations, the volume of food waste, and its causes.
- Set a national target for food waste reduction with a named lead ministry responsible and a clear mandate to act.
- While there is increasing political pressure to address food waste, more investment is required in education, training, adoption of technology, infrastructure improvement, and enhanced communication, especially in trades that involve smallholder farmers.
- There should be a nationwide legal framework for food waste reduction or food donation.
- Practical solutions to reduce food waste should mobilize the collective experience and expertise of stakeholders from across the supply chain, working in collaboration with researchers to solve specific food-related challenges.
- It would need the development of systematic data collection and reporting mechanisms that help quantify the waste streams, provide comparable data across countries and companies, and set measurable improvement targets.
- The production of animal feed from food waste is an important strategy in Europe. Although this can't be directly applied to global food chains, it may inspire context-specific solutions in Pakistan.
- Strategies to handle excess and leftover food, including food donations to charity, selling prepared foods, and offering price reductions, will help lessen wastage in the country of consumption. They could also be an example for Pakistan.

b. Diverting waste

In this respect, it is very relevant to avoid sending biodegradable organic waste into landfills and dumpsites for the prevention of emissions of methane from future waste streams. Diversion can

[110] Khalid, S., Malik, A.U., Ullah, M.I. *et al.* Food waste: causes and economic losses estimation at household level in Pakistan. *Environ Sci Pollut Res* **30**, 99284–99297 (2023). https://doi.org/10.1007/s11356-023-28775-4

take place at several stages: during the generation of waste, collection and transport, and also in the recovery and treatment phases.

Despite improvements worldwide in separating recyclables such as metals, plastic, and paper at the source, many cities do not mandate the segregation of food and yard waste by households and commercial establishments at the point of generation. In areas where source segregation initiatives are in place, waste generators often struggle to effectively separate organic materials due to a lack of awareness and challenges in changing established behavioral patterns[111].

Organic waste separation at source strategies are designed to separate organic waste right at the source of generation. Programs can begin with pilot projects in places that produce large amounts of organic waste, for example, restaurants, food markets, universities, and apartment complexes. These pilot projects allow testing of effective means, collection of insights, and readiness for a broader roll-out. This is seen to gradually scale up to include all waste generators within the program's area of operation.

Key findings and recommendations for Pakistan

- Develop solid waste management plans with a set of goals in terms of segregated biodegradable waste collection.
- Provide color-coded bins with explicit instructions to waste generators.
- Organize public awareness activities to educate the community. Decrease the amount of residual waste collection, while on the increase is the collection of biodegradable waste.
- Monitor the status of segregated organic waste collection.
- Establish centralized composting facilities for the treatment of organic wastes.
- Engage community leaders to ensure support and participation.
- Offer training programs to develop the capacities of waste management officers.

Waste collection systems play a vital role in connecting communities with treatment and disposal facilities. While Organic waste separation at source start at the waste generator, it's crucial to maintain their separation during transport to processing facilities to prevent contamination. In Pakistan, however, the current collection trucks aren't equipped to transport segregated organics, as they often become contaminated with mixed waste like plastic, glass, and other unwanted materials, as well as leakage from wet waste. This contamination leads to lower-quality end products, such as compost and biogas, making them harder to sell. Moreover, additional costs are incurred when impurities must be removed to improve product quality and make organic recycling more economically viable.

Municipalities and waste management companies, in Pakistan, should, therefore, look at the capacity of their fleets with existing vehicles in order to determine whether there is a need for specialized vehicles. The purchase of specialized trucks designed to haul organic waste to processing facilities becomes necessary if modifying the existing fleet is impossible.

[111] Ebun Ayandele, et al. A Playbook for Municipal Solid Waste Methane Mitigation, 2024

Figure 10 :Unmannerly Carrying of Waste (Source: Hafsa Yasin et al. 2017) [112]

Reducing residual mixed waste collection frequency can incentivize proper separation of biodegradable waste. Good practice would be to collect food waste more often than residual waste and other recyclables, e.g., daily or weekly for food waste, and every other day or week for the latter two[113].

Waste haulers will need to look at the cost-effectiveness of collection routes and use existing ones where possible. For example, communities that already require separate collection of yard waste can use existing yard waste bins and routes to accommodate food waste, thereby maximizing collection efficiency[114].

The success of organic waste diversion hinges on the availability of adequate infrastructure to process and manage the diverted organic fraction. In several provinces in Pakistan, the necessary infrastructure to treat and convert organic waste into beneficial end products is either non-existent or insufficient.

c. Organics Processing

Effective methane mitigation through organic waste diversion depends not only on segregating organics via source separation or mixed waste processing but also on having sufficient processing options that do not emit methane[115]. Potential processing methods for organic waste include anaerobic digestion, composting, gasification, and waste-to-energy (WTE) facilities. Limited or prohibitively expensive processing capacity will impede efforts to divert organic waste from landfills and dump sites. Building the necessary infrastructure will require substantial capital investments. Conducting further studies to assess the additional processing capacity and scale-up costs needed will help facilitate investment and the creation of incentive programs for developing these facilities.

---

112 Hafsa Yasin1* and Muhammad Usman1 Site investigation of open dumping site of Municipal Solid Waste in Faisalabad. Earth Sciences Pakistan (ESP)1(1) (2017) 23-25

113 British Columbia Ministry of Environment and Climate Change Strategy, Best Management Practices for Curbside Collection of Residential Organic Waste, accessed October 27, 2023,

114 Ebun Ayandele, et al. A Playbook for Municipal Solid Waste Methane Mitigation, 2024

115 EESI, "Fact Sheet — Biogas: Converting Waste to Energy,"

d. Methane Generation in Disposal Sites

For Pakistan and other developing economies, the most significant opportunity to reduce methane emissions from non-diverted organic waste lies in rehabilitating dump sites into sanitary landfills equipped with gas capture systems.

Figure 11 : View of open dumping sites in Pakistan (Source: Muhammad et al [116] and brecorder.com [117])

The existing municipal waste management system in Pakistan is inadequate. Generally, municipalities handle the services, which typically involve only partial waste collection and either open dumping or burning. Open dumping poses significant risks to both health and the environment. The uncontrolled burning of waste releases toxic fumes and greenhouse gases, contributing to air pollution and climate change. These impacts highlight the urgent need for improved waste management practices to protect public health and the environment.

Upgrading open dump sites to sanitary landfills with gas capture systems, liners, landfill covers, and other control systems significantly reduces methane emissions and improves the health and safety of nearby communities. The EPA estimates that landfill gas (LFG) collection systems capture 75% of the methane generated at active sanitary landfills[118]. Although there is uncertainty about achieving these levels in practice, converting dump sites into sanitary landfills with gas capture systems can still substantially decrease methane emissions and associated health hazards[119].

116 Muhammad et al. a case study of groundwater contamination due to open dumping of municipal solid waste in Faisalabad, Pakistan, 2017

117 https://www.brecorder.com/news/40251632/punjab-has-only-one-landfill-site-epd-report-msw-management-cos-in-only-seven-districts

118 "Quantifying Methane Abatement Efficiency at Three Municipal Solid Waste Landfills," US Environmental Protection Agency, 2012,

119 Ebun Ayandele, Kenzie Huffman, Matt Jungclaus, Eugene Tseng, Riley Duren, Daniel Cusworth, and Bryan Fisher, Key Strategies for Mitigating Methane Emissions from Municipal Solid Waste, RMI, 2022

The recovered landfill gas (LFG) can be used in various energy projects, such as generating electricity, fueling industrial boilers, dryers, or cement kilns, or upgrading to pipeline-quality natural gas. However, the high cost of rehabilitating dump sites and the lack of financing and incentives significantly hinder the advancement of methane management in developing countries.

Key findings

- Financial barriers hinder the development of LFG projects in Pakistan.
- the lack of capacity at the governmental level in understanding the NDCs, GHG emissions
- There is a lack of knowledge and training among landfill operators in Pakistan on available financing options and implementing LFG projects.
- A supportive regulatory framework and government incentives are essential for LFG project success in Pakistan

Recommendations for Pakistan

- Improve access to affordable capital and establish government incentives for LFG projects.
- Organize training programs for landfill operators on financing options and technical implementation.
- Develop and enforce regulations supporting LFG recovery and utilization, and create a framework for generating carbon credits.

Effective landfill management in the Republic of Pakistan is essential and serves as a foundational step in understanding the repercussions of uncontrolled waste disposal. The potential impacts of such dumping primarily relate to emissions such as greenhouse gases, particularly methane from anaerobic decomposition of organic matter, as well as particulate matter generated by fires.

Exposed wastes are susceptible to catching fire during dry months and to water infiltration into the water table during wet seasons. Additionally, increased production of leachate accelerates the decomposition process, leading to the release of methane and other gases. The high biochemical oxygen demand and toxic leachate can deplete oxygen levels in surface waters, turning them anaerobic and leading to significant methane production[120] .

To enhance waste storage conditions and mitigate methane production and biochemical oxygen consumption, it is essential to regularly employ machinery designed for compacting and covering waste. This practice facilitates better access to the landfill, optimizes space utilization, and prevents the burning of exposed waste[121] .

[120] Guideline on climate change mainstreaming into waste sector policies, 2021
[121] Guideline on climate change mainstreaming into waste sector policies, 2021

4.1 Technologies and solutions for the mitigation of GHG emissions in the waste sector

After identifying the potential for GHG emissions reduction in this sector, it is crucial to understand the technologies and solutions that can aid in achieving these reductions. Improper waste management practices—such as burning, illegal dumping, lack of treatment, and insufficient recycling—significantly contribute to GHG emissions. The technologies outlined below each have varying degrees of potential to mitigate GHG emissions. The most significant source of mitigation is preventing biodegradable organic materials from reaching disposal sites, as already mentioned, where they generate methane. Additionally, there are various other sources of GHG mitigation that contribute to this effort.

Applying a cover material on the landfill can significantly oxidize the methane produced within the landfill[122] . Moreover, recovering and flaring landfill gas will also help in reducing methane emissions. The text below summarizes the appropriate waste streams and treatment and recovery option for waste management (Adapted from [119])

a. Residual and Raw Waste: Garden and Food Wastes

Mechanical-biological treatment

- **Description:** A facility that integrates mechanical separation methods with biological treatment to either stabilize or dry the organic portion of waste. Mechanical separation is employed to recover relatively low-grade recyclable materials similar to the process in a dirty Materials Recovery Facility (MRF). The organic fraction can be utilized as Refuse-Derived Fuel (RDF), a feedstock for anaerobic digestion to produce biogas, or converted into a stabilized compost-like product with reduced volume.
- **Correlation with the current situation in Pakistan:** Currently, Pakistan does not have any dedicated Mechanical-Biological Treatment (MBT) facilities. For Pakistan to adopt MBT technology, there would need to be significant investment in infrastructure, technology transfer, and training to ensure effective implementation and operation.

Dirty Materials Recycling Facility

- **Description:** A facility utilizing various separation techniques to extract recyclable materials from mixed waste, typically of lower quality. The residual waste is then processed into refuse-derived fuel (RDF), which can be used in energy recovery facilities.
- **Correlation with the current situation in Pakistan:** Overall, Pakistan has a developing infrastructure for material recycling with a growing emphasis on expanding and improving these facilities to handle various types of waste efficiently. In Pakistan, several companies are utilizing waste as RDF, particularly in the cement industry. Key players include: Lucky Cement, DG Khan Cement, and Bestway Cement[123].

---

122 Guideline on climate change mainstreaming into waste sector policies, 2021
123 https://mapia.pk/blog/cement-industry-in-pakistan-booms-despite-challenges

Mechanical Heat Treatment

- **Description:** The primary objective of these processes is to sort a mixed waste stream into distinct components, providing additional opportunities for recycling, recovery, and in some cases biological treatment. This process sanitizes the waste, reduces its volume, and generates by-products like syngas and char, which can be utilized for energy generation and other applications.
- **Correlation with the current situation in Pakistan:** No data available.

Incineration treatment

- **Description:** All recyclables should be extracted from the processed waste. Modern facilities should include Waste-to-Energy or waste incineration with energy recovery.
- **Correlation with the current situation in Pakistan:** The main regulations relevant to waste management include the Pakistan Environmental Protection Act 1997, which lays the groundwork for managing all types of waste, including municipal solid waste.

Landfill

- **Description:** The systematic disposal of waste in landfills under controlled conditions allows for the recovery of energy. This energy can be obtained by collecting gases produced during the natural decomposition of the waste.
- **Correlation with the current situation in Pakistan:** Currently, the most commonly used method for municipal waste treatment is landfilling, often in uncontrolled conditions.

b. Waste stream: Commingled Dry Recycling

Clean Materials Recycling Facility

- **Description:** Mixed dry recycling is sorted into different fractions through a combination of mechanical and manual separation techniques and conveyors. The fractions can be selected based on their value with varying levels of purity achieved depending on the demands of the end market.
- **Correlation with the current situation in Pakistan:** Pakistan should promote and implement selective collection systems across all localities targeting both the household and production sectors as well as enhancing sorting, composting, and recycling facilities.

c. Waste stream: Refuse Derived Fuel

Incineration treatment

- **Description:** When incinerating pre-treated residual waste such as RDF, the feedstock is burned to reduce its volume and to recover energy by generating steam, which can be used in a steam circuit to produce electricity and/or heat. Metals can be extracted from the resulting bottom ash and prepared for re-melting and reuse.
- **Correlation with the current situation in Pakistan:** Considering the relatively low fraction of inorganic waste, low calorific value of mixed waste (less than the minimum 3000 btu/lb required),

and a high moisture content up to 70%, this option is less feasible. However, it is possible with segregation and drying or co-mixing with other fuel.

Co-combustion

- **Description:** RDF serves as an alternative feedstock in conventional power plants when combined with fossil fuels or traditional feedstock and as an auxiliary fuel in industrial settings such as cement kilns.
- **Correlation with the current situation in Pakistan:** In the recent past, production of RDF and its use as a coal substitute in cement factories (at least four plants in Punjab) have been implemented in Lahore and Multan. However, feasibility depends on coal prices as it needs segregation, processing, and transportation to factories, which are away from the large cities where RDF is available. The potential market is there and could be an option in an integrated waste management facility.

d. Waste stream: Garden wastes

Open composting

- **Description:** Garden waste typically has lower moisture content and fewer hazardous elements than mixed organic waste, making it ideal for aerobic composting, often done in open environments. While open composting uses the same biological processes as in-vessel composting, it lacks controlled conditions and thus takes longer to decompose.
- **Correlation with the current situation in Pakistan:** Reduction in methane emissions that would occur from anaerobic decomposition of garden waste. Reduction in emissions from the production and use of synthetic fertilizers by providing a natural alternative compost.

e. Waste stream: Mixed organic waste

Open composting

- **Description:** Mixed organics, which include food and other potentially hazardous or nuisance substances, necessitate in-vessel treatment. In-vessel composting involves breaking down the feedstock within an enclosed aerobic environment resulting in compost that can be applied to agricultural land.
- **Correlation with the current situation in Pakistan:** There is hardly any significant example in Pakistan. There are some small-scale pilots in universities and research institutes. The most common practice is windrow composting.

Dry anaerobic digestion

- **Description:** Anaerobic digestion employs natural microbes to break down materials in an oxygen-free environment, producing biogas (which can be used in combined heat and power (CHP) engines or as a substitute for natural gas) and nutrient-rich digestate. The digestate can be applied to land directly or after dewatering, which is preferable if there is no immediate end user.
- **Correlation with the current situation in Pakistan:** Pakistan should encourage the recovery of waste through aerobic and anaerobic processes and strengthen composting and fermentation capacities with a goal of establishing at least one facility per province.

f. Waste stream: Food wastes

Wet anaerobic digestion

- **Description:** Anaerobic digestion employs natural microbes to break down and decompose food waste, including animal products, in an oxygen-free environment, producing biogas and nutrient-rich digestate. The biogas can be used in combined heat and power (CHP) engines or processed to replace natural gas. The digestate can be applied directly to land or after dewatering, which is preferable if there is no immediate end user.

- **Correlation with the current situation in Pakistan:** Pakistan has significant potential for biogas generation due to its large livestock population and agricultural activities. In 2018, the potential production from livestock manure alone was estimated to be 417.3 million tons, which could generate around 26,871.35 million cubic meters of biogas[124]. Currently, several biogas plants are operational, focusing on waste from livestock farming and processing agricultural products. These plants help in producing biogas for energy and nutrient-rich digestate that can be used as fertilizer, contributing to sustainable waste management and energy production[125]

In-vessel composting

- **Description**: Food waste is suitable for in-vessel composting if its moisture content is appropriate or if it is blended with a co-substrate to optimize the digestion process. In-vessel composting decomposes the feedstock in an enclosed aerobic environment, producing compost suitable for agricultural or horticultural land applications.

- **Correlation with the current situation in Pakistan**: While IVC technology is not yet widespread in Pakistan, its application is feasible and beneficial, particularly for urban waste management and sustainable agricultural practices. Research and pilot projects have demonstrated the benefits of IVC for processing food waste and other organic materials. These projects highlight the potential for IVC to improve waste management practices by reducing greenhouse gas emissions, producing high-quality compost, and diverting waste from landfills [126].

124 https://link.springer.com/article/10.1007/s11356-023-28767-4
125 https://link.springer.com/article/10.1007/s11356-023-28767-4

126 https://link.springer.com/chapter/10.1007/978-3-031-37428-9_43

4.2 Cost Analysis for selected technologies

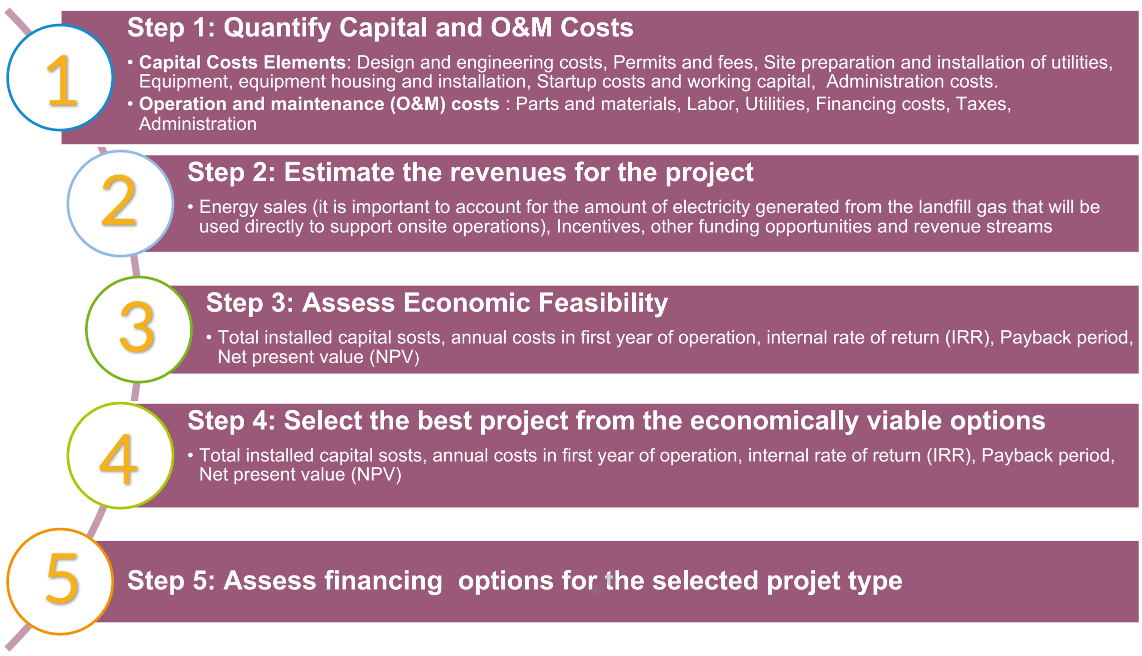
4.2.1 Landfill gas with energy recovery as mitigation technology

Landfilling continues to be a common method for disposing of municipal solid waste (MSW). In the absence of oxygen, biodegradable waste in landfills breaks down over time, producing landfill biogas (LFG), which mainly consists of methane (CH_4) and carbon dioxide (CO_2), along with a small amount of non-methane organic compounds[127],[128]. Methane emissions from these sites, known as fugitive CH_4 emissions, have a high global warming potential (GWP) and make up about 5% of the world's annual human-caused GHG emissions[129]. In this section, only a primary preliminary economic feasibility assessment will be presented, that means only standard cost estimates.

For project development, a detailed feasibility studies incorporate project-specific cost and benefit estimates is needed. These include cost quotes for specific equipment models suitable for the landfill, right-of-way costs for projected pipeline routes and current landowners, state-specific permitting requirements, and specific financing methods and interest rates.

The following figure summarizes the costs evaluation process.

Figure 12: costs evaluation process (source: lmop[130])



4.2.2 Composting as mitigation technology

Based on the projected size of the composting facility, the capital expenditure (CAPEX) should be calculated in terms of unitary cost in local currency, in the below example are presented in U.S. dollars per ton of treatment capacity (source: CCAP[129]). The table below shows an example of CAPEX for the development of a composting facility with forced aeration for 20,000 Tons Per

[127] Amini, et al. A. Comparison of First-Order-Decay Modeled and Actual Field Measured Municipal Solid Waste Landfill Methane Data. Waste Manag. 2013, 33, 2720–2728

[128] Machado, et al. Methane Generation in Tropical Landfills: Simplified Methods and Field Results. Waste Manag. 2009, 29, 153–161.

[129] Bogner ; et al. Waste Management, in Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. 2007.

[130] https://www.epa.gov/lmop/basic-information-about-landfill-gas

Annum (TPA). These costs exclude expenditures for land purchase, obtaining licenses and authorizations from local authorities, and the detailed planning of the facilities.

Table 5: Example of CAPEX for the development of a composting facility with forced aeration for 20,000 TPA (55% FW) (Source: CCAP[131])

Civil Works and Equipment	Items	$/ton
Civil works		35
Land preparation		
Fence		
Pavements (including grid floor for ACT and 1st curing step)		
roof (Reception, ACT, compost storage)		
Offices		
Equipment		108
Process control equipment		
Electric system		
Weighing bridge		
GW shredder	30 m^3/h	
Mixer	50-60m^3/h	
Bio-cells (ACT)	8	
Fans (for ACT and curing)		
Drum screen	10-12mm	
Air classifier	20m^3/h	
Wheel loaders		
Total		**143**

The operational expenditure (OPEX) for the planned composting facility is estimated by considering the primary costs for:

- Maintenance and general management,
- Personnel,
- Energy and material purchases,
- Disposal of rejects.

The anticipated revenues include:

- Gate fees, with specific rates for green waste (GW) and food waste (FW),
- Sales of compost.

4.2.3 Anaerobic digestion as mitigation technology

Anaerobic digesters, also referred to as biogas plants, offer an improvement over traditional methods of digesting animal waste, such as those employed in landfills and other waste disposal sites. Biogas produced by these digesters mainly consists of methane (50-70%), carbon dioxide (30-40%), and trace amounts of other gases[132]. Digestate, a mixture of liquid and solid digested waste, is commonly used as a soil amendment. Biogas facilities are gaining popularity as a method for generating renewable energy and reducing waste. Biogas, a renewable energy

[131] High-level Pre-feasibility Study and Implementation Plan for an Organic Waste Treatment Project in the municipality of Quito, CCAP, 2007

[132] Nabi, D., Ashfaq, A., Riaz, H.B. (2019). Organic and Inorganic Contaminants from E-waste and Their Effects on Environment. In: Hashmi, M., Varma, A. (eds) Electronic Waste Pollution. Soil Biology, vol 57. Springer, Cham. https://doi.org/10.1007/978-3-030-26615-8_7

source, can be produced from organic waste, such as food scraps or animal manure. This clean and efficient fuel can be used to generate heat, electricity, and even power vehicles.

The cost of constructing a biogas facility varies widely based on several factors, including the facility's size, the type of feedstock used, and its location. According to Biogas World, the estimated cost of building a biogas facility ranges from $400 to $1,500 per wet ton of material processed[133].

The cost of constructing a biogas facility can differ significantly based on the facility's size, complexity, and location. It is essential to thoroughly evaluate all associated expenses before undertaking the construction of a biogas facility. Assessing the costs of a biogas plant involves considering several crucial factors, as following[134] :

Construction and infrastructure costs (CAPEX): The construction and infrastructure costs for a biogas plant encompass the following components:

- Land acquisition
- Designing, constructing, and commissioning the biogas plant
- Incorporating redundancy and phasing into the plant design
- Selecting the appropriate technology
- Automating the biogas production process
- Ensuring the process meets the desired quality standards for digestate and biogas
- Setting up laboratory facilities and office spaces

Operating and maintenance costs of a biogas plant (OPEX): These expenses relate to the ongoing management, operation, and upkeep of a biogas plant. Specifically, this category includes, but is not limited to:

- Labor for plant operation and maintenance
- Spare parts, equipment maintenance, and repairs
- Purchase, collection, and transportation of feedstock
- Consumables (polymers, filter media, etc.)
- Energy costs (electricity, natural gas, etc.)
- Transportation, sale, or application of digestate
- Laboratory analyses
- Insurance, taxes, and interest payments

In Pakistan, large landfills, especially in urban centers like Karachi and Lahore, are significant sources of methane emissions. However, few of these landfills have gas recovery systems in place. The implementation of landfill gas-to-energy systems could greatly reduce methane emissions while also contributing to the generation of renewable energy. Costs for implementing landfill gas systems in Pakistan can range between PKR 150 million and PKR 500 million, depending on the size of the landfill and infrastructure development[135]. Additional costs will include land acquisition, equipment import taxes, and workforce training.

In urban centers such as Islamabad and Lahore, there is a growing interest in composting as a mitigation activity. Composting can reduce methane emissions from organic waste in landfills while producing valuable compost for agriculture. The estimated capital cost for setting up a 20,000 TPA facility in Pakistan is approximately PKR 40 million to PKR 60 million, depending on the land and infrastructure costs[136]. Operational costs (OPEX) range from PKR 5 million to PKR 10 million per year, considering labor, electricity, and maintenance.

133 https://sksgreen.com/evaluating-the-cost-of-building-a-biogas-facility/

134 https://www.biogasworld.com/news/reduce-the-costs-of-biogas-plant/

135 Government of Pakistan. (2022). National Waste Management Strategy Report. Ministry of Climate Change.

136 Pakistan EPA. (2021). Environmental Report on Urban Waste Management in Pakistan.

Anaerobic digestion is gaining attention in Pakistan, particularly in agricultural regions like Punjab, where livestock waste can be utilized for biogas production. The cost of constructing a medium-sized biogas facility in Pakistan is estimated to be around PKR 80 million to PKR 150 million, depending on the scale and feedstock type[137]. Operational costs, including feedstock transportation and maintenance, could amount to PKR 10 million to PKR 20 million annually. Such plants could significantly reduce methane emissions and produce renewable energy.

4.2.4 Anaerobic Digesters for GHG Emissions from Wastewater in Pakistan

In Pakistan, wastewater management systems are often outdated or inefficient, leading to the release of significant GHGs. The emissions largely arise from anaerobic conditions in wastewater treatment plants (WWTPs) and the improper management of sludge[138]. According to the Pakistan Environmental Protection Agency (EPA), the country generates approximately 3.2 billion cubic meters of wastewater annually, of which only a small fraction undergoes proper treatment[139]. This contributes substantially to methane and nitrous oxide emissions, increasing Pakistan's carbon footprint.

Anaerobic digestion is a widely recognized technology for both waste management and energy production. By treating wastewater sludge in anaerobic digesters, methane can be captured and used as a renewable energy source, reducing emissions from untreated sludge. This technology has seen limited but increasing adoption in Pakistan, particularly in large cities like Lahore and Karachi[140]. The installation of biogas plants alongside wastewater treatment facilities allows for the energy produced from methane to be fed into the national grid or used on-site.

The installation cost of an anaerobic digester in Pakistan ranges between PKR 5 million and PKR 20 million depending on the capacity and location. These costs include the civil construction, equipment, and methane capture systems[141]. The operational costs, primarily associated with maintenance and energy recovery processes, range between PKR 500,000 to PKR 1 million per year. The payback period for such systems, depending on energy sales or internal usage, is estimated at 5-10 years[142]

4.2.5 Aerobic Treatment Systems

Aerobic treatment processes, such as activated sludge systems, reduce the potential for methane production by ensuring that oxygen is available for microbial processes[143]. While more energy-intensive, aerobic systems are effective in reducing GHG emissions. In Pakistan, the main challenge for widespread adoption of aerobic systems is the high operational cost due to energy requirements.

The capital cost for aerobic systems is higher than anaerobic systems due to the need for additional aeration equipment. For large municipal setups, the installation cost ranges between

137 ADB. (2020). Renewable Energy Projects in South Asia. Asian Development Bank.

138 World Bank. (2019). Wastewater and Climate Change: A Global Review. Available at: https://worldbank.org/wastewater-2019

139 Pakistan EPA. (2021). Environmental Report on Urban Waste Management in Pakistan.

140 Government of Pakistan. (2022). National Waste Management Strategy Report. Ministry of Climate Change.

141 Government of Pakistan. (2022). National Waste Management Strategy Report. Ministry of Climate Change.

142 World Bank. (2019). Wastewater and Climate Change: A Global Review. Available at: https://worldbank.org/wastewater-2019

143 UNEP. (2015). Wastewater Treatment Technologies and GHG Emission Reduction. United Nations Environment Programme. Available at: https://www.unep.org/wastewater-tech

PKR 10 million to PKR 30 million[144]. However, the energy-intensive nature of these systems means that operational costs are significant, often ranging from PKR 2 million to PKR 5 million per year[145]. Despite the higher cost, the GHG mitigation potential is significant when considering the reduction in methane emissions.

4.2.6 Upgrading Conventional Wastewater Treatment Plants (WWTPs)

Upgrading existing wastewater treatment plants to more advanced biological systems can significantly reduce both methane and nitrous oxide emissions. Conventional WWTPs in Pakistan are often underperforming, resulting in incomplete breakdown of organic matter and the uncontrolled release of CH4 and N2O. Upgrading these plants with technologies like activated sludge systems or membrane bioreactors (MBRs) improves the efficiency of wastewater treatment, directly reducing emissions[146].

Capital Expenditure (CAPEX): Upgrading WWTPs to advanced biological treatment technologies typically costs between $500,000 and $2 million, depending on the size and complexity of the plant[147].
Operational Expenditure (OPEX): Operating costs are higher than conventional systems due to energy requirements but can be offset by improved treatment efficiency and reduced emissions.

4.2.7 Decentralized Wastewater Treatment Plants (DEWATS)

DEWATS are decentralized systems designed for smaller communities or peri-urban areas without access to centralized wastewater treatment. These systems often include anaerobic processes that reduce methane emissions from organic waste in wastewater. DEWATS are particularly relevant for rural areas in Pakistan, where infrastructure for centralized wastewater treatment is lacking[148].

Capital Expenditure (CAPEX): The cost of implementing DEWATS ranges from $20,000 to $200,000 depending on the system design and size[149].

Operational Expenditure (OPEX): OPEX for DEWATS is relatively low, typically under $10,000 annually[150], due to minimal energy and maintenance requirements.

The key takeaway from this chapter is the critical need to adopt mitigation technologies in Pakistan's waste management sector. Technologies such as landfill gas recovery, composting, and anaerobic digestion provide effective ways to reduce greenhouse gas emissions while also generating renewable energy or producing valuable products like compost and biogas. The cost analysis provided highlights the investment needed for these technologies, but also the long-term economic and environmental benefits. For Pakistan, implementing these technologies is

---

144 ADB. (2020). Renewable Energy Projects in South Asia. Asian Development Bank.

145 UNEP. (2015). Wastewater Treatment Technologies and GHG Emission Reduction. United Nations Environment Programme. Available at: https://www.unep.org/wastewater-tech

146 United Nations Environment Programme (UNEP), "Wastewater and GHG Emissions: A Global Overview." 2021.

147 World Bank, "Financing for Wastewater Treatment in Developing Countries." 2023.

148 International Water Management Institute (IWMI), "Decentralized Wastewater Treatment Systems in Rural Communities." 2020.

149 Global Water Intelligence, "Cost Breakdown for DEWATS in Developing Countries." 2022.

150 Milbrandt, Anelia. 2021. Comparison of Select Food Waste Utilization Options. Golden, CO: National Renewable Energy Laboratory. NREL/BR-6A20-81024. https://www.nrel.gov/docs/fy22osti/81024.pdf.

essential to curbing methane emissions, particularly in large urban centers like Karachi and Lahore, where landfill emissions are a major issue. Policymakers and stakeholders must prioritize these technologies to meet national climate goals and ensure sustainable waste management practices.

The key messages from this chapter highlight the significant costs involved in adopting GHG mitigation technologies in Pakistan's waste management sector, as well as the potential long-term savings and environmental benefits. For landfill gas recovery, the capital investment ranges between PKR 150 million to PKR 500 million, with the potential to reduce methane emissions while generating renewable energy[151]. Composting offers a cost-effective alternative, especially in urban centers like Lahore, with capital costs ranging from PKR 40 million to PKR 60 million for a 20,000 TPA facility[152]. Similarly, anaerobic digestion is a growing opportunity in agricultural regions, with costs ranging from PKR 80 million to PKR 150 million depending on the scale and feedstock type[153].

The importance of this chapter lies in providing a clear cost assessment, enabling stakeholders to make informed decisions about investing in these technologies. Incorporating such solutions into Pakistan’s waste management strategies is crucial for achieving both environmental sustainability and national climate goals. By understanding the financial and operational requirements, policymakers can better prioritize and allocate resources toward high-impact technologies.

5. Carbon market opportunities and challenges

As emerging country facing the dual challenges of rapid urbanization and inadequate waste management infrastructure, Pakistan is exploring various avenues to reduce its greenhouse gas (GHG) emissions. The waste sector, a significant contributor to these emissions, presents both opportunities and challenges within the framework of Article 6 of the Paris Agreement. This section outlines the potential benefits and obstacles for Pakistan in leveraging carbon markets to improve waste management practices while contributing to its climate goals.

The waste sector in Pakistan holds significant potential to contribute to the country’s climate objectives through the mechanisms provided by Article 6 of the Paris Agreement. However, realizing these opportunities requires addressing a range of challenges, particularly in terms of institutional capacity, financial investment, and social inclusion. By strengthening its regulatory frameworks and building the necessary capacity, Pakistan can effectively leverage carbon markets to improve waste management practices, reduce emissions, and support sustainable development.

a. Emission Trading Systems (ETS)

Although Pakistan currently does not have an operational Emission Trading System (ETS), there is potential for the country to participate in regional or international ETS mechanisms under Article 6.2. Waste management activities, especially landfill gas capture, could contribute to emission reductions that can be traded internationally as Internationally Transferred Mitigation Outcomes (ITMOs). For instance:

---

151 Milbrandt, Anelia. 2021. Comparison of Select Food Waste Utilization Options. Golden, CO: National Renewable Energy Laboratory. NREL/BR-6A20-81024. https://www.nrel.gov/docs/fy22osti/81024.pdf.

152 Milbrandt, Anelia. 2021. Comparison of Select Food Waste Utilization Options. Golden, CO: National Renewable Energy Laboratory. NREL/BR-6A20-81024. https://www.nrel.gov/docs/fy22osti/81024.pdf.

153 https://www.dawn.com/news/1865081

- **Landfill gas capture in urban centres**: Major cities like Karachi and Lahore could capture methane from landfills and either flare it or use it for energy, generating credits for trade.
- **Waste-to-energy projects**: Incineration or gasification of municipal solid waste could produce energy while displacing the need for coal or oil, thus contributing to emission reductions tradable under ITMOs [154]

b. Baseline-and-Credit Mechanisms

Pakistan could also engage in project-based mechanisms under Article 6.4, where specific waste management projects are credited for measurable reductions in methane emissions. Such projects might include:

- **Anaerobic digestion**: Organic waste from agriculture or urban sources can be processed through anaerobic digestion to produce biogas, which can reduce reliance on traditional fuels and mitigate methane emissions.
- **Recycling and composting initiatives**: Pakistan faces challenges with solid waste management, especially in informal settlements. A structured approach to composting organic waste could help reduce methane from landfills, while promoting recycling could avoid emissions from the extraction and production of new materials[155]

Result-Based Financing (RBF)

Under Result-Based Financing mechanisms, Pakistan could receive funding for verified emission reductions in waste management. These projects would focus on:

- **Improved landfill management**: Implementing better practices in existing landfill sites to control methane emissions. This would involve sealing off older landfill areas and using methane capture technologies.
- **Waste segregation and processing**: Introducing large-scale waste segregation at collection points and transfer stations in cities, ensuring organic waste is separated for composting or energy production [156], [157]

c. Standardized Baselines

Pakistan could adopt standardized baselines for common waste management practices to streamline carbon credit generation. For example:

- **Unmanaged landfills in secondary cities**: Setting a baseline for methane emissions in smaller urban areas where waste management infrastructure is less developed, and awarding carbon credits for emissions avoided through proper landfill management or composting.

These methodologies, adapted to Pakistan's waste sector, could play a vital role in leveraging international cooperation and finance through Article 6 mechanisms, driving both emissions reductions and economic development in line with Pakistan's climate goals.

[154] https://www.iea.org/reports/implementing-effective-emissions-trading-systems
[155] Baker McKenzie; COP 28: Article 6 and Global Carbon Markets, 2023
[156] https://www.iea.org/reports/implementing-effective-emissions-trading-systems
[157] https://icapcarbonaction.com/en/publications/emissions-trading-and-carbon-capture-and-storage-mapping-possible-interactions

5.1 Cooperative Approaches under Article 6.2

Under Article 6.2, countries can cooperate to trade ITMOs, where emissions reductions achieved in one country can be transferred to another. This mechanism allows countries to meet their NDCs cost-effectively. For Pakistan, the waste sector offers substantial opportunities to engage in such trading, particularly by capturing methane from landfills and converting it into energy[158].

Example: Japan-Pakistan Bilateral Cooperation for Waste Management

Japan's Joint Crediting Mechanism (JCM) provides an example of how cooperative approaches under Article 6.2 can work in practice. Japan has signed agreements with several developing countries to implement waste-to-energy projects, which could serve as a model for Pakistan. For instance, in Karachi, the Jam Chakro landfill is a significant emitter of methane due to the uncontrolled decomposition of waste. A cooperative project could involve Japan providing technology and financial support to capture and utilize the methane from this site. The resulting emissions reductions could be traded as ITMOs to help Japan meet its NDCs[159].

5.2 Mechanism for Sustainable Development under Article 6.4

Article 6.4 establishes a global market mechanism to certify emissions reductions from sustainable development projects. Similar to the Clean Development Mechanism (CDM) under the Kyoto Protocol, this mechanism enables developing countries like Pakistan to implement mitigation projects and sell certified emission reductions (CERs) on international markets. The waste sector is well-suited to this mechanism, with projects focused on reducing methane emissions through landfill gas recovery, composting, and anaerobic digestion [160].

Example: Lahore Composting Facility under Article 6.4

Lahore, with its large population and significant organic waste streams, is a prime candidate for a composting facility under Article 6.4. Organic waste collected from municipal solid waste streams could be processed into compost, reducing methane emissions from uncontrolled landfill disposal. This project would generate CERs, which could be sold in the international carbon market [161].

5.3 Incentives and Opportunities for Pakistan in the Waste Sector

Pakistan's waste sector presents substantial opportunities for reducing GHG emissions, particularly through methane capture and renewable energy projects. Engaging with international carbon markets can provide key incentives for Pakistan, including access to finance, technology transfer, and capacity building. For example, carbon finance can help cover the high upfront costs of building waste-to-energy plants or modernizing landfill management systems. Karachi

---

158 UNFCCC. "Cooperative Approaches under Article 6.2 of the Paris Agreement." 2022.
159 Joint Crediting Mechanism (JCM) between Japan and Developing Countries. Government of Japan, 2022
160 United Nations Environment Programme (UNEP). "Waste Management and Climate Change." 2021
161 Lahore Waste Management Company (LWMC) Annual Report, 2023

and Lahore, as two of the largest cities, face immense waste management challenges, but they also present the greatest opportunities for emissions reductions[162].

Example: Landfill Gas Capture in Karachi

The Jam Chakro landfill in Karachi is one of the largest in Pakistan, emitting significant amounts of methane. A landfill gas capture project at this site would not only reduce GHG emissions but also generate renewable energy by converting methane into electricity. Such a project could be registered under Article 6.4, enabling Pakistan to sell CERs to international buyers. This would attract foreign investment and help finance the modernization of Karachi's waste management infrastructure. The electricity generated from this project could be fed into the local grid, providing a clean energy source for the city[163].

Incentive Structures for Project Developers

The Pakistani government can play a key role in encouraging the development of waste sector projects by providing incentives such as tax exemptions, subsidies for methane capture technologies, and fast-tracked regulatory approvals for waste-to-energy projects. International partnerships with carbon buyers, such as those established under bilateral agreements, can also provide guaranteed purchase agreements for emissions reductions, ensuring a stable revenue stream for project developers [164].

5.4 Opportunities in the Waste Sector Under Article 6 for Pakistan

1. **Potential for Carbon Credit Generation**: Pakistan's waste sector has considerable potential to generate carbon credits through projects such as methane capture at landfills, waste-to-energy initiatives, and enhanced recycling programs. By participating in international carbon markets, Pakistan could attract investment and generate revenue from the sale of these credits, supporting both environmental and economic objectives.
2. **Access to International Funding and Technology Transfer**: Article 6 provides a mechanism for Pakistan to access international funding and advanced waste management technologies. Through technology transfer agreements, the country can adopt modern waste management practices such as anaerobic digestion and waste incineration, leading to more efficient and sustainable waste processing and significant reductions in GHG emissions.
3. **Support for Nationally Determined Contributions (NDCs)**: The waste sector offers Pakistan a cost-effective avenue for achieving its Nationally Determined Contributions (NDCs) under the Paris Agreement. By participating in carbon markets, Pakistan can leverage international finance to implement waste management projects that contribute to its emission reduction targets.
4. **Economic and Employment Opportunities**: The development of carbon market projects within the waste sector can stimulate economic growth and create jobs, particularly in urban areas. From the construction and operation of waste-to-energy plants to expanded recycling facilities, these projects can offer employment opportunities and contribute to local economic development.
5. **Promotion of a Circular Economy**: Carbon market mechanisms under Article 6 can encourage the adoption of circular economy practices in Pakistan, where waste is

[162] Pakistan Climate Change Policy, Government of Pakistan, 2022

[163] Global Methane Initiative, "Landfill Gas Recovery in Developing Countries: Case Studies." 2021.

[164] International Carbon Action Partnership (ICAP). "Emissions Trading Worldwide: Status Report." 2023

minimized, and resources are reused or recycled. This shift not only reduces emissions but also enhances resource efficiency and environmental sustainability.

5.5 Challenges in the Waste Sector Under Article 6 for Pakistan

1. **Institutional and Regulatory Framework**: Pakistan's current waste management systems face challenges related to weak institutional capacity and regulatory frameworks. To fully participate in carbon markets under Article 6, Pakistan will need to strengthen its governance structures and develop robust Measurement, Reporting, and Verification (MRV) systems to ensure transparency and accountability in emissions reduction projects.
2. **Baseline Determination and Additionality**: Establishing accurate baselines and demonstrating additionality—ensuring that emission reductions are truly additional to what would have occurred without the project—are critical for the credibility of carbon credits. This process can be complex in Pakistan, where waste management practices vary widely, and reliable data may be limited.
3. **Avoiding Double Counting**: To maintain the integrity of carbon credits, it is essential that emission reductions are not double-counted. Pakistan will need to develop and implement comprehensive accounting systems to track and verify emission reductions, ensuring that these are properly attributed and not claimed by multiple parties.
4. **Financial Viability and Market Stability**: The financial sustainability of waste management projects in Pakistan that rely on carbon credit revenues may be affected by market volatility. The initial capital investment required for such projects can be substantial, and fluctuations in carbon credit prices can create uncertainty, potentially deterring investment.
5. **Social and Environmental Considerations**: While carbon market projects can provide environmental benefits, it is important to consider their social impacts, particularly in communities that rely on informal waste management activities. Projects should be designed to ensure that they are inclusive and provide opportunities for all stakeholders, including those in the informal sector.
6. **Capacity Building and Stakeholder Engagement**: Enhancing the capacity of local governments, project developers, and other stakeholders is essential for the successful implementation of Article 6 mechanisms in Pakistan's waste sector. This includes raising awareness of carbon market opportunities and building the technical expertise required to develop and manage such projects effectively.
7. **Political and Economic Stability**: The success of carbon market initiatives in Pakistan's waste sector is linked to broader political and economic stability. Ensuring consistent policy support and a stable investment environment will be crucial for the long-term sustainability of these projects.

6 Policy recommendations

Decarbonizing the waste sector requires a comprehensive overall for the entire value chain from generation to disposal. Briefly, speaking the Policy Scenario related to decarbonizing the sector can be described as:

6.1 Barriers and Challenges

Decarbonizing the waste sector in Pakistan faces several challenges, including:

Lack of Integrated Waste Management Systems: Fragmented and uncoordinated waste management practices at provincial and local levels hinder the implementation of a cohesive decarbonization strategy.

Insufficient Infrastructure and Technology: Limited infrastructure for collection, transport, recycling, composting, and waste-to-energy conversion makes it challenging to reduce greenhouse gas (GHG) emissions effectively.

Financial Constraints: Many municipalities lack the financial resources needed to invest in advanced waste management technologies and practices, starting with limited collection and hardly any treatment facilities.

Inadequate Regulatory Enforcement: Weak enforcement of existing environmental laws and regulations results in continued reliance open dumping, burning or mismanaged landfilling, which contribute to significant methane emissions.

Public Awareness and Participation: Low public awareness and engagement in waste segregation and recycling practices limit the potential for effective decarbonization.

6.2 Possible Policies/Regulations and Their GHG Mitigation Impacts

To achieve decarbonization of the waste sector, Pakistan could consider implementing the following policies and regulations:

Waste Management Act and Rules: There is a need for a comprehensive law on the subject, along with subordinate rules and regulations, so that all stakeholders are clear on the roles and responsibilities. This shall include regulatory frameworks on 'Extended Producer Responsibility' and 'Polluter Pays Principle' etc.

Stricter Enforcement of Regulations: Strengthening the enforcement of existing waste management laws and introducing penalties for non-compliance.

National Waste Management Strategy: Develop a comprehensive national strategy that integrates waste reduction, recycling, composting, and waste-to-energy initiatives, aiming for zero waste to landfill, with clear targets and milestones.

Incentives for Waste related Projects: The Government may consider providing financial incentives, such as tax breaks and subsidies, for the development of infrastructure for collection, transport, treatment and disposal projects, as the whole value chains needs to be strengthened.

Extended Producer Responsibility (EPR): Implement EPR regulations to hold manufacturers accountable for the entire lifecycle of their products, including waste management, thus reducing overall waste generation.

Mandatory Waste Segregation and Recycling: Enforce regulations that require segregation of waste at source and promote recycling and composting to minimize landfill use and reduce methane emissions.

Improved Landfill Management: Introduce regulations that require the capture and utilization of landfill gas (methane) for energy production, thereby reducing direct emissions.

Polluter Pays Principle: To ensure sustainability of the sector, a system of generating revenue may be firmed up and implemented.

Public Awareness Campaigns: Launching nationwide campaigns to educate the public on the importance of waste management and recycling.

6.3 Social, Environmental, and Economic Benefits

Implementing these policies and regulations can lead to several co-benefits:

Social Benefits: Improved public health due to reduced exposure to harmful waste and emissions, increased job opportunities in the waste management sector, and enhanced community engagement in environmental protection.

Environmental Benefits: Reduced GHG emissions, improved air and water quality, conservation of resources through recycling and composting, and minimized land use for landfills.

Economic Benefits: Creation of green jobs, reduced costs associated with waste disposal and health impacts, potential revenue generation from waste treatment and recovery projects and increased foreign investments in clean technologies.

By adopting these strategies, Pakistan can significantly reduce its carbon footprint, enhance sustainable development, and meet its international climate commitments.

7 Conclusions

The waste management sector in Pakistan, while contributing a smaller share of the country's overall greenhouse gas (GHG) emissions, holds significant potential for emissions reductions, particularly in methane emissions from landfills and untreated waste. With the right investments and policy changes, the waste sector could play a critical role in reducing the country's overall GHG emissions, as outlined in Pakistan's Nationally Determined Contributions (NDCs).

Carbon finance offers a pivotal opportunity for Pakistan to achieve its emission reduction targets while also addressing its waste management challenges. Under mechanisms such as Article 6 of the Paris Agreement, Pakistan can generate carbon credits by implementing methane capture technologies at landfills, enhancing recycling efforts, and establishing waste-to-energy facilities. These credits can then be sold on international carbon markets, providing the country with much-needed financial resources for further investment in sustainable waste management infrastructure.

Importance of Carbon Finance to Pakistan:

1. Revenue Generation: Carbon credits generated through methane capture from landfills or improved waste management practices could attract significant foreign investments. This revenue can be reinvested into scaling up waste-to-energy plants, composting, and recycling facilities, creating a sustainable cycle of improvements.
2. Supporting Infrastructure Development: Carbon finance can bridge the gap in funding for the development of modern landfill sites, waste segregation systems, and efficient transport networks. These improvements are necessary to reduce methane emissions, which currently account for a large share of emissions from the waste sector in Pakistan.
3. Attracting Foreign Investment: By establishing a strong Monitoring, Reporting, and Verification (MRV) system and ensuring transparency in emissions reductions, Pakistan can become an attractive destination for global carbon finance. Investors and multinational corporations, looking to offset their emissions, can invest in Pakistani projects aimed at methane reduction and waste management, further driving economic growth.
4. Job Creation and Economic Benefits: Carbon finance can stimulate local economies by creating green jobs in areas like recycling, waste sorting, and infrastructure development. It will also help reduce health-related costs by addressing poor waste management, which has significant public health implications.
5. Contribution to Global Emissions Reduction: As part of global climate action, carbon finance allows Pakistan to contribute meaningfully to the international effort to reduce GHG emissions. The country can play a key role in methane mitigation through the

waste sector, while benefiting financially from the sale of carbon credits on international markets.

Path Forward

To fully leverage the potential of carbon finance, Pakistan must strengthen its regulatory and institutional frameworks. Establishing partnerships with international organizations and countries with advanced waste management systems will be crucial. Pakistan can also explore international funding mechanisms such as the Green Climate Fund (GCF) to support large-scale waste management projects that can be tied to carbon finance.

By tapping into the financial opportunities provided by global carbon markets, Pakistan can accelerate its transition to a circular economy while also meeting its climate commitments. Carbon finance offers a win-win solution: reducing GHG emissions, improving waste management, and generating new economic opportunities for the country.

Supporting Preparedness for Article 6 Cooperation

Important Notice:
IKI Independent Complaint Mechanism (ICM)

Any person who believes they may be negatively affected by this IKI-supported project or who wishes to report corruption or misuse of funds can file a complaint through the IKI Independent Complaint Mechanism.

Complaints are reviewed by an independent panel of experts. The process includes consultation with the complainant to avoid any unnecessary risks.

Please scan the QR code for further information on the Independent Complaint Mechanism and how to file a complaint:

E-Mail: iki-complaints@z-u-g.org

Ministry of Climate Change and Environmental Coordination Government of Pakistan

UN environment programme | copenhagen climate centre

GFA CONSULTING GROUP

The Federal Government

IKI INTERNATIONAL CLIMATE INITIATIVE

GGGI

SPAR6C

Supporting Preparedness for
Article 6 Cooperation

Ministry of Climate Change
and Environmental Coordination
Government of Pakistan

UN environment programme

copenhagen climate centre

GFA CONSULTING GROUP

The Federal Government

IKI INTERNATIONAL CLIMATE INITIATIVE