RASTA
PIDE & PLANNING COMMISSION
COMPETITIVE RESEARCH GRANTS

PIDE
PAKISTAN INSTITUTE OF DEVELOPMENT ECONOMICS

Policy Brief

CLIMATE RESILIENCE APPROACH TO SUSTAIN THE SOLID WASTE SECTOR THROUGH ANALYTICAL HIERARCHY PROCESS (AHP) FOR POLICY DECISION

Asif Iqbal

(CGP # 07-282)

(This document is unedited author's version submitted to RASTA)

INTRODUCTION

Pakistan, being the fifth-largest populated country, produces around 46 million tons of MSW each year. This is increasing at a pace higher than 2.4% per annum. Notwithstanding major public spending estimated at around PKR 221 billion per annum, the solid waste sector has been proven to be environmentally unsustainable, economically burdensome, and institutionally fragmented.

The solid waste management sector has also seen an increase as a greenhouse emission source. It annually releases an estimated 26.5 million tons of CO_2 equivalent into the atmosphere from generated waste. This primarily occurs as a result of methane production as a result of the anaerobic decomposition of organic solid waste disposed of in open dumpsites. The impact of methane emissions on the atmosphere is severe as it has a global warming potential that is estimated to be twenty-eight times that of CO_2. Provinces, through the power conferred by the 18th Constitutional Amendment, have taken up various models of operations for managing their municipal wastes. Punjab has the Suthra Punjab Authority at central level with district agencies, Sindh has the Sindh Solid Waste Management Board, while Khyber Pakhtunkhwa has Water and Sanitation Service Companies being operated on districts levels. On the other hand, Balochistan, Islamabad, and Azad Jammu and Kashmir have varying models that combine outsourcing and insourcing concepts. However, their efforts are limited to waste collection and disposal activities, viewing waste as an obstacle to their development, as opposed to viewing it as a resource.

Without a national solid waste policy, some critical gaps continue to exist in waste segregation, recycling, emissions, cost recovery, and institutional waste management, while, in the meanwhile, a major portion of waste is estimated to be recycled by the informal sector at a rate of 14-20% of recyclables.

Policy Brief

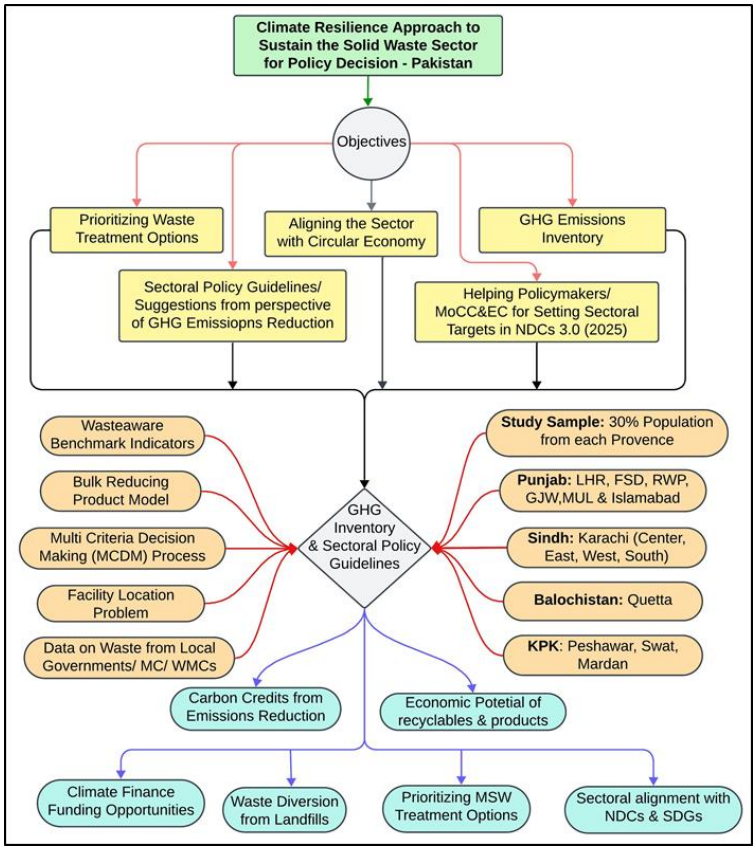
With this challenge in mind, this study seeks to redefine the waste sector as a climate resilient, closed-loop, and financially sustainable sector. By integrating greenhouse gas accounting, economic analysis, and Multi-Criteria Decision Analysis using Analytical Hierarchy Process (AHP), this study sheds light on how to use science to guide the sector in prioritizing waste treatment options for its sustainability and circularity.

METHODOLOGY

For the purposes of conducting research about greenhouse gas emissions from waste sector and providing their solution through AHP tool, this study has been designed using multiple phases and methods that span about 30% of the entire population of Pakistan and projected to all over the Pakistan through bottom-up approach. This has been done by covering major cities within Punjab, Sindh, Khyber Pakhtunkhwa, Balochistan, Islamabad, and Azad Jammu and Kashmir. The Framework of study in graphically presented in Figure 1 for understanding.

Figure 1: Research Framework

Policy Brief



Source: Author's compilations.

Waste Characterization Study

In first phase a detailed physical and chemical characterization study of the waste was done by following the guidelines of the UN-Habitat Waste Wise Cities Tool (WaCT). The waste samples, measuring between 300 and 500 kg, were taken from vehicle loads, which collected waste from residential (from low, medium, and high-income areas), commercial, and institutional areas. By using the quarter coning method, the samples were then reduced to representative sub-samples of 70-100 kg.

Afterwards Manual sorting was done involving the classification of waste into 14 categories, such as biodegradable waste, plastics, paper, metals, textiles, diapers, hazardous waste, and electronic waste. A sample for chemical analysis, as per the ASTM standards, was performed for the selected cities to ascertain the chemical properties of the waste, including moisture, ash, organic compounds, calorific values, and carbon/nitrogen ratios.

Policy Brief

Greenhouse Gas (GHG)

A GHG emissions inventory at the national and provincial level was formulated using the IPCC-compatible Emissions Quantification Tool (EQT) Version III developed by the Institute for Global Environmental Strategies (IGES) Japan. The waste collection, transportation, open burning, and disposal methods were simulated in a Business as Usual (BAU) scenario. Both long-lived GHGs (CO_2-equivalents) and short-lived climate forcers, such as black carbon, were considered.

Scenario Development for Emissions Reduction

Four different scenarios for waste diversion: 20%, 40%, 60%, and 80% diversion of waste from landfills depicted in Table 1, have been considered in modeling for potential emissions reductions. Treatment routes included recycling, composing, biogas production, Refuse Derived Fuel, Mechanical Biological Treatment, incineration, and gas recovery in a landfill. These scenarios were simulated latterly in EQT Version III for assessing the Emission reduction potential of waste treatment options.

Table 1 Scenario Development for Treatment Option

Scenario	Waste Diversion Target	Treatment Pathways (Diversion Portion)	Residual Management
1	20%	Composting (Organics) + Recycling Facility (Recyclables)	Landfilling with Gas Recovery (LFG)
2	40%	Composting (50% Organics) + AD (50% Organics) + Recycling Facility (Recyclables)	Landfilling with Gas Recovery (LFG)
3	60%	Composting (50% Organics) + AD (50% Organics) + Recycling (50% Recyclables) + RDF Facility (50% Recyclables)	Landfilling with Gas Recovery (LFG)
4	80%	Composting (35% Organics) + AD (35% Organics) + MBT (30% Organics) + Recycling (50% Recyclables) + RDF Facility (50% Recyclables)	LFG (80%) + Incineration (20%)

Source: Author's compilations.

Economic Potential Assessment

Economic modeling was done using the base values for operational, capital cost and latterly unlocking the financial potential after applying the treatment options in selected headquarters of four provinces and their estimated carbon credits potential was also calculated in this phase a cumulative revenue generation estimated from this modelling is shown in figure 3 as well.

Analytical Hierarchy Process (AHP)

A Multi-Criteria Decision-Making technique with AHP was applied to priorities different solid waste treatment alternatives. Ten criteria ranging from capital and operational cost of waste treatment facility to the potential of related emissions reduction for carbon financing were considered to simulate against seven alternatives waste treatment options such as composting, recovery of

recyclables, anaerobic digestion, refuse derived fuel, mechanical biological treatment, incineration and landfill gas recovery.

KEY FINDINGS

Waste Composition

Nationally, the organic (biodegradable) fraction of the waste stream predominates at 53.98%, followed by plastics (11.55%), diapers (9.08%), non-combustible (8.98%), and textiles (5.58%). High moisture levels (approximately 50.5%) and ash content (about 21.2%) make the waste less amenable to incineration and more suitable for biological processes such as composting and anaerobic digestion. The fluctuations in waste composition among the provinces arise because of differences in consumption patterns and service delivery, although the organic fraction has remained the largest consistently throughout and, has major unused treatment potential. Detailed physical and chemical composition of solid waste at national level are discussed in Table 2 and Table 3 respectively.

Table 2 National Level Physical Composition of Municipal Solid Waste

Components	Punjab (%)	Islamabad (%)	AJK (%)	Sindh (%)	Baluchistan (%)	KPK (%)	National (%) Average
Combustibles	3.41	4.48	4.0	2.8	4.9	2.1	**3.62**
Diaper	12.33	13.03	8.0	11.8	0.0	9.3	**9.08**
Elec.-Electronic W.	0.22	0.06	0.0	0.0	0.0	0.0	**0.05**
Glass	1.4	1.66	1.0	0.8	2	0.6	**1.24**
Hazardous W	0.2	0.77	0.0	0.0	0.0	0.0	**0.16**
Biodegradable W.	54.09	55.08	62.0	59.7	32.9	60.1	**53.98**
Metals	0.21	0.22	0.0	0.0	0.3	0.0	**0.12**
Non-Combustibles	4.03	1.42	4.0	2.9	34.4	7.1	**8.98**
Paper-Cardboard	1.48	3.45	5.0	1.9	3.6	1.9	**2.89**
Pet	0.75	0.28	0.0	0.0	0.0	0.0	**0.17**
Nylon	0.61	12.26	0.0	0.0	0.0	0.0	**2.15**
Plastics	13.42	0.99	13.0	13.7	15	13.2	**11.55**
Tetrapak	1.25	1.43	0.0	0.0	0.0	0.0	**0.45**
Textile	6.61	4.87	3.0	6.4	6.9	5.7	**5.58**
Total	100	100	100	100	100	100	**100.00**

Source: Author's compilations.

Table 3 National Level Chemical Composition of Municipal Solid Waste (Urban Unit)

SN	Parameters	Methods	Average %
1	Moisture, Total %	Based on ASTM D3302	50.6
2	Moisture, Laboratory Sample %	Based on ASTM D3173	4.0

Policy Brief

3	Ash %	Based on ASTM D3174	21.2
4	Volatile Matter %	Based on ASTM D3175	49.5
5	Fixed Carbon by Calculation %	Based on ASTM D3172	10.0
6	Sulfur %	Based on ASTM D4239 Method A	0.2
7	Gross Calorific Value kcal/kg	Based on ASTM D5865	3414.4
8	Net CV @ Constant Pressure kcal/kg	Based on ASTM D5865	2813.9
9	Oxygen (by difference) %	Based on ASTM D31761	19.6
10	Carbon %	Based on ASTM D5373	31.7
11	Hydrogen %	Based on ASTM D5373	5.0
12	Nitrogen %	Based on ASTM D5373	0.8

Source: Author's compilations.

Greenhouse Gases

The waste sector releases an estimated 26.5 million tons of annual CO_2 equivalent per annum from generated waste (excluding sludge waste), accounting for some 9% of Pakistan's domestic emissions as discussed in Table No.4. The BAU scenario emissions projections continue to grow as Pakistan's population becomes more urbanized.

Table 4 Current Emissions from Solid Waste Sector of Pakistan

Province	**Emissions per tonne of generated waste**		**Emissions per tonne of collected waste**		**Emissions from yearly generated waste**		**Emissions from yearly collected waste**	
	BC	**GHG**	**BC**	**GHG**	**BC**	**GHG**	**BC**	**GHG**
	kg/ ton	**kg of CO_2-eq./ ton**	**kg/ ton**	**kg of CO_2-eq./ ton**	**Tons**	**Tons of CO_2-eq.**	**Tons**	**Tons of CO_2-eq.**
Punjab	0.023	930.3	0.024	1051.0	473.2	16,025,062	378.02	13,407,509
Sindh	0.021	529.8	0.023	561.6	222.1	5,650,345	126.68	3,269,770
Baluchistan	0.035	320.6	0.067	328.7	95.3	808,526	64.79	316,086
KpK	0.033	582.5	0.068	602.9	208.2	3,476,329	131.69	1,162,116
Capital	0.070	618.0	0.074	504.9	29.2	259,169	16.432	112,774
AJK	0.015	578.1	0.015	593.7	6.9	275,573	5.07	198,077
Total Impact	0.033	593.2	0.045	607.1	**1,034**	**26,495,007**	**722**	**18,466,335**

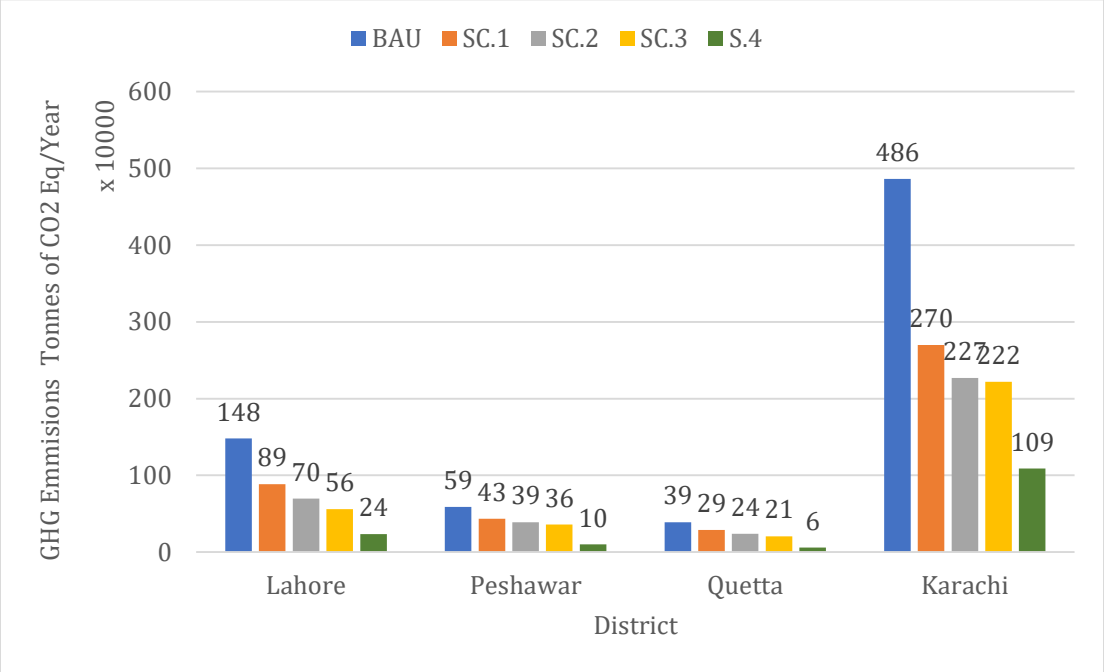
Source: Author's compilations.

Emissions Reduction Potential

Results of scenario analysis show that with waste management, up to 70% of waste sector emissions can be avoided through a systematic waste diversion approach to landfills. Higher waste diversion rate such as 60% and 80% at scenario 3 and 4, respectively, show larger emission reductions, especially in recycling, composting, and land fill gas capture.

Figure 2 GHG Emmision Reduction Potential in Scenarios Per Annum

Policy Brief



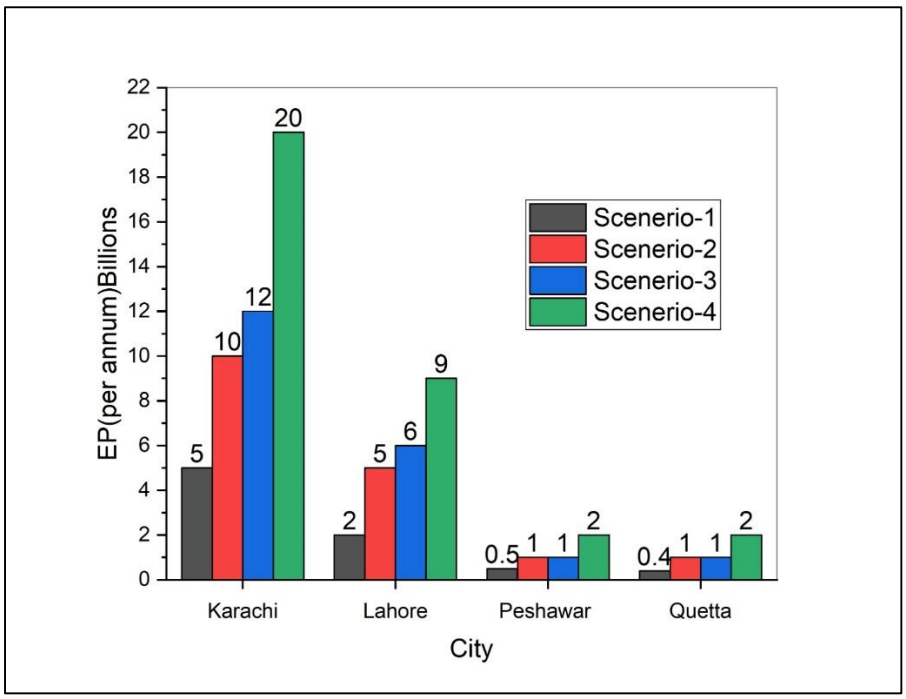
Source: Author's compilations.

Economic and Financial Potential

The findings of this study indicate the potential of the waste management sector to finance up to 40% of its operational costs through the generation of funds from the sale of recyclable materials, compost, energy generated from waste, and through carbon credits. Carbon finance is identified as a major opportunity in this process, where the reduction of carbon is monetized in addition to supporting the climate goals of Pakistan.

Figure 3 Economic Potential from Different Scenario Development

Policy Brief



Source: Author's compilations.

Prioritization of Treatment Options (AHP Results)

AHP tool has prioritized the waste treatment options (Table 5) as follows:

Policy Brief

1. Recovery of recyclables gets the highest overall priority because of low costs, large market potential, and subsequent CO_2 emission savings.
2. Composting which is suited to organic kitchen waste and its utilization in agricultural practices.
3. Landfilling with Gas Recovery is preferred over Controlled Dumping for interim arrangements, aligned with BAU practices in Pakistan.
4. Aerobic Digestion suitable in selective urban environments.
5. RDF and MBT: Moderator of Potential with increased cost and complexity.
6. Incineration for waste to electricity generation is low priority due to high moisture and ash contents in local waste, and related environmental and economic factors.

Table 5 Final Analytical Hierarchy Process Ranking

Alternatives	Rank Score	Ranking
Recycling	0.60	1
Compost	0.55	2
LFG	0.46	3
AD	0.31	4
MBT	0.27	5
Incineration	0.22	6
RDF	0.20	7

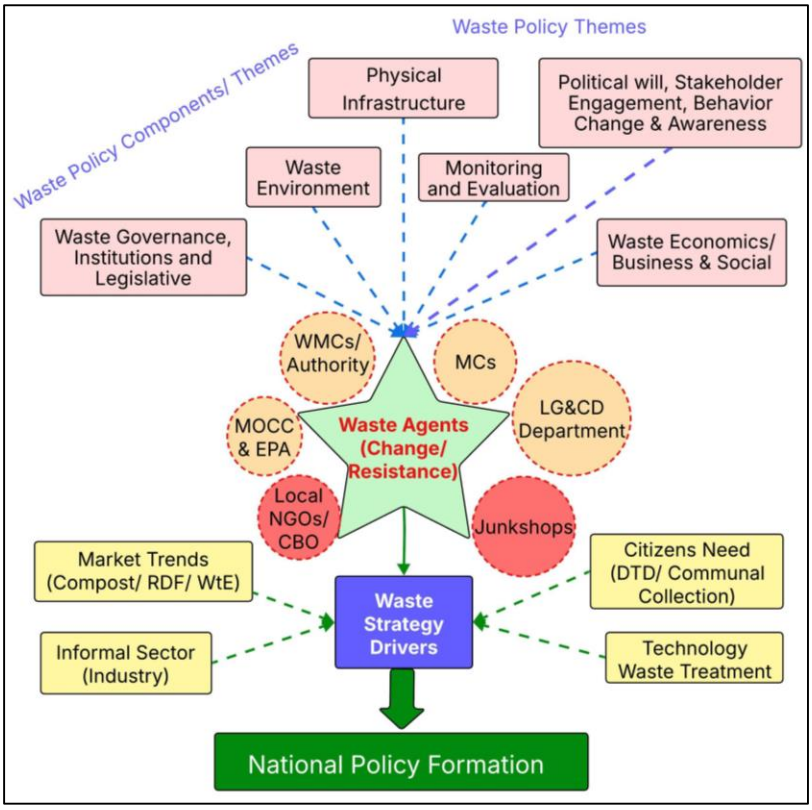
Source: Author's compilations.

Institutional and Governance Gaps

Lack of policy integration is the key constraint on national level. Punjab performs relatively better because there has been systemic reform and monitoring under suthera Punjab program. Nevertheless, issues relating to environmental management, resource recovery, cost recovery, and the integration of the informal sectors still prevail at the macro-level. Some key interventions linking the crucial nodes and drivers of systems are mentioned in figure no 4.

Figure 4: Hawk Eye on National Waste Scenario

Policy Brief



Source: Author's compilations.

CONCLUSION

It concludes that the waste sector in Pakistan, being currently of fiscal and environmental concern, has the potential to be made a backbone of the climate change-resilient economy and the green economy for the following reasons: There is a substantial organic waste component, there is a vast potential for emissions reduction, and there are carbon market opportunities. Without public policy measures, the trend towards open dumping would worsen matters related to climate change, public health implications, and budgetary strain. On the other hand, effective diversion and appropriate technology investments could help the waste sector sustain itself and be brought into the global system on the right track on matters related to climate change.

Policy Brief

KEY POLICY RECOMMENDATIONS

1. Develop a National Solid Waste Management Policy that fits with NDCs, Sustainable Development Goals, and Circular Economy concepts.

2. Enforce segregation of waste at the source of generation through behavior change communications.

3. Make recycling and composting first-tier treatment alternatives based on AHP outcomes.

4. Transitioning from open dumping to controlled landfills with gas recovery as the short-term solution for climate change under business-as-usual practices

5. Engage the informal sector in the formal waste management sector through licensing, incentives, and social protection programs.

6. Use carbon finance and climate funds to finance sectoral infrastructural development and sustain operations.