



Transforming Waste into Worth: A PPP-Based Framework for Waste-to-Energy Projects in Punjab, Pakistan

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ABSTRACT

This study investigates the primary obstacles hindering WtE implementation and proposes a context-specific Public-Private Partnership (PPP) framework tailored to the institutional and financial needs of Punjab. Using reflexive thematic analysis of semi-structured interviews with 21 stakeholders in the form of government agencies, private sector investors, waste management companies and technical consultants, the study reveals that there are six underlying determinants of success; implementation capacity transcending legislative provisions, feedstock reliability as operational base, fair allocation of risk to enable bankability, policy stability to enable investment confidence, non-negotiable government support mechanisms and community engagement addressing stakeholder acceptance. The suggested framework focuses on institutional reinforcement via capacity building and coordination of agencies, novel financial structuring via blended finance tools, and participatory governance via crystal clear stakeholder involvement. The results would add new information on trust-building processes, the resource optimal risk allocation methods, and institutional capacity issues that are necessary to develop sustainable Waste-PPP projects in the environment of developing countries.

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INTRODUCTION

Inappropriate waste disposal transcends beyond aesthetic issues than just being numbers and figures. Methane emissions from decomposing organic waste in open dumpsites and poorly managed landfills signify a critical climate hazard (Meegoda et al., 2025). More than half of global methane emissions come from human activities in three sectors, i.e. fossil fuels (35 percent of human-caused emissions), waste (20 percent) and agriculture (40 percent) (Ramachandran et al., 2024). In Punjab particularly, major urban hubs like Lahore that relies heavily

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on the Mehmood Booti landfill and other such disposal sites, creating public health concerns through disease vector spread and air quality dilapidation while releasing substantial methane volumes into the atmosphere (Zafar et al., 2024). Pakistan faces social and health issues due to the mismanagement of Municipal Solid Waste (MSW) in urban and rural areas. Unhygienic conditions due to roadside disposal of MSW negatively affect society, aesthetics, economy, and tourism.

This study aims to determine the potential of thermal energy-based MSW incineration technology for electricity production and waste volume reduction in six big cities of Punjab, namely Lahore, Rawalpindi, Islamabad, Faisalabad, Gujranwala and Sialkot. Population, waste generation rate, waste characteristics, moisture levels in the waste and common local habits also influence how much energy that can be generated, and these factors were taken into account when calculating electricity production potential. Additionally, three different sensitivity analysis tests were conducted to examine the power generation capacity of waste-to-energy (WtE) plants, each using different efficiency levels for the plant output.

LITERATURE REVIEW

As Gebrekidan et al. (2024) highlighted, ineffective orientation development patterns are the result of the absence of systematic and targeted orientation, as well as an inadequate system of monitoring. These governance weaknesses are evident in disjointed inter-departmental communication, lack of alignment between the federal and provincial, as well as weak technical capability at the municipal level issues, which are reflected by stakeholder interests highlighted in the Punjab waste management system. There are several avenues through which municipal solid waste can be converted to energy forms that may be useful through waste-to-energy technologies. According to the literature, the mainly used three technological methods are thermal treatment such as incineration, gasification, pyrolysis, biological treatment such as anaerobic digestion and landfill gas capture (Gebrekidan et al., 2024). All technologies have different benefits and limitations with regard to composition of waste, size of operation, and the capability of the technological facility available in the locality.

These case studies show that the viability of the Waste depends on the choice of the technologies as well as the favourable regulatory environment, the ensured availability of waste, and the correct risk distribution mechanisms. The achievement of China in the scaling of Waste infrastructure using PPPs presents valuable metrics in the development of Punjab. Cheng et al. (2024) performed the risk analysis of the PPP Waste incineration projects and found that waste supply reliability, payment Model, and Government support ranked to be the most significant. The research, carried out on a survey of 100 respondents, determined that attribute of feedstock quantity and quality was in the top ten list of risks, with the other attributes of revenue uncertainty and construction costs overruns. This result highlights the criticality of upstream management system reforms, especially the valuable practice of segregation and data collection, being a precondition of WtE feasibility. The authors Wang and Zhang (2018) used Bayesian analytics to approximate the risk probability in PPP Waste disposal projects and have shown that the uncertainty associated with the nature of waste directly corresponds to financial risk by the private investor. Their quantitative results support the qualitative results that predictable and well-characterized waste streams whose supply is contractually guaranteed to be available are basic to project bankability. Public-Private partnerships have become an emerging tool of mobilizing capital, expertise and innovation of the private sector in the delivery of infrastructure where the state resources are deficient.

According to the reports provided by the World Bank (as cited by Mundial, 2020), the results of the countries that have undertaken significant reforms to PPP regulatory frameworks show that on average, there is a rise of \$488 million of infrastructure investment between the year 1990 and 2022. This linear relationship between quality regulations and investment flows accentuates the need to set up sound legal and institutional frameworks which indeed is a valuable lesson in the PPP development experience of Punjab. The use of PPPs is not to fund vehicles, though; it is an elaborated form of governance that needs thorough design. According to Liu et al. (2015), PPPs also establish hybrid institutional frameworks via Special Purpose Vehicles (SPVs) which connect networks of state and corporate interests to finance, construct and run facilities of infrastructure. The allocation of risks, responsibilities, and rewards among partners is a critical dependent factor on the effectiveness of the arrangements.

The heart of any PPP transaction is risk allocation, and efficient allocation is one of the main mechanisms to ensure a realization of value of money. The major tenet, developed by Irwin (2007) and supported by the World Bank in their guide on PPP (as cited by Mundial, 2020) is the principle that any risk must be placed with the party in the best position to as follows: (1) contain the probability of risk occurrence, (2) contain the effect of the risk on the project results, or (3) bear the risk at the least possible cost. The PPP Risk Allocation Tool of Global Infrastructure Hub offers specific risk matrices in 18 types of projects, including waste management ones (Mazher, 2019). These matrices indicate that optimum allocation of risks is different across sectors, project stages as well as market maturity. Almeile et al. (2024) have carried out an extensive review of the existing research on PPP with the specific emphasis on developing nations and have discovered that the common problem in risk allocation strategies still exists. They found that transfer of risk to the private partners in excess without proper compensation systems is not viable in projects. This fine line is particularly not easily reached in the situation where limited experience of PPP, insufficient enforcement of the law, or political unrest exist.

A recent thorough analysis of risk allocation and sharing in PPP infrastructure projects by Mazher et al. (2025) discussed the trends in 2000-2023 and discovered that there had been methodological advancements in risk allocation. Scholars have utilized multi-criteria decision making (MCDM), game theory, genetic algorithms and artificial intelligence methods in modelling of optimal allocation of risk. Cao et al. (2022) revealed ten significant risks in PPP Waste materials project as: rural appearance issues, payment risk, local employment, local economic development, government succession, operation cost overruns, waste supply's reliability, construction cost overruns, revenue risk, and price change risk. Markedly, those associated with governance were a common characteristic of the risks in addition to the more traditional technical and commercial risks. The idea of risk severity matrix of sustainable PPP projects in developing countries developed by Khahro et al. (2021) argues that financial, technical, social, or environmental risks should be regarded equally. Benchmarking Infrastructure Development of the World Bank estimates the PPP regulatory framework of 140 economies and monitored its association with investment flows (as cited by Mundial, 2020).

The analysis has determined that 45 economies have started implementing PPP regulatory reforms from June 2019 to June 2022, which strengthen their frameworks. The report, however, highlighted that regulation is just but one of the ingredients in successful PPP ecosystems. Others that are demanded are economic and political stability, involvement of the public sector, mature financial markets, efficient risk allocation and long-term vision by the government and partners. Such weaknesses at the stage of preparation then translate into difficulties in implementing the project, which indicates that the PPP structure that Punjab should focus on strict project development criteria, as well as the contractual aspects. The literature has emphasized collaboration between the agencies as one of the key implementation challenges. According to Huang et al. (2018), effective WEST PPPs in China meant the creation of specialized coordination structures, which interconnected environmental control bodies, energy bodies, city-planners, and finance ministries (Wang, 2019).

Osei-Kyei et al. (2021) conducted a review of the changes in the research on PPP risk management and focused on the role of dispute resolution procedures. In their analysis, they determined that ambiguity in the contractual terms of the contract and the absence of enforceable dispute resolution mechanisms are important causes of project failure, especially in emerging markets where a PPP specific skill may be lacking in the judicial system. Projects that use waste-to-energy through the PPP models also directly promote several Sustainable Development Goals. In particular, Waste to energy can serve SDG 7-Affordable and Clean Energy through generating renewable energy and decreasing fossil fuel use, SDG 11-Sustainable Cities and Communities by developing waste management systems and eliminating open dumping and SDG 13-Climate Action by harvesting methane and avoiding the release of greenhouse gases (Cao et al., 2022; Gebrekidan et al., 2024).

Yu et al. (2018) have carried out a systematic review of the factors of social responsibility that are necessary in sustainable PPPs, with the stakeholder engagement, sharing community benefits, and environmental protection being presented as the key elements. Their framework highlights the fact that sustainability is a multifaceted concept including environmental, social, and economic aspects at the same time, which is confrontational to those narrow conceptions of project success through the approach of financial returns or energy production. Opposition by the population is among the major

risks facing Waste management projects in almost all countries around the world commonly known as the Not In My Backyard (NIMBY) syndrome. The literature suggests that social acceptance will rely on open communication, evidenced environmental performance, apparent community gains and significant stakeholder interest in decision-making (Khahro et al., 2021). In the context of Punjab, this implies that the design of the PPP projects must consider the aspect of public awareness campaigns, community consultations and benefit sharing arrangements as vital components of the project design but not as a means of an afterthought.

Conceptual Framework

Drawing on the theoretical foundations established in the literature review, containing PPP governance theory, risk sharing principles, institutional capacity frameworks, and sustainable infrastructure development, the following conceptual framework demonstrates the relationships among the key constructs checked in this study. The framework policies Municipal Solid Waste generation as the contextual input driving the need for WtE solutions in Punjab. It identifies six interacting determinants of PPP based WtE project success, derived from the synthesis of existing literature: (1) Institutional and Regulatory Capability, referring to the power of the legal framework and inter-agency coordination; (2) Feedstock Reliability, involving waste assemblage efficiency, source segregation practices, and contractual supply guarantees; (3) Risk Allocation Mechanisms, representing the equitable distribution of financial, technical, and operational risks between public and private partners; (4) Policy Stability and Government Promise, capturing the strength of policy frameworks and the availability of financial tools such as Viability Gap Funding (VGF); (5) Financial Viability and Bankability, addressing tariff structures, revenue guarantees, and investment appeal; and (6) Community Engagement and Social Acceptance, incorporating public awareness, stakeholder participation, and NIMBY mitigation strategies.

The six determinants interact dynamically; deficiencies in any one domain generate cascading failures across others. For instance, inadequate feedstock reliability amplifies financial risk, which is further compounded by imbalanced risk allocation and the absence of government financial guarantees. Conversely, when all six determinants are adequately addressed through a coordinated PPP framework, the model predicts the achievement of the intended outcomes: operational WtE infrastructure, sustainable waste management, renewable energy generation, and alignment with SDGs 7, 11, and 13. The framework is grounded in a constructivist-interpretivist paradigm and informed by critical realism (Bhaskar, 2013), recognizing that while structural mechanisms such as legal frameworks and financial constraints are real, their effectiveness is mediated by stakeholder interpretations and institutional practices. This epistemological positioning justifies the qualitative, interview-based methodology employed in the study and frames the thematic findings as contextually situated insights rather than universal laws.

METHODOLOGY

The research follows the methodology of qualitative research design in which the author employs flexible thematic analysis to unravel the understanding of the stakeholders concerning the existing PPP models, obstacles during implementation, and how risk is allocated, and sustainability considered. The study falls under a constructivist-interpretivist paradigm (Braun & Clarke, 2021). This standpoint recognizes the fact that information of PPP frameworks, waste management issues, and stakeholder views, is socially constructed in the form of interactions, experiences, and contexts of situations instead of being objective and discoverable. This constructivist stand would be well suited to this study since:

- The effectiveness of PPP framework is not an intrinsic characteristic of legal texts, but comes because of the process of interpretation, implementation, and experience of these frameworks in practice by the stakeholders.
- The very notions of risk, bankability and sustainability are understood differently by all stakeholders (government officials, private investors, consultants) so the two sets of perspectives need to be investigated.
- Implementation obstacles are associated with complex relations among formal policies and institutional cultures, resource limitation, and political-economic environments that are not easy to simplify into a few causal relations.

This study does not aim to establish universal facts regarding PPP frameworks but instead aims at formulating contextualized insight on how Waste-PPP initiatives can be organized successfully given the institutional, regulatory, as well as socio-economic setting of Punjab (Lincoln, 1985). The innovative theoretical approach taken by the study is critical realism epistemology that recognizes that though real structures and mechanisms do exist to affect the outcomes of PPP e.g. legal systems, financial constraints, waste properties, our comprehension of these realities is inseparably mediated by stakeholder understandings and experiences (Bhaskar, 2013). In this position, the research is able to:

- Realize material limits (e.g., actual rates of waste generation, current limitations of infrastructure) and investigate how the same is perceived and handled by various actors.
- Peruse at surface-level expressions as well as structural factors e.g. deficient institutional capacity structures, power relations that impact operations of PPP.
- Avoid naive realism that resorts to the accounts of stakeholders as the direct reflections of objective reality, on the other hand, do not resort to extreme relativism that would refuse any element that would provide the ground in evaluating conflicting claims on the effectiveness of PPP.

A qualitative research design is applied in this study, with the intent to look deep into the experiences and meanings of the stakeholders and their perceptions (Creswell & Poth, 2016). The rationale behind the qualitative approach to methodology is that the research objectives attempt to get an insight into:

- The nuanced challenges in implementing PPP frameworks for WtE TE projects
- Stakeholder interpretations of framework adequacy and improvement needs
- Complex interactions between policy provisions, institutional practices, and project outcomes
- Local conditions determine the viability of Waste to Power Plant in Punjab.

The qualitative method allows the investigation of these dimensions that cannot be satisfactorily reflected in the quantitative approach, especially due to the limited number of existing projects of WtE -PPP applied to Pakistan and the necessity of establishing an exploration before it is possible to develop a hypothesis testing in the quantitative approach.

Rationale for Single-Method Qualitative Design

Although the research synopsis initially suggests the hybrid form of qualitative-quantitative, this research in question provides the qualitative component alone due to a number of reasons:

- Exploratory Research Context: Since the development of WtE -PPP in Punjab is at an early stage, qualitative investigation is required to discover the useful variables, connections, and models and the quantitative measurement method is then meaningful.
- Depth vs. Breadth Trade-off: The paucity of stakeholders with substantive PPP and WtE knowledge requires focusing on in-depth qualitative inquiry to quantitative distribution which is larger in scope.
- Complexity of Phenomena: The complexity of the PPP implementation is multi-dimensional and encompasses all aspects of law, institutions, financial, technical, and social which are extremely complicated and demand a rich qualitative data to sufficiently represent.

Future research may employ quantitative methods to test hypotheses or assess relationships identified through this qualitative investigation, potentially using survey instruments validated through the themes emerging from this study.

Data Collection Methods

Semi-Structured Interviews

Future studies can utilize quantitative research to support hypotheses or determine the relationship of various variables determined out of this qualitative research and this can be done using survey research that has been validated with the help of the themes discovered during this research. Semi-structured individual interviews involving key informants who represent different categories of stakeholders that are involved in the implementation of WtE -PPP in Punjab were to be done as the major way of collecting data. The use of semi-structured interviews was due to the fact that:

- Both should be allowed to cover predetermined themes systematically and then allow flexibility to

pursue areas of interest about an emergent theme and pursue leads along interesting lines (Braun and Clarke, 2006).

- Allow participants to explain their point of view using language of their choice, as opposed to choosing answers on a list of pre-established responses.
- Make it easy to probe and seek clarification, examples and elaborations.
- Allow variance in expertise of the stakeholders as the flow of the interview varies based on the knowledge area of the participant.

The purposive sampling method was used to choose participants according to the criterion sampling and expert sampling strategies (Patton, 2014). This approach worked well because the study needed to include people who had specific roles or knowledge and experience in the PPP frameworks, wastage management policy, WtE technology, or infrastructure finance.

Inclusion Criteria

- PPP policy formulation, project design or project implementation.
- Direct experience with waste management governance or WtE projects
- Expertise in infrastructure, finance, environmental regulation, or public procurement
- Willingness to participate and provide informed consent

This sample size is appropriate concerning reflexive thematic analysis. Braun and Clarke (2021) also note that sample size in qualitative studies should be calculated through the information power as the sufficiency of the data on answering the research questions instead of using arbitrary numbers as a metric. The 21 stakeholders made thick descriptions covering the varied perspectives and fields of competency delivering the depth of data to work with the thematic analysis satisfactorily.

Data Collection Procedures

The interviews took place in November, 2025 - January, 2026. Data quality and observation of ethical standards were made following the requisite procedure. The potential respondents were selected via the employment of professional networks, institutional affiliation, and snowballs. The first contact outlined the purpose of research and requested them to take part. All the respondents signed informed consent forms after obtaining information sheets on informing them of the purpose of the research, data handling, provisions of confidentiality, and right to withdraw. Interview time was 20 minutes to 30 minutes long and was done (face-to-face/written form) according to the choice of the participant. The structure was semi-structured and it was aimed at facilitating conversations.

Recording and Transcription

Interviews were recorded in audio and written down exactly as they were said, with the permission of the people who took part. All the transcripts were anonymized and identifiers of the participants were substituted with role codes (e.g., Government official 1, Consultant 2).

RESULTS & FINDINGS

Reflexive Thematic Analysis

The study uses a type of thematic analysis called reflexive thematic analysis, which was introduced by Braun and Clarke in 2006, 2021. This method was chosen because it provides a flexible yet consistent way to find, understand and share patterns in meaning from qualitative data. It helps uncover both obvious and hidden meanings in the data. Additionally, this approach allows for both data-driven and theory-driven analysis. Moreover, it is consistent with constructivist paradigm that this study uses. Braun and Clarke (2021) note the difference between reflexive TA and the coding reliability and codebook methods.

This study embraces the values of reflexive TA of using the Big Q qualitative values where themes are researcher-created products of interpretation and is not problematic when using the analytical subjectivity. Nevertheless, this was not an inductive analysis since it could not have been done without the knowledge of the researcher about the PPP literature, waste management issues, and the concept of sustainable infrastructure. This is what Braun and Clarke (2021) refer to as inductive analysis data-driven

theme generation, which is researcher-oriented and takes place within a researcher who introduces theoretical knowledge and applicability of the context.

Familiarization with Data

Participant Codes

- A1: MN (PPP Authority)
- A2: MS (PPP Authority)
- A3: SR (PPP Authority)
- A4: AR (Environment Dept)
- A5: MT (Environment Dept)
- A6: PB (Environment Dept)
- A7: UZ (Environment Dept)
- A8: AR (LWMC)
- A9: SD (LWMC)
- A10: NA (NGO)
- A11: ST (NGO)
- A12: QI (NGO)
- A13: DS (Environmental Expert)
- A14: WQ (Environmental Expert)
- A15: NR (Environmental Expert)
- A16: AB (Energy/PPDB)
- A17: DN (Energy/Academia)
- A18: UT (Academia)
- A19: HM (Academia)
- A20: MU (Academia)
- A21: FL (Academia)

One of the key things to think about when doing research, especially when it's qualitative and involves people, is keeping their identities and information private (Moore, 2012). To make sure participants' details are not revealed and their privacy is protected, researchers took away their real names and use made-up names instead.

Generating Initial Codes



Fig. 1. Code Categories & Frequency Institutional & Regulatory Codes

Initial Candidate Themes

The table above indicates initial codes after applying TA (Figure 1).

Constructing Themes

Theme 1: Implementation Gap - Framework Exists but Execution Fails

Codes: INST-01, INST-10, POL-01, INST-07, INST-09

Core Concept: Though legal frameworks (Punjab PPP Act 2025) exist, actual implementation is primarily compromised due institutional weaknesses, coordination failures, and policy upheavals.

Supporting Evidence

- A1: Framework is structurally adequate, effectiveness depends on implementation
- A4: If framework were satisfactory, at least one WtE project would be operational
- A2: Framework largely adequate... sector-specific guidelines still required

Theme 2: Waste Segregation Crisis - The Foundational Barrier

Codes: WM-01, WM-02, WM-07, STAKE-01, WM-06

Core Concept: Poor at-source segregation emerges as the single most critical operational barrier, affecting feedstock quality, project profitability, and environmental consequences.

Supporting Evidence

- A4: Diapers in waste significantly affect calorific value negatively
- A15: If waste is segregated at source, things become much easier
- A17: Wet waste mixed with dry waste reduces recyclability quality

Theme 3: Risk Imbalance Erodes Trust and Investment

Codes: RISK-02, RISK-03, RISK-07, STAKE-05, FIN-01

Core Concept: Uneven risk allocation to private stakeholders without adequate guarantees destroys stakeholder trust and makes projects non-bankable.

Supporting Evidence

- A4: Private partners expected to bring expertise, invest capital, while government only provides land - serious injustice
- A12: No formal system exists to share risks in land acquisition and waste supply
- A6: When private companies absorb all uncertainties, they demand higher returns

Theme 4: Government Support - Essential but Inconsistent

Codes: POL-04, POL-01, POL-02, POL-07, FIN-03

Core Concept: Government support is universally acknowledged as imperative, but policy inconsistency over political cycles dents long-term investor confidence.

Supporting Evidence

- A5: Until provincial and federal governments support unanimously and harmoniously, initiatives cannot move forward
- A13: Whenever government changed, waste supply stopped - project shut down despite profitability
- A17: Policies introduced then changed within 2-3 years during project teething phase

Theme 5: Institutional Coordination Deficit

Codes: INST-02, INST-06, INST-03, INST-08

Core Concept: Wasted inter-departmental responsibilities and the lack of inter-agency coordination, combined with federal and provincial misalignment generate approval bottlenecks and implementation paralysis.

Supporting Evidence

- A4: One window solution needed - assigning person one task then sending to another department

causes delays

- A17: Provincial government not aligned with federal - donor agencies concerned only with federal policies
- A2: Limited coordination capacity of municipal corporations

Theme 6: Community Awareness and Behavioural Change Gap

Codes: STAKE-01, STAKE-03, WM-03, STAKE-02

Core Concept: Public needs to be informed about the practices of segregation, the benefits of Waste Treatment and the effects on the environment, and this should be organized with the help of awareness campaigns and behavioural interventions.

Supporting Evidence

- A13: Awareness is very important since people don't know conversion to energy benefits
- A17: Students throw wet waste into dry bins despite attractive two-bin systems - mindset problem
- A5: Waste-Wise Program in schools to bring behavioural change through five-bin system

Reviewing Themes

Theme Refinement Process

Merging Decision

- Original Theme 5 (Institutional Coordination Deficit) merged into Theme 1 (Implementation Gap) as sub-theme
- Rationale: Coordination failures are manifestations of broader implementation weaknesses

Splitting Decision

- Theme 3 split into two distinct themes:
- Theme 3A: Risk Allocation Imbalance
- Theme 3B: Financial Non-Viability and Bankability Crisis
- Rationale: While related, risk allocation focuses on contractual/trust issues, bankability addresses investment attractiveness

Revised Theme Structure

Theme 1: Policy-Practice Gap - Framework Without Function

Sub-Themes

- Legislative success vs. operational reality
- Inter-departmental coordination breakdown
- Local participation and bureaucratic bottlenecks

Theme 2: Segregation Crisis - The Missing Foundation

Sub-Themes

- Absence of source segregation mechanism
- Feedstock quality degradation
- Community conduct and awareness deficit

Theme 3: Risk Allocation Imbalance and Trust Erosion

Sub-Themes

- Excessive private sector risk load
- Absent waste supply guarantees
- Stakeholder distrust and detachment

Theme 4: Policy Instability - The Investor Deterrent*Sub-Themes*

- Government succession interruptions
- Short-term political horizons
- Need for long-term policy securing

Theme 5: Financial Non-Viability Without Public Support*Sub-Themes*

- Basic role of government subsidies like Viability Gap Fund
- Lack of tariff and revenue clarities
- Bankability issues

Theme 6: Community Engagement Deficit*Sub-Themes*

- Lack of public awareness of WtE benefits
- NIMBY opposition and social recognition
- Informal sector integration challenges

Phase 5: Defining and Naming Themes

- Theme 1: Implementation Over Legislation
- Theme 2: Feedstock Foundational
- Theme 3: Risk Imbalance Erodes Bankability
- Theme 4: Policy Stability Determines Investment Horizon
- Theme 5: Government Support Non-Negotiable for Viability
- Theme 6: Community Buy-In -The Overlooked Prerequisite

Phase 6: Producing The Report**Summary of Findings**

This reflexive thematic analysis of 21 stakeholder interviews shows six major themes illuminating why Waste-to-Energy projects under PPP frameworks have failed to materialize in Punjab despite acknowledged potential.

- Implementation over Legislation: There exist progressive policies but an inability to carry them out, lack of coordination, and monitoring.
- Feedstock Foundational: Lack of source segregation compromises whole value chain.
- Risk Imbalance Destroys Bankability: Inequalities in risk allocation kill trust and investment.
- Investment is a matter of Political Stability: Long run capital is discouraged by political instability.
- Government Support Non-Negotiable: Financial viability cannot be achieved without government support.
- Social Approval Neglected: Community Acceptance of Buy-In.

Convergence Across Stakeholders

- All groups (government, private, NGO, academia) identify segregation as critical
- Universal agreement on government support necessity
- Widespread recognition of policy instability as barrier

Divergence by Position

- Government officials (A1, A2) emphasize framework adequacy with implementation gaps
- Environmental experts (A4-A7) lay stress on federal-provincial coordination failures

- NGOs (A10-A12) highlight community exclusion and informal sector integration
- Academia (A13-A21) focuses on systemic behavioural change and R&D needs

Implications for PPP Framework Design

Priority Interventions

- Develop WtE -specific PPP manual addressing waste supply guarantees
- Implement mandatory source segregation with enforcement mechanisms
- Establish risk-sharing frameworks with public sector guarantees
- Establish policy stability mechanisms insulating PPP commitments from political transitions
- Structure Viability Gap Fund and minimum revenue guarantee for bankability
- Integrate community participation from project inception

Evidence-Based Recommendations

- One-window approval system (A4, A12, A17)
- Performance-based segregation contracts (A1, A2, A19)
- Pilot-scale demonstration projects (A2, A17)
- Federal-provincial coordination protocols (A4, A17)
- Transparent dispute resolution mechanisms (A1, A4, A19)
- Public awareness campaigns in PPP contracts (A5, A13, A17)

Table 1

Participant Theme Contribution Matrix

Participant	T1	T2	T3	T4	T5	T6
A1 (PPP Auth)	✓✓	✓	✓	✓	✓✓	✓
A2 (PPP Auth)	✓✓	✓✓	✓✓	✓	✓✓	✓
A4 (Env Dept)	✓✓✓	✓✓	✓✓	✓✓	✓✓	✓✓
A5 (Env Dept)	✓	✓✓	✓✓	✓✓	✓✓✓	✓✓
A6 (Env Dept)	✓✓	✓✓	✓✓✓	✓✓	✓	✓
A7 (Env Dept)	✓	✓✓	✓	✓✓	✓✓	✓
A12 (NGO)	✓✓	✓✓	✓✓✓	✓	✓✓	✓✓
A13 (Expert)	✓✓	✓✓	✓	✓✓	✓✓	✓✓✓
A15 (Expert)	✓	✓✓✓	✓	✓	✓✓	✓
A17 (Academia)	✓✓✓	✓✓✓	✓✓	✓✓✓	✓✓	✓✓✓
A18 (Academia)	✓✓	✓✓	✓	✓✓	✓✓	✓✓
A19 (Academia)	✓✓	✓	✓✓	✓✓	✓✓	✓

Legend: ✓ = mentioned; ✓✓ = emphasized; ✓✓✓ = central to response

Discussion

This study investigated the barriers to and enablers of Public-Private Partnership based Waste-to-Energy project implementation in Punjab, Pakistan, through reflexive thematic analysis of 21 stakeholder interviews. The six emergent themes, policy-practice gap, feedstock inadequacy, risk imbalance, policy instability, insufficient government support, and community disengagement, collectively explain why Punjab’s WtE potential remains unrealized despite acknowledged technical feasibility and policy commitments. The following discussion places these findings within the broader scholarly literature and communicates their theoretical and practical implications.

Policy-Practice Gap: When Legislation Leads Institutional Capacity

The most consistently identified barrier across all stakeholder groups was the disconnect between formal policy frameworks and actual implementation. Participants uniformly acknowledged the existence of the Punjab PPP Act 2025 but questioned its operational effectiveness, if the framework were satisfactory,

at least one WtE project would be operational. This finding echoes strongly with the observation of Gebrekidan et al., 2024 that ineffective governance patterns in developing nations appear not from the nonappearance of policy but from the absence of systematic supervising and targeted administration. Similarly, Almeile et al. (2024) found that PPP frameworks in developing countries frequently undergo from implementation deficits rooted in weak institutional capacity rather than legislative failure. The inter-departmental coordination failures identified in this study, mainly the disconnect between environmental, energy, and planning authorities, mirror the conclusions of Huang et al. (2018), which documented that successful WtE -PPP programs in China required the deliberate creation of specialized coordination structures linking multiple regulatory bodies. The absence of such structures in Punjab creates the approval bottlenecks that participants described as one-window problem; (A4, A12, A17), suggesting that institutional architecture reform must go before or accompany any new PPP contracting activity.

Feedstock Reliability: The Commercial Core of WtE Viability

The near-worldwide identification of waste segregation failure as the initial operational barrier indicates a well-established challenge in WtE literature. Cao et al. (2022) identified feedstock quantity and quality as among the topmost risks in PPP-based WtE incineration projects, and Wang and Zhang (2018) demonstrated through Bayesian risk modelling that uncertainty in waste stream characteristics directly translates into eminent financial risk for private investors. The current study provides qualitative depth to these quantitative findings: participants described how mixed waste of low calorific value is exemplified by reference to diaper contamination which renders energy conversion calculations commercially not viable. This study extends the existing literature by determining that feedstock failure in Punjab is not simply a technical issue but a governance one. The absence of contractually enforceable waste supply guarantees, noted by seven participants (RISK-03), means that even a well-designed PPP structure cannot protect investors from revenue volatility caused by irregular or inadequate waste delivery. This finding supports Gad et al. (2024) argument that sustainable WtE solutions demand risk allocation mechanisms that specifically address demand and feedstock supply risks, not merely construction and operational risks.

Risk Imbalance and the Erosion of Investor Trust

The risk allocation dynamics identified in this study reveal a structural asymmetry that undermines project bankability. Private partners are expected to absorb construction, operational, and revenue risks while the government's contribution is frequently limited to land provision, a configuration that participants characterized as; a serious injustice; (A4) and which NGO representatives confirmed lacks any formal risk-sharing mechanisms (A12). This imbalance is consistent with Almeile et al (2024) systematic review finding that excessive private sector risk transfer without ample compensation mechanisms is a common failure mode in developing-country PPPs. The conceptual principle communicated by Irwin (2007) that risk should be allocated to the party best positioned to appear systematically violated in Punjab's emerging WtE landscape. Khahro et al. (2021) risk severity matrix for sustainable PPP projects in developing countries provides further grounding for this outcome, emphasizing that financial, technical, social, and environmental risks must be evaluated and distributed with equal rigor. The Viability Gap Fund mechanism referenced by participants (FIN-03) signifies a potential corrective instrument, but its current underdevelopment leaves a critical organizational gap in project financing architecture.

Policy Instability as an Investor Deterrent

Long-term private investment in capital-intensive WtE infrastructure requires policy environments that stretch beyond electoral cycles. Participants described multiple instances of project abandonment following government transitions A13 noted that; whenever government changed, waste supply stopped and documented policy reversals within two to three years of a project launch phase (A17). This finding is consistent with the World Bank (as cited by Mundial, 2020) conclusion that PPP regulatory quality improvements are necessary but insufficient without accompanying political stability, as investor confidence depends on the durability of contractual commitments beyond the tenure of any individual administration. The implications for PPP framework design are significant. The literature on PPP performance, including Liu et al. (2015), emphasizes that long-term infrastructure partnerships require

performance measurement frameworks embedded in legally binding, politically insulated contractual arrangements. Punjab current PPP framework lacks such insulation mechanisms, which this study identifies as a critical design deficiency that discourages both domestic and international investors from committing capital to WtE projects whose viability depends on decade-long operational windows.

Government Support as a Non-Negotiable Precondition

Fourteen out of twenty-one participants (POL-04) identified government support as imperative to WtE project viability, the highest frequency finding in the entire dataset. This convergence across government, private sector, NGO, and academic respondents reflects a broad stakeholder consensus that the WtE-PPP model cannot function as a purely market-driven initiative in Punjab current institutional and financial environment. The World Bank documentation of PPP (as cited by [Mundial, 2020](#)) investment flows confirms that governmental guarantee is among the strongest predictors of private infrastructure investment. Participants explicitly identified the Viability Gap Fund, feed-in-tariff guarantees, and minimum revenue assurances as the most vital forms of government support (FIN-02, FIN-03, FIN-04). The absence of these mechanisms explains why Punjab's WtE projects, including the Lahore 40-50 MW Expression of Interest, remain stalled despite granted technical feasibility. The policy implication is clear: government support must be structured as formal, legally binding financial instruments rather than stated as political intention.

Community Engagement: The Overlooked Prerequisite

The NIMBY (Not In My Backyard) syndrome identified by participants reflects a global pattern in WtE project opposition that the literature consistently links to inadequate community consultation and benefit-sharing mechanisms. [Yu et al. \(2018\)](#) established that sustainable PPPs require stakeholder engagement, shared community benefits, and transparent environmental performance communication as core project design elements rather than supplementary activities. The present study finds that community awareness campaigns have been largely absent from Punjab WtE planning processes (STAKE-01, nine participants) suggests that this dimension of project design has been systematically undervalued by policymakers and project developers alike. Participants proposed that behavioural change programs particularly in schools, informal sector integration, and transparent community consultations embedded from project inception, could substantially mitigate social acceptance barriers. These proposals align with [Khahro et al. \(2021\)](#) framework and reinforce the conclusion that community engagement is a governance responsibility, not a communications challenge.

Toward an Integrated PPP Framework for Punjab

Taken together, the six themes reveal that Punjab WtE implementation failures are systemic rather than isolated, and effective solutions must address institutional, technical, financial, and social proportions simultaneously. The projected PPP framework emerging from this study recommends: a streamlined one-window approval system to eliminate bureaucratic fragmentation; mandatory waste characterization and source segregation with contractual enforcement; a restructured risk-sharing model incorporating Viability Gap Funding and minimum revenue guarantees; legally binding long-term policy commitment mechanisms insulated from political transitions; and community engagement integrated from project initiation as a governance requirement. The multi-dimensional framework, as displayed in Figure 2, responds to the density of WtE-PPP challenges in developing-country perspectives and contributes to the growing body of literature advocating integrated methods to sustainable infrastructure governance ([Cao et al., 2022](#); [Gebrekidan et al., 2024](#)).

Proposed Strategic Framework

The Strategic Framework (Figure 2) demonstrates how three mutually reinforcing failure systems i.e. Institutional Failure, Technical Failure and Risk & Social Failure all demand an effective framework for Punjab. The framework then responds to each failure with a targeted solution pillar which include Governance reforms through a One-Window System and Policy Anchoring, Technical fixes via Waste Data Specifications and Segregation At-Source, Risk & Finance mechanisms including VGF and Policy Guarantees and Community Trust building through Campaigns, Pilots and Dispute Resolution. Figure 2 argues that Waste-to-Energy Public-Private Partnership success in Punjab requires simultaneously

addressing all three failure dimensions and focusing on the suggested solutions, rather than tackling them in isolation.

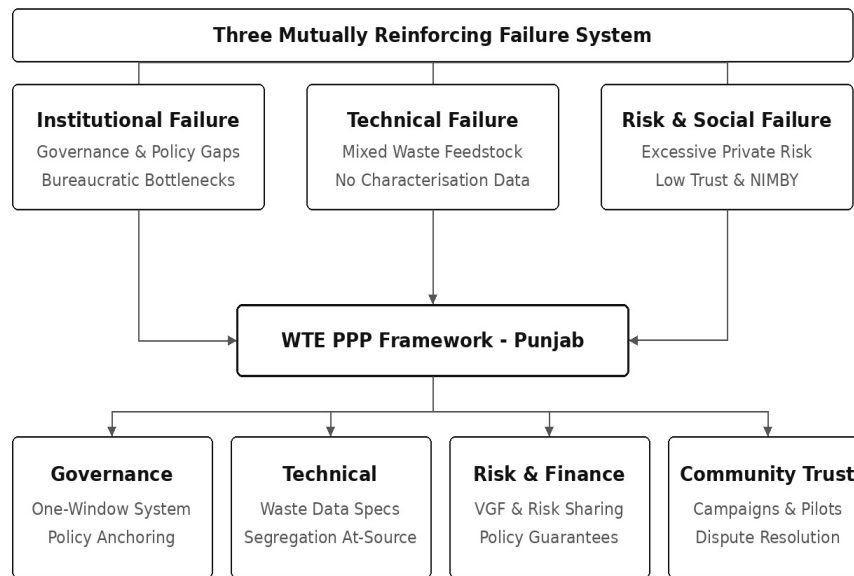


Fig. 2. Strategic Framework

CONCLUSION

The results of TA in terms of barriers and policy amendments needed to attain a sustainable Waste to Energy Framework in the Punjab PPPs are presented in the following diagram. Punjab's Waste-to-Energy objectives are collapsing under the weight of three mutually reinforcing failure systems and cosmetic interventions will not save them. The first, among this system, is institutional failure. The Punjab PPP Act does exist as a policy, but inter-departmental coordination remains functionally absent. Bureaucratic approval bottlenecks do not emerge from incompetence alone; they are the conventional product of a regulatory architecture that was never designed to accommodate complex infrastructure partnerships. Policy succession risks further make this complex as private investors do not commit capital to frameworks that evaporate with each change of government.

The second failure is technical. Feedstock quality degradation resulting from the absence of at source segregation systems makes the entire energy conversion calculus defective. No serious investor will underwrite a plant whose primary input i.e. municipal solid waste that arrives as an uncharacterised, heterogeneous mass. This is not a peripheral inconvenience; it smashes the commercial core of every WtE project in the province. The third failure is economic and social. The private sector is being asked to absorb risks that no rational market actor should face alone, while Viability Gap Funding (VGF) mechanisms remain structurally underdeveloped. Simultaneously, uninformed communities mobilise opposition rooted in fear rather than evidence, it is a problem that governments have persistently treated as a communication challenge when it is, in fact, a governance failure.

Hence, what Punjab therefore requires is not another policy document, but a sequenced, binding intervention framework: streamlined One-window approvals, mandatory waste characterisation, enforceable risk-sharing mechanism and community engagement embedded from project inception not added as an afterthought. The technology exists. The waste certainly exists. What remains absent is the institutional will to fill the gap between them.

Competing Interests

The authors declared no competing interests.

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