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**A CASE STUDY OF MOSHI LANDFILL: ADDRESSING CHALLENGES THROUGH A SYSTEMATIC FRAMEWORK.**

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Article Received: 24 February 2026 \*Corresponding Author: Roshani Salunkhe

Article Revised: 14 March 2026

PG Students, School of Construction, NICMAR University, Pune.

Published on: 04 April 2026

DOI: <https://doi-doi.org/101555/ijrpa.1998>

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**ABSTRACT**

Landfilling is the most prevalent method of waste management globally and is a crucial alternative, especially in low- and middle-income nations, owing to its comparative ease and affordability. Due to budget constraints, numerous landfills do not have sufficient environmental protection measures like effective liners and leachate collection systems, resulting in considerable environmental pollution. Despite having mitigation systems implemented, it is not always possible to ensure the total prevention of pollution. This research offers a case study of Pune's Moshi Dumping Yard, with the goal of performing a systematic evaluation of municipal dumping grounds and sanitary landfills from social, technical, and environmental viewpoints. Information was gathered via site visits, field surveys, and stakeholder engagements to pinpoint the existing challenges in landfill management. The research highlighted crucial problems like the significant amount of waste, byproducts from waste-to-energy facilities, and inadequate internal access routes in the landfill site. In light of these discoveries, a structured framework has been created to tackle the pinpointed issues using efficient planning and management techniques. The suggested framework seeks to minimize environmental and social effects while acting as a blueprint for future sustainable landfill design and administration in India.

**KEYWORDS:** Landfill, leachate, Environment.

**1. INTRODUCTION**

Rapid population growth, urbanization and expansion of economic activity, causes the

municipal solid waste (MSW) management to be a major city problem in India due to its exponential growth in waste production (Sharholly et al., 2008; Kapoor and Chakma, 2024).

The process of unscientific disposal, improper planning of waste location areas, and the poor quality of the environment, along with human health risks as well as the impact on the infrastructure systems of the municipalities, have led to the worsening of the environmental quality (Sharholly et al., 2008; Joshi, 2016). Landfills have become the last resort when waste is unable to be recycled or treated and thus the planning and management of these facilities is key in ensuring the quality of the environmental conditions in the urban areas (El-Fadel et al., 1997; Kaza et al., 2018).

Poor separation of waste in the Indian cities, improper collections, and disposal in the cities have led to environmental degradation and health risks. Pune is an example of such a challenge, and its increasing urbanization has overloaded municipal infrastructure (PMC, 2022). The Moshi Dumping Yard reveals the ineffectiveness of the prevailing landfill management systems in terms of poor separation of waste, no engineered liners, open dumping, poor management of leachate, contamination of groundwater, odor, and social effects among the local communities. Although some efforts are in place like decentralized waste segregation and recycling efforts, there are still technical and operational issues in landfill planning.

The majority of studies concentrate on waste segregation and collection whereas very little attention has been taken on landfill planning, design and sustainability in the long run. This paper involves systematic analysis of Moshi Dumping Yard in Pune in terms of social, technical, and environmental situations through field surveys, site visits and interactions with the stakeholders. According to the diagnosed issues, the systematic framework is suggested to enhance planning and control of landfills to build sustainable solid waste management in India..

## **2. LITERATURE REVIEW**

### **a) Waste Generation Trends**

The amount of waste generated on Earth is quite high and reaches 7-9 billion tonnes annually, which consists of 2 billion tonnes of Municipal Solid Waste (MSW) produced at households (Wilson and Velis, 2015; Kaza et al., 2018). MSW has environmental and health risks which include plastic contamination, emission of greenhouse gases, leaching of nitren, and air pollutants caused by open burning. The recycling, composting, and waste-to-energy categories of the circular economy are supported throughout the globe; the problem is that currently 70 percent of waste are deposited in ill-maintained dumps and landfills (EC, 2015a; Kaza et al.,

2018). Recent data collections, such as What a Waste, provide an approximate number of waste production but lack detailed information on type of waste, treatment, and environmental implications.

However, nowadays 70 percent of the global waste is deposited into dumps and landfills (Kaza et al 2018), herein abbreviated as Solid Waste Disposal Systems (SWDS). The simplest SWDS is dump; it consists of depositing waste in large quantities without any technical control, which contributes to significantly increasing the pollution of waste as well. The landfills can also entail diverse levels of technical interventions to lessen and reclaim the quantity of leachate and gas produced, which may involve the incorporation of impervious layers and cover, respectively (Manfredi et al 2009).

**b) Landfill as a Disposal Option.**

Effective disposal of municipal waste (MSW), is still among the most challenging environmental issues in the world (Kaza et al., 2018; El-Fadel et al., 1997). Waste management practices that are common among the developing countries include landfills and open dumps (Kaza et al., 2018). Generally solid waste of a municipal nature is disposed through the following methods. 1. Solid waste open burning 2. Sanitary landfill of solid waste 3. Incarnation process 4. Composting 5. Ploughing into fields disposal 6. Disposal by hog feeding 7. Salving procedure 8. Fermentation or biological digestion. Among all the solid waste management methods existing, landfill is the most popular method of waste management in the globe (El-Fadel et al., 1997; Kaza et al., 2018). These landfills have been the ultimate recipient of municipal waste, industrial or agricultural waste, sewage sludge, incineration ash, recycled waste and / or treated hazardous waste (Christensen et al., 2011), thereby creating more interest in innovation and development of waste management systems.

Landfills help in minimizing environmental pollution through elimination of seepage of pollutants into soil and ground water (Rowe, 2005). This is achieved through the use of clay liners in sanitary landfills and synthetic liners, such as plastics, in the municipal landfills (Mmereki et al., 2016). To minimize the exposure of waste to air, they are packed and buried, thereby limiting decomposition and environmental release of the pollution (Joshi et al., 2017). Approximately, 55 percent of waste generated in the USA is disposed in landfills in 2008 (US EPA, 2008). Since they are widely used, there is need to understand the environmental and

public health impacts of landfills (Domingo et al., 2015).

**c) Landfill design and Engineering-**

Contemporary landfills are well planned structures which are situated, designed, run and monitored to avail adherence to federal standards (U.S. EPA, 2016). Solid waste landfills should be constructed in such a way that they keep off the environment of the contaminants that might exist in the solid waste stream (El-Fadel et al., 1997). The landfill siting plan helps to avoid location of landfills in the environmentally-sensitive zones and on-site environmental monitoring plans keep it under control in case of any gas contamination of groundwater and landfill gases, and it offers other protective measures (Christensen et al., 2011). Also, there are numerous new landfills that receive potentially dangerous landfill gas emissions and turn the gas into energy (Bogner et al., 2007).

The volume of the landfill required ought to be calculated according to the waste generation expected in future and the expected life of landfill (Tchobanoglous & Kreith, 2002). Foot print area of the landfill can be estimated when the depth is finalized (Kumar et al., 2017). The general size of the landfill has to include service, buildings, access roads, buffer zones and so on as a facility (El-Fadel et al., 1997). Another study on the identical subject by (Jay N. Meegoda, Hiroshan Hettiarachchi, Patrick Hettiaratchi) indicates that the concept of the labour market being competitive has not succeeded in clarifying the relationship between wages and employee productivity. A different study on the same topic by (Jay N. Meegoda, Hiroshan Hettiarachchi, Patrick Hettiaratchi) suggests that labour market being competitive has failed to explain the relationship that exists between wages and the productivity of the employee.

**d) Site Selection for Landfilling –**

The suitability map of solid waste dumping/landfilling sites of the Ludhiana city was made after overlay operation of the site selection criteria based on remote sensing and GIS methods (Singh et al., 2014). The site suitability map shows that the majority of dumping/landfilling sites were located in southern sides, western sides and south western sides of the city of Ludhiana (Singh et al., 2014). Eastern side of the city had no appropriate location where solid waste could be disposed (Singh et al., 2014). Five solid waste disposal sites were found viz. Alamgir(100.78 ha), Issewal (92.14 ha), Dakha (77.32 ha), Narangwal(50.89 ha) and Assi Kalan (25.69 ha) villages at 10 Km, 20Km, 18 Km,18 Km and 17 Km respectively, of the center of the city (Singh et al., 2014). Among them, three locations were identified and suggested to dump solid wastes/landfill lithologs of locations which are located in Alamgir,

Assi Kalan villages. It was discovered that the Amalgir village site was very appropriate with area of 100.78 ha to solid waste dumping/landfilling on south side of the city of Ludhiana located at 10 km distance of the centre of the city (Singh et al., 2014). The location to be proposed is well environmental and has enough space to handle the massive volume of solid waste produced daily in Ludhiana city (Singh et al., 2014).

### **Challenges of landfilling in India:**

The paper has reviewed this problem and issues associated with waste disposal in landfills. The most economical method of disposing waste is landfill, which is outengineered and therefore a tremendous threat to human health and environment. The current paper highlights the construction of new sanitary landfills and treatment of waste using different waste-to-energy technologies. This will address the majority of the landfill related problems like the leachate, toxic and the migration of green house gases to the environment. Health/ Environmental Hazards: Mishandled landfills result in toxic gases, leachates, and air and water pollution, which impact on the health of people. Waste Segregation and Recycling: Recycling and sorting waste at the point will decrease the size of the landfill and improve resource recovery. Waste-to-Energy Solutions: By turning waste into energy, the space used in landfills is reduced and power is produced.

### **Research Gap-**

Current studies of municipal solid waste management cover the landfill problems in a rather disconnected way, with various authors paying attention to the site location, waste treatment, leachate management, or environmental consequences. There is however an evident deficit in integrated frameworks of landfill planning that integrate landfill size, progressive zoning, infrastructure planning and future land use, specifically in the Indian urban conditions. Moreover, resource recovery principles like fly ash utilization in waste-to-energy plants or biomining in the old waste are usually addressed separately, without being connectively attached to landfill design, internal infrastructure construction, or land recovery policies. Other issues such as ineffective internal traffic control, ineffective logistics, and phased but not preplanned operations are poorly studied yet have a profound impact on the efficiency of the landfills and their environmental results.

Moreover, the available literature pays an insignificant focus on the institutional, policy, and social aspects of landfill management. Although there are regulatory guidelines, their combination with the technical planning and contractual implementation is not explored

properly in the literature. Odor, health and social concerns as well as dissatisfaction of the people are mostly addressed descriptively and very few studies are done to quantitatively analyze the role of social perceptions and environmental consciousness in the effectiveness of landfill management. This identifies a pressing research gap of systematic and place-specific framework that incorporates planning and design, resource management, operational efficiency and policy alignment coupled with integrating social and environmental aspects into landfill management decision-making..

### **3. METHODOLOGY**

This study has a systematic and step-by-step approach to the methodology as shown in Fig 1 in an attempt to comprehend and solve the landfill management issues in the Moshi Dump Yard. It starts with the comprehensive literature review of the research papers, reports and guidelines on the topic of sanitary landfill planning and waste management to determine the gaps in research. This is then followed by the primary data collection in terms of site surveys and a social perception survey, which creates raw data that is quantifiable in terms of the perception of the stakeholders as well as the local residents. The data gathered is then evaluated, in order to evaluate social features and operational issues relating to landfill planning and implementation at the Moshi location. On the basis of the challenges identified, a case study- based framework is created through the systematization of the best practices and viable solutions in the context of the local situation. Eventually, SmartPLS analysis of Likert-scale survey data allows making conclusions and recommendations and identifying the most influential factors and formulating evidence-based and practical recommendations regarding the enhancement of landfill planning and management.



**Fig 1: Research Methodology Flow Chart.**

### 3.1 Data Collection Site Survey:

The Moshi dump is one of the largest landfills in the region and it lies within the neighbourhood of Pimpri Chinchwad of Pune. As part of the primary data collection, a site visit to the Moshi Dumping Yard was conducted on 27th September 2025 to understand the on-ground operational conditions and existing waste management practices (Figure 2). It has been used since early 1990s to dispose of municipal solid waste, which has a size of approximately 80-81 acres. Pimpri-Chinchwad Municipal Corporation (PCMC) area currently delivers about 1,100 to 1,400 tonnes of rubbish to the facility on a daily basis. The landfill has evolved through the years to be more than just a dump site, it is now a high-tech waste management plant with numerous waste processing plants, one of them is the 400-ton-per-day composting plant and the other one is the 1,000-ton material recovery plant where the dry and wet waste is separated. Trash disposal has been mitigated in the recent years with the commissioning of a 14 MW trash-to-Energy (W2E) plant which converts Refuse Derived Fuel (RDF) into energy.



Fig 2. Site visit to Moshi Dumping Yard.

The problems are reflected in Pune where the stress on city infrastructure is growing with the rise in urban population (PMC, 2022). The Moshi Dumping Yard highlights the flaws of the current landfill management practices. Problems such as Volume of waste growing day-by-day, Transportation problem, lack of designed liners across the board, open dumping and lack of proper leachate management have caused ground water pollution, odorous and negative social impacts on the local communities.

### Social Survey:

The management of urban landfills is a technical, social, and environmental problem. As more solid waste is generated by the municipality in Pune, it is becoming significant to know what people think of how landfills are managed. The study focuses on the impacts of the social awareness and the environmental perceptions of residents in landfill management, in terms of their satisfaction and trust. In order to be able to capture such perceptions, a structured questionnaire was designed that highlights three key constructs such as social factors, environmental factors and management of landfills.

The social factors construct measured the effect of the landfill operations on the everyday life in terms of odor, health issues, air and water pollution, pests, noise, government transparency,

and effects on property value through a five point impact scale. The environmental factors considered perceptions on the loss of green cover, destruction of biodiversity, water pollution, and sustainability using a four-point agreement scale. The landfill process was directed to the social attitudes of effectiveness, cleanliness, organization, and municipal intervention as a measure of five-point efficiency scale.

**Table no 1: Details of the survey respondents.**

<b>Sr. No.</b>	<b>Parameter</b>	<b>Description</b>
1	Number of Participants	124 respondents
2	Type of Survey	Semi-structured questionnaire
3	Survey Method	Field-based primary survey
4	Target Respondents	Residents living near Moshi Dumping Yard
5	Study Area Coverage	Within 2 km radius of dumping yard
6	Age Group	26–55 years
7	Data Type	Likert scale responses (5-point scales)
8	Key Factors Studied	Social Factors, Environmental Factors, Landfill Management
9	Purpose of Survey	To assess public perception and impact of landfill operations
10	Analysis Tool Used	SmartPLS (PLS-SEM approach)

SmartPLS software will be used to analyze the data collected in order to test the relationships between social awareness, perceptions about the environment, and perceived effectiveness in landfill management. The results can be assumed to assist the policymakers and the local governments in detecting major issues of concern among the population and enhance their operations and integration with the communities. The details of the survey respondents and data collection are summarized in Table 1.

### 3.2 Data Analysis

#### Social Aspects:

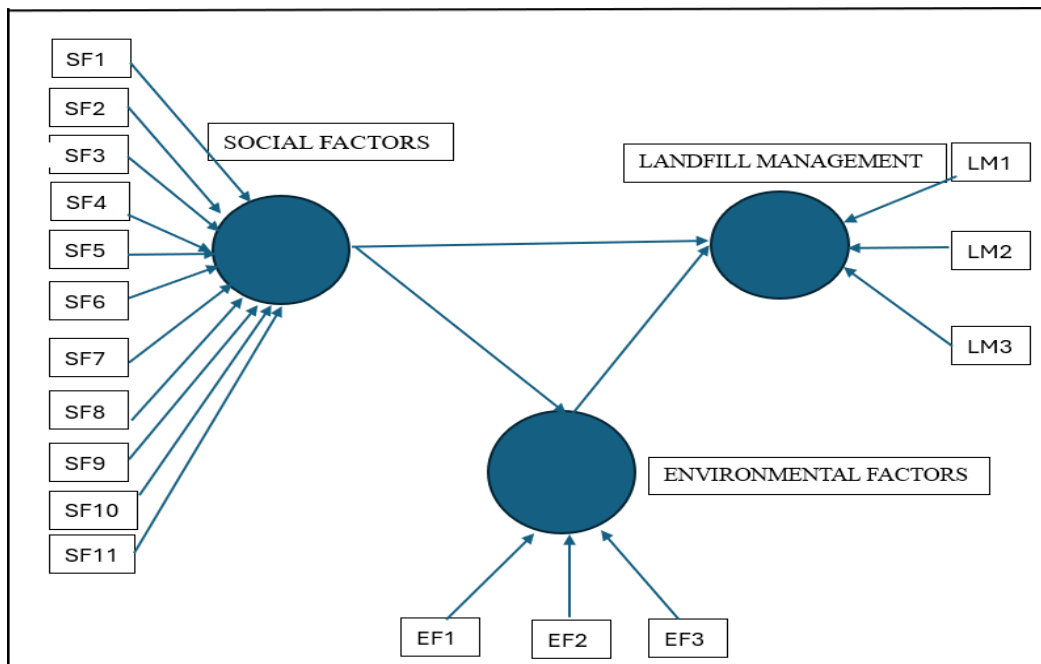


Fig 3: Structural Equation Model (PLS-SEM) for Landfill Management.

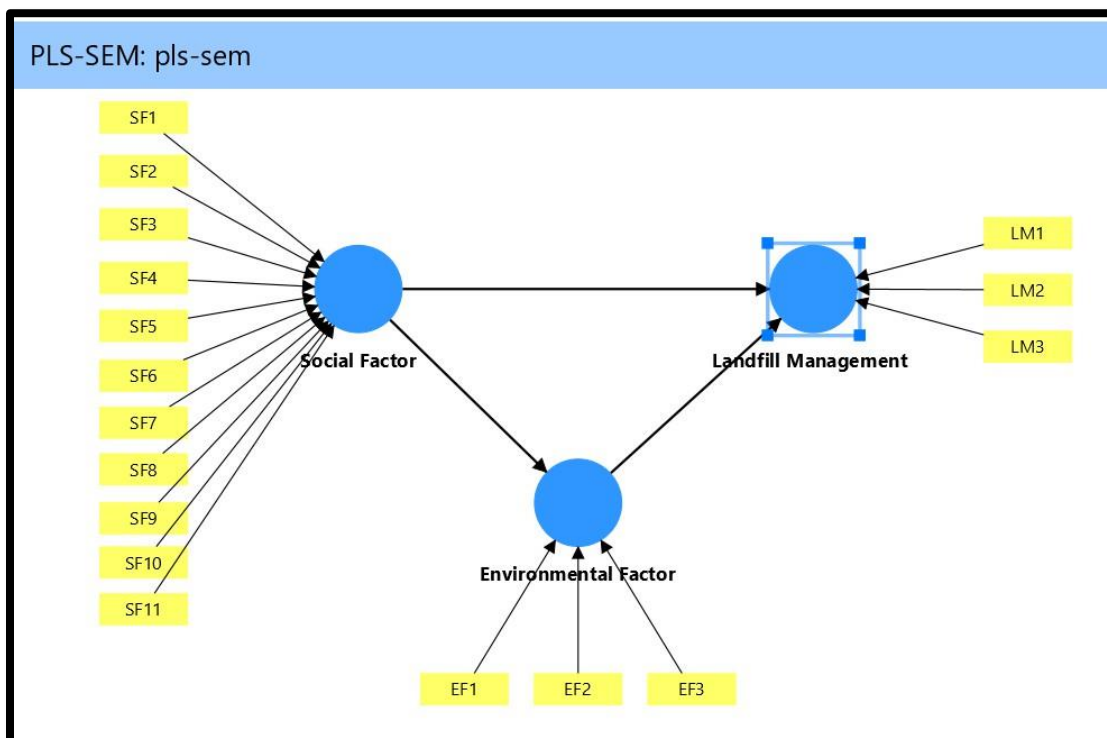
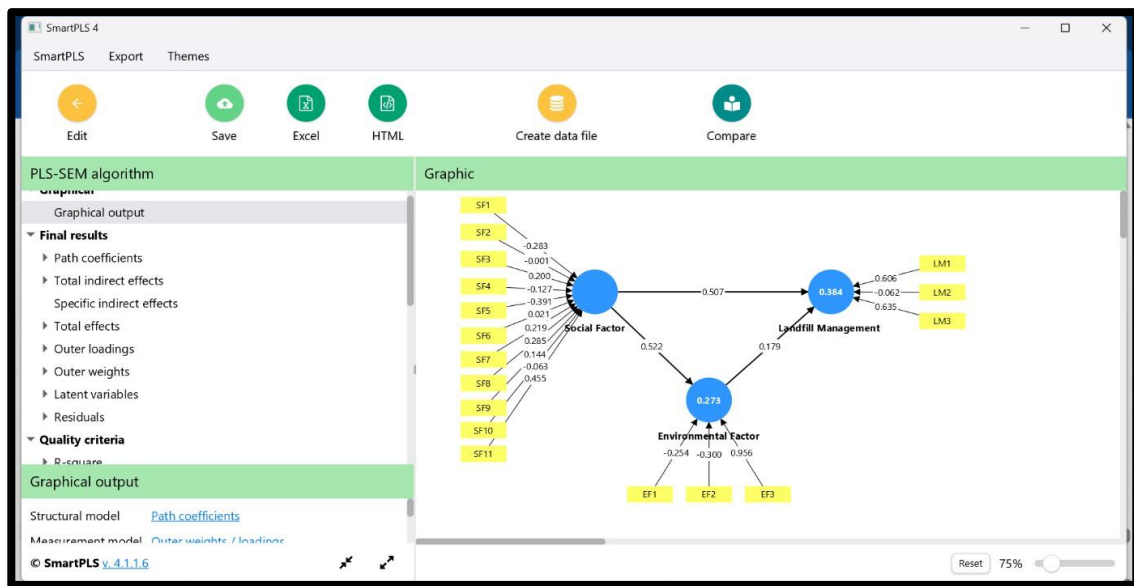


Fig 4: PLS-SEM Path Model of Social, Environmental Factors and Landfill Management.



**Fig 5: PLS-SEM Structural Model Output. (SmartPLS)**

A PLS-SEM analysis was conducted using SmartPLS software to examine the social factors, environmental factors, and the perceived effectiveness of landfill management at the Moshi Dumping Yard as shown in Fig 3.

According to this analysis, the structural model shows a positive correlation of the social factors with the environmental factors ( $b = 0.522$ ) and moderate positive correlation of the social factors and landfill management ( $b = 0.507$ ). The structural model additionally reveals that the relationship between the environment factors and landfill management is weak, but positive ( $b = 0.179$ ). All in all, the model showed a reasonable level of explanatory power since social factors explain approximately 27.3 percent variance. Finally, the overall impact of the social factors as well as the environmental factors on the management of landfills was found to explain the factor with an approximate power of 38.4 as shown in Fig 5.

The measurement model was further adjusted to eliminate the indicators with weak or negative loadings and four new and reliable factors were retained that are EF3, LM1, LM3, and SF11. To test all the relationships on a five percent (5%) level of statistical significance, a bootstrapping analysis (5,000 subsamples) was performed to make inferences. The analysis showed that there is a significant positive association of social factors with landfill management ( $b = 0.342$ ,  $p = 0.001$ ) and environmental factors ( $b = 0.353$ ,  $p = 0.000$ ), thereby giving further support to the fact that environmental factors are also significantly associated with landfill management ( $b = 0.309$ ,  $p = 0.004$ ). Consequently, there is a systematic plan of landfill management efficiency in the Moshi location, which is highly influenced by the social

perceptions and environmental consciousness.

### **Challenges in the Landfill (Moshi):**

The Moshi Dumping Yard in Pune is impacted by a number of environmental and operational issues that can influence the sustainability of waste management and its efficiency. One of them is the creation of waste levels beyond the planned limit of the landfills because of the rapid population growth, urbanization, and the growth in the commercial activity. The waste that arrives at the site is mostly unsegregated, and this makes it even more difficult to handle, process, and dispose of the waste.

The other major issue is the fly ash control produced as a result of the local waste-to-energy plant. Poor infrastructure to collect, store and dispose of fly ash safely, coupled by high cost of transportation and treatment, are associated threats of air, soil and groundwater contamination and health threats on workers. The constraint of land is also a significant limitation and landfill is hard to expand. To reclaim the land and recover resources biomining activities have been launched, these are met with difficulties in terms of bulk of wastes, dust, odor management, equipment requirement, and disposal of inert materials.

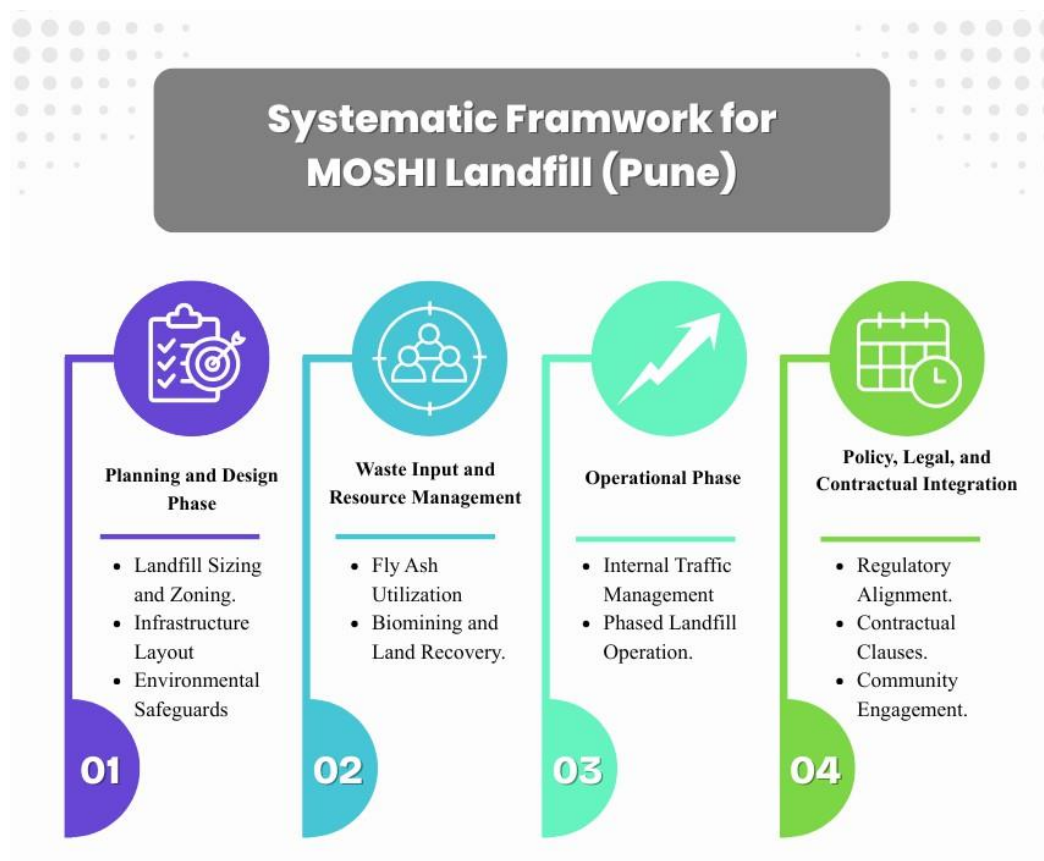
The presence of poor internal road conditions and inappropriate drainage affects the internal logistics resulting in vehicle congestion, delay and poor waste positioning. The draining of the surface and the rising of the leachates are added during the monsoon season, which further contaminates the environment and limits the activity of the landfills. These problems help to demonstrate that it is necessary to improve planning, have better infrastructure at the Moshi Dumping Yard and have a better landfill management practice.

### **3.3 Framework and solution generation Case Study Review:**

As the Moshi Dumping Yard is the service provider to the rapidly growing population in Pune, it has a variety of environmental and operational concerns that undermine the sustainability and efficiency of garbage management. The primary issues include poor internal roads and logistics, fly ash dumping as a result of the nearby Waste-to-Energy project, a large amount of waste and limited land space. The congestion is brought about by poor road conditions and lack of space leading to further slows in the operations and inflow of trash and unsegregated rubbish heightens the depletion rate of the landfill capacity.

These issues are proposed to be addressed through a systematic methodology as shown in Fig 6.

## Systematizing the framework:



**Fig 6: Systematic Framework for MOSHI Landfill. (Pune)**

The landfill will have five zones of operation and 14 years horizon each, hence should be designed to enable gradual deposition and superimposing biomining to reclaim space (Qian, Koerner & Gray, 2002). Fly ash may be utilized in a temporary internal road or be diverted to the road activities being done nearby, which will minimize the effects of disposal and enhance efficiency of operation. (Ministry of Road Transport and Highways. (2014). Guidelines for use of fly ash in road construction. Government of India.) The internal logistics can be enhanced by having holding bays, vehicle scheduling systems, and an effective road network.

The application of these solutions provides a long term landfill management approach that is efficient and sustainable. The use of fly ash reduces the environmental impact, staged zoning through biomining ensures maximum land utilization, and draining and infrastructure sustains its operations and the ecosystem around. This framework has offered a replicable model of managing urban landfills in other cities that are growing and is aligned with the country-wide regulations, including the Solid Waste Management Rules, 2016, the CPCB landfill guidelines and directives of MoRTH/NHAI

#### **4. RESULTS AND DISCUSSION**

These findings of the SmartPLS analysis demonstrate that social and environmental factors have a significant impact on the effectiveness of landfill management at the Moshi Dumping Yard. Based on the study, social factors play a major role in influencing the overall perception of the environment by individuals and the general quality of landfills. Public perceptions on environmental effects and evaluation of landfill management processes are highly determined by the concerns of the people on health hazards, odour nuisance, water pollution, and transparency about the municipal activities. The landfill management is also influenced by environmental factors, which have a less significant influence and are largely mediated by the experience and social awareness of the community. On the whole, the model demonstrates a fair capability to determine the way in which the population perceives landfill management, which proves that the issue of landfill management is a social-environmental concern and not a purely technical issue.

These findings are closely correlated to the challenges encountered when conducting site inspections and field surveys at the Moshi landfill. The significant issues affecting operational performance and environmental safety are the large amounts of trash, low-access roads, fly ash management through the waste-to-energy facility, limited access to land, and the leachates produced during the monsoon season. The prevailing social aspects in the analysis show the discontent in the community due to odor problems, poor hygiene, health problems, and lack of effective communication between neighbors and officials. According to these findings, the proposed systematic framework lays much emphasis on integrated solutions, including the controlled application of fly ash to minimize the risk of environmental risks, the adoption of better internal road and drains infrastructure to enhance operational efficiency, the phased zoning of landfill with biomining to overcome the problem of land scarcity, and enhanced leachate management infrastructure to safeguard soil and groundwater. It is clear in the discussion that the sustainable landfill management at Moshi requires a balanced approach encompassing all aspects of environmental protection, improved social participation, and technical interventions.

#### **5. FUTURE STUDY**

The research could be extended by the future research that would examine the ways in which the attitude of society and the environmental performance change once the more improved landfill management methods have been implemented. A better understanding of landfill

sustainability would arise through the expansion of the analytical framework to incorporate institutional capacity, regulatory effectiveness, economic considerations, and technological adoption. Comparative studies made at a number of waste places in different urban settings would further contribute towards development of scalable and policy-relevant landfill management solutions in India.

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