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Research Article

# Geographical Study of Solid Waste Management in Lucknow City: A Review

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## Abstract

Municipal solid waste management (SWM) is a challenging task for the developing-country authorities. Integrating recycling systems into SWM is essential for mitigating this problem. Understanding the elements that influence recycling is vital for sustainable waste management. Institutional components such as enabling legislation and regulations support effective Integrated Solid Waste Management (ISWM). Solid waste management is the organised handling, disposal, and recycling of solid waste generated by human activities. This includes collecting, transporting, processing, and correctly disposing of diverse types of solid waste to reduce their negative influence on the environment and public health. The phrase "solid waste" refers to neither liquid nor gaseous items. The literature review on municipal solid waste management (MSWM) revealed significant insights into the subject matter. One key finding was the importance of adopting a comprehensive and integrated approach encompassing waste reduction, reuse, recycling, and disposal methods. This holistic approach, guided by waste hierarchy principles, such as source reduction and recycling, is crucial in minimising waste generation and promoting sustainable practices. The review also identified several challenges faced by municipalities in managing solid waste. The main hurdles were inadequate infrastructure, insufficient funding, and limited public awareness and participation. To address these challenges effectively, improved policies, regulations, and governance frameworks were deemed necessary. Municipalities can create a conducive environment for sustainable waste management by implementing these measures. Advanced technologies and innovative solutions were highlighted as potential game-changers in MSWM. Waste-to-energy systems, anaerobic digestion, and landfill gas capture were identified as valuable options that contribute to waste diversion, energy recovery, and reduction of greenhouse gas emissions. Integrating these technologies into waste management strategies can significantly enhance sustainability efforts.

**Keywords:** Municipal Solid Waste Management (SWM); Integrated Solid Waste Management (ISWM); Municipal Solid Waste Management (MSWM)

## Introduction

Much research on municipal solid waste management from various angles has been undertaken at the global, national, and local levels [1]. Here is a selection of case studies, papers, reports, books, journals, and websites on solid waste management. State governments and municipal corporations regulate solid waste management in Indian cities. Furthermore, municipal organisations must handle local solid waste [2]. Various academics in India and overseas have researched the difficulties with and solutions to solid waste at multiple levels. These researchers find ways to manage substantial trash and dispose of it safely in India and other countries. Some effort is made in this section to summarise some of the studies relevant to the previously mentioned issue. Material waste management in India's metropolitan cities has become relatively significant in the twenty-first century. Indian researchers began their work in this field in the twenty-first century is first decade. The following reflects numerous Indian and foreign thinkers' perspectives on solid waste management [3]. Municipal waste management concerns directly result from increased urbanisation and population [4]. Waste is currently created in increasing volumes and a variety of compositions. Emerging countries such as India have faced logistical challenges as municipal solid waste generation has increased dramatically in recent decades [5].

Municipal solid waste is a primary environmental challenge in rising urban and rural countries. This is primarily due to increased solid waste generated due to population expansion, rapid urbanisation, and changes in consumer habits [6,45]. The ability to store, organise, administer, and analyse data is a feature of Geographical Information Systems (GIS), which is very helpful when describing issues [7]. Because of its geographical component, spatial multi-criteria analysis distinguishes itself from traditional multi-criteria decision-making processes [8]. Solid waste management is the organised handling, disposal, and recycling of solid waste generated by human activities. This includes collecting, transporting, processing, and correctly disposing of diverse types of solid waste to reduce their negative influence on the environment and public health. The phrase "solid waste" refers to neither liquid nor gaseous items. However, in the context of waste management, containerised liquid and gaseous waste are included in this category. Municipal solid waste (MSW), industrial waste, hazardous waste, agricultural waste, and waste from thermal power plants are the most frequent types of solid waste. The generation, collection, transfer, transport, separation, recycling, and disposal of municipal solid waste (MSWM) are all crucial operations. Under the recently established Municipal Solid Waste (Management and Handling) Rules 2000, the administrative authority of an area is responsible for all solid waste management actions except garbage generation. Solid waste management comprises trash minimisation, collection and segregation, recycling and resource recovery, treatment and disposal, landfill management, public awareness and education, and policy and regulations [9]. Municipal solid waste management (SWM) is critical for developing-country authorities. Integrating recycling systems into SWM is essential for mitigating this problem.

Understanding the elements that influence recycling is vital for sustainable waste management. Institutional components such as enabling legislation and regulations support effective Integrated Solid Waste Management (ISWM). Social traditions and cultural practices have an impact on SWM systems. Financially, acquiring funds from sources such as user fees, the private sector, grants, and loans is critical. Economic effects such as employment generation and tourism development should be differentiated from economic factors affecting SWM. Examining public willingness to pay, waste management success and job possibilities is necessary. The technical parts of ISWM implementation include locating tools and facility locations. Every approach influences the environment, health, and resources, mandating eco-friendly practices to offset adverse effects.

## Methodology

A complete picture of trash generation patterns has been attained by integrating data from many secondary sources, including the World Bank report, and widely referenced papers and studies. This methodical technique has made it possible to analyse trash creation worldwide, giving insights into trends and variations. A comprehensive amalgamation of many sources provides a sturdy basis for well-informed decision-making and strategic planning to tackle the obstacles of growing global garbage production.

### 1.3 Solid Waste Management in Global Scenario

In the 1950s, WHO investigated the environmental effects and health hazards of drinking water, wastewater treatment, solid waste management, and vector control. Stead (1960) investigated the impact of technology on solid waste disposal issues [10]. Rabin and Schwartz (1972) studied solid waste definitions, sources, types, and human health implications, Olaniya and Sexena (1973) investigated the effects of sanitary landfills on river water quality. In a seminar, Ram Prasad (1976) linked waste, food habits, and

personality types. Leaderman (1976) examined waste amount, quality, and disposal methods. Flintoff (1980) proposed low-cost garbage disposal options for poor countries [11]. Karan and Bladen (1976) emphasised the importance of solid waste in urban environmental degradation in India. Park and Park (1979) also studied the effects of different types of pollution, such as water, air, and solid waste, on human health. Brown (1981) studied the effects of sanitary landfills on groundwater and streams. Kumra (1982) has significantly contributed to environmental pollution in Kanpur city and highlighted the problems of solid waste and its management. Cointreau (1982) tried to give a picture of solid waste collection and management systems in developing countries. John (1983) discussed the problem of waste disposal in Third World cities concerning climatic conditions. Nath (1984) has tried to analyse Indian city waste and its physicochemical composition for the first time. Halmes (1984) discussed the solid waste situation in Asian cities. Jain (1984) studied Delhi's solid waste collection and disposal system. Nanda (1985) studied physico-chemical properties in different zones of Delhi. Singh (1985) studied the problem of solid waste in Varanasi City and suggested that mechanical composting provides the most satisfactory solution for the city waste. Kayastha and Kumra (1986) have highlighted solid waste generation, collection, and disposal methods in some Indian towns and cities. Valdiya and Asnani (1987) have significantly contributed towards the scientific management of solid wastes. MCD (1988) contributed to the generation rate of garbage in Delhi, the number of workers involved, the total number of dustbins and future demand for solid-waste disposal. Simons (1988) contributed to the relationship between scientific and technological development and waste generation. Gopal Krishnan (1988) studied the effect of solid waste on the environment. Singh and Singh (1988) studied the generation and quality of solid waste and its proper management in Ghaziabad. Singh., *et al*. (1988) studied the nature of garbage generation and rate and its role as the land, air and water pollutants. This is followed by a comprehensive survey of the collection and disposal of refuse in the Varanasi municipal area and the Banaras Hindu University campus. The physicochemical characteristics of the refuse and the water-logging problem of Varanasi, which is directly related to the garbage fillings, have also been studied. Peavy., *et al*. (1988) have identified the various sources and types of solid waste generation and examined the physico-chemical composition of wastes along with the management system. Ambasht (1990) explained solid waste disposal, reclamation, and recycling processes. In their study, Taylor., *et al*. (1990) analysed the psycho-social impacts caused by solid waste disposal in Southern Ontario. Shekdar AV (1992) critically analysed disposal sites and offered cost-effective alternatives for Calcutta's trash disposal [12]. The composition of municipal solid trash is varied and typically subject to fluctuations from city to city and nation to country, according to White., *et al*. (1995), in contrast to other waste streams that are more homogenous with a decent amount of each element [13]. Cheremisinoff (2003) has written that it is an essential resource addressing a significant environmental challenge, It offers a detailed exploration of solid waste management, catering to newcomers and experts in the field [14]. Dixon and Jones (2005) reported that municipal solid compositions include soil, garden and food waste, wood, paper, ashes, plastics, textiles, and rubber [15]. According to Buah., *et al*. (2007), MSW mostly comprises textiles, paper or cardboard, plastics, glass, metals, food and garden waste, and paper [16]. They contended that the trash might be readily utilised for fuel generation or energy recovery because of the nature of MSW. The characteristics of MSW also vary greatly depending on where it comes from, according to a study [15,16]. In Turkey, for instance, almost half of all MSW comprises putrescible materials. In contrast, recyclable materials like cardboard, paper, glass, and plastics account for a sizable portion of all municipal solid waste [16]. Scarlat., *et al*. (2019) reported that Africa generates 125 million tons of solid waste annually, which is projected to reach 244 million tons annually by 2025 [17]. Amasuomo., *et al*. (2016) have worked on a paper entitled "The concept of waste and waste management" [18]. The paper addresses key questions regarding the definition of waste, the understanding of what should be classified as waste, and the historical context of waste management [18]. Debrah., *et al*. (2021) have discussed the need for awareness about sustainability in developing countries. Waste is a by-product of human activities that cannot be avoided and is generally considered useless or unwanted material [19]. Fadhullah., *et al*. (2022) have worked on poor waste disposal practices. The study examines household waste management practises and attitudes in Panji, one of Kota Bharu's subdistricts in Kelantan, Malaysia [20]. Teshome., *et al*. (2022) discussed waste management on a regional level in their paper entitled [21].

## Solid waste management in Indian scenario

The government of India, Ministry of Urban Development (October 2013), states that at present, Urban India produces about 54.75 million Tons of municipal solid waste annually, i.e. 1.50 Lakh Tones Per Day (LTPD). Prasad (1991) has evaluated separately the problems of solid waste disposal and its management in Delhi. Olaniya.,., *et al*. (1991) studied the effects of solid waste disposal on land [22]. Rao (1991) has examined the relationship between solid waste and human health and discussed the issues related to scientific and bet-

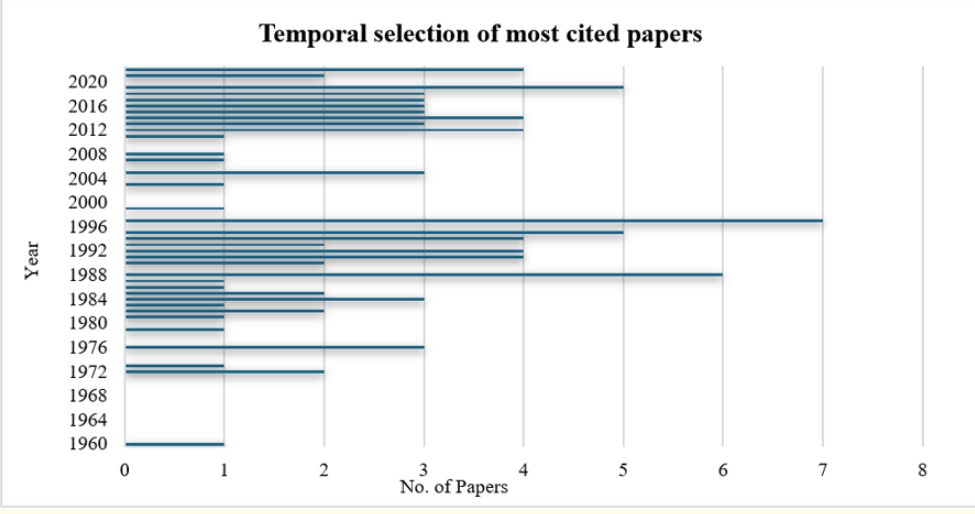


**Figure 1:** Temporal selection of most cited papers

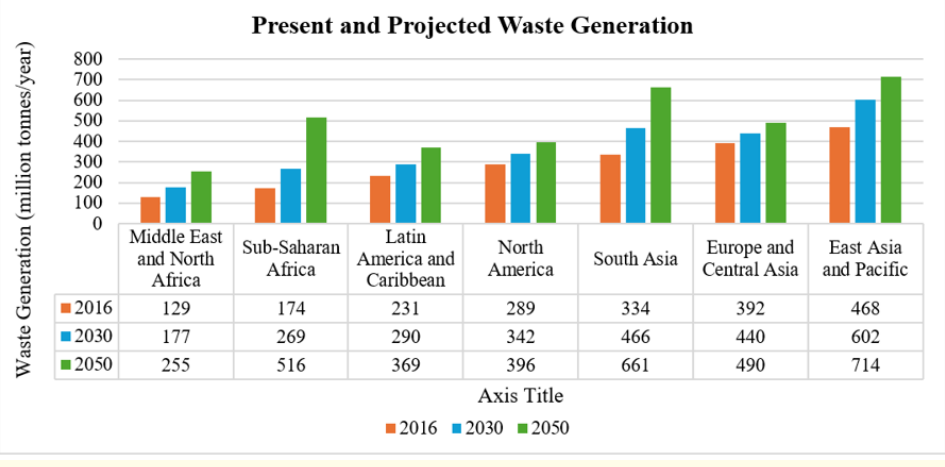


**Figure 2:** Present and Projected Waste Generation.

ter garbage management in the Indian context. Gupta (1991) made a detailed study of the master plan in Delhi, keeping in view solid waste as a major problem in environmental degradation. Vyas (1992) has discussed the issues related to the scientific management of solid wastes in Bhopal City. Bhatia (1992), in his study, gave an account of a better method of collecting and transporting household and marked garbage by the Hydromech Dumper Placers in conjunction with modern wheelbarrows. The Administrator Jaipur Municipal Council (1992) tried to give a picture of the solid waste collection and management system in Jaipur city. Park and Bhargava (1992) gave an account of the adverse impact of solid waste incineration, particularly regarding the gaseous pollutants released into the environment. Misra and Mani (1993) have highlighted the characteristics, generation, collection, transportation, and disposal methods of solid waste in the Indian scenario. Alvi (1993) describes the problems associated with solid waste management. Khan (1994), in his paper, identifies the problems in the context of population growth in urban areas. He also explained the various constituents in the municipal solid wastes and treatment and disposal options. Shah (1994) described municipal waste recycling and its economic, social and ecological benefits. Kala and Khan (1994) have discussed the issues related to scientific garbage

management in Indian cities. The Forum for Environmental Concern, Bombay (1994) has examined the working conditions and resultant occupational hazards at six major dumping grounds in Bombay and has observed serious health constraints for the workers involved in the dumping operations. Govind (1995), in his article, described in detail the unhygienic situation in Thiruvananthapuram due to untreated sewage and solid waste. Muthahar (1995) highlighted Tirunelveli's low-cast sanitary and sewerage system. Shastri (1955) has also highlighted the problems of an improper disposal mechanism in Bhopal city. Roy (1995), in his article, highlighted the sanitation problem in Lucknow city due to improper sewerage system and solid waste disposal. Mehta and Dave (1997), in their case study of solid waste management in Vadodara city, suggested vermiculture as a technique for garbage management. Kumar (1997), in his study, examined the relationship between unhygienic conditions and water-borne diseases in Chennai city. Malik (1997) has highlighted the adverse impact of hospital waste on human health and has emphasised special attention to its proper and safe disposal. Bhattacharya (1997) has discussed the issues related to the scientific management of urban waste. Roy (1997) has highlighted the impact of improper disposal of solid waste on public health in Lucknow city. In the paper, Dubey and Singh (1997) highlighted the hazardous impact of nuclear waste. They suggested suitable techno-economic designs and mediums for its safe disposal to minimise the hazardous impact on the ecosystem and surrounding environment. Gunaselvam (1997) has discussed the environmental threat due to improper disposal of solid waste in Chennai city. In his study paper "Sustainable Solid Waste Management in India," written in January 2012, Annepu Ranjith Kharvel looked at the state of trash management in India today, how it affects the environment and public health, and how new and better garbage disposal techniques may help. Shalini., *et al*. (2012), in their paper entitled "Study on solid waste management in different income groups of Lucknow city", talked about how Solid waste management in India's growing urban areas is a complex issue, with the current practice of unscientific dumping of household waste leading to significant environmental and public health concerns [23]. Mishra, S. (2013) attempted to pinpoint the environmental problem in the Puri urban zone in her study titled Geographical Interrogation of Solid Waste Management: A Case Study of Puri Town, Odisha. Francis (2013), in their paper entitled "Solid waste management and characteristics in Lucknow, Uttar Pradesh, India", has discussed the various characteristics related to solid waste management in Lucknow [24,49,50]. Gupta., *et al*. (2013), in their paper entitled "Municipal solid waste characterisations and management strategies for Lucknow City, India", talked about the management of municipal solid wastes in Lucknow. He has discussed that the issue of municipal solid waste management (MSWM) is a significant environmental problem in Indian cities, and this case study focuses on Lucknow, a major city in Northern India, which faces serious challenges in managing its solid waste [25,51]. Pamnani., *et al*. (2014) reviewed the municipal solid waste management system in their paper. Particularly in developing nations like India, where urbanisation and population expansion have drastically increased garbage creation, municipal solid waste (MSW) is a major worldwide challenge [26]. In their paper, Khan., *et al*. (2014) discussed how Municipal Solid Waste Management (MSWM) poses significant environmental challenges in developing countries [27]. Kumar., *et al*. (2014) demonstrated the integration of remote sensing and GIS to identify an optimal landfill site in Lucknow, India, addressing escalating municipal waste challenges [28]. Srivastava., *et al*. (2014) wrote their paper entitled "Characterisation and Management of Municipal Solid Waste: A Case Study of Varanasi City, India". The research paper aims to analyse and describe the waste generated in Varanasi [29]. In their study, Gupta., *et al*. (2015) reviewed significant environmental concerns in India as the country experiences rapid urbanisation, industrialisation, and population growth. Consequently, the amount of municipal solid waste produced in Indian cities and towns has also increased [30]. Joshi, R., and Ahmed, S. (2016) examined the dire status of and difficulties in managing municipal solid waste (MSWM) in urban India in their study titled status and problems of municipal solid waste management in India: A review [31]. In their paper, Mani., *et al*. (2016) discussed that Municipal solid waste management (MSWM) has become a significant challenge in India [32]. The authors of this paper, Nitin Kamboj and Neeraj Pandey (2017), describe their use of GIS to map the locations of solid waste disposal sites in Allahabad, Uttar Pradesh, India. A working paper on "Solid Waste Management in India" by Patel Utkarsh and Ahluwalia Isher Judge (2018) examined the long-term viability of solid waste management in Indian cities from an environmental and economic standpoint. Priyadarshi., *et al*. (2018), in their paper entitled "Municipal Solid Waste Management Study and Strategy in Aligarh City, Uttar Pradesh India", studied a broader aspect of municipal solid waste in the Aligarh city. They have provided a strategy to plan and decompose the solid wastes [33]. Garg, N., and Adhana, D. (2019), in their paper entitled "E-waste management in India: A Study of Current Scenario", discussed the management of electronically generated wastes in India [34,48]. Mohd Nishat Faisal., *et al*. (2019), in their paper entitled "Enablers of Sustainable Municipal Solid Waste

Management System in India", has worked on creators and generators of Municipal solid waste management (MSWM) has evolved from its conventional focus on collection and disposal to a more sustainable approach that addresses problems with waste avoidance, waste reduction, and waste segregation [35,47]. In their 2019 paper titled "Studying Municipal Solid Waste Management in Meerut City, Uttar Pradesh," Rani., *et al*. examine the solid waste landscape in Meerut, the second-largest city in India's National Capital Region. Managed by Meerut Municipal Corporation (MMC), waste generation reflects socio-economic progress [36,45,46]. Sharma, Kapil Dev, Jain, and Siddhart (2019), in their research article "Overview of Municipal Solid Waste Generation, Composition, and Management in India," states that urban India produces around 62 metric tons of solid waste [37]. In their paper, Sharma., *et al*. (2019) discuss municipal solid waste generation on a national level. India's fast population expansion, urbanisation, and industrialisation have drawn interest from worldwide. However, this progress has also increased waste generation, resource consumption, and consequent ecological degradation and pollution. Thakur., *et al*. (2021), in their paper, talked about the population pressure in the Indian Himalayan region and how it is affecting the climate due to poor sustainability and solid waste management [38,44]. Tirkey (2022), In his paper entitled "Theoretical Study on Solid Waste Management", has worked on the review of solid waste management. He says many types of waste, such as liquid and solid, are found in our surrounding environment [39,42,43]. Kaur., *et al*. (2022), in their paper entitled "Implementation analysis of municipal solid waste management in Dinanagar City of Punjab, India", talked about implementing a management system in Didanagar City of Punjab [40,41,42].

| S.N. | States | MSW Generated 2010 (Mt/Day) | Percentage (2010) | Rank(2010) | MSW Generated 2015 (Mt/Day) | Percentage (2015) | Rank (2015) |
|---|---|---|---|---|---|---|---|
| 1 | Andaman And Nicobar Islands | 50 | 0.04 | 31 | 70 | 0.05 | 31 |
| 2 | Andhra Pradesh | 5680 | 9.02 | 5 | 11500 | 8.21 | 4 |
| 3 | Arunachal Pradesh | 94 | 0.07 | 30 | 180 | 0.13 | 29 |
| 4 | Assam | 1146 | 0.90 | 19 | 650 | 0.46 | 20 |
| 5 | Bihar | 1670 | 1.31 | 17 | 1670 | 1.19 | 17 |
| 6 | Chandigarh | 380 | 0.30 | 22 | 340 | 0.24 | 24 |
| 7 | Chhattisgarh | 1167 | 0.92 | 18 | 1896 | 1.35 | 15 |
| 8 | Dadra And NagarHaveli | 20 | 0.02 | 35 | 40 | 0.03 | 34 |
| 9 | Daman And Diu | 21 | 0.02 | 33 | 45 | 0.03 | 33 |
| 10 | Goa | 193 | 0.15 | 27 | 183 | 0.13 | 28 |
| 11 | Gujarat | 7379 | 5.79 | 8 | 9227 | 6.59 | 5 |
| 12 | Haryana | 537 | 0.42 | 21 | 3490 | 2.49 | 12 |
| 13 | Himachal Pradesh | 304 | 0.24 | 25 | 300 | 0.21 | 25 |
| 14 | Jammu And Kashmir | 1792 | 1.41 | 15 | 1792 | 1.28 | 16 |
| 15 | Jharkhand | 1710 | 1.34 | 16 | 3570 | 2.55 | 11 |
| 16 | Karnataka | 6500 | 5.10 | 9 | 8784 | 6.27 | 6 |
| 17 | Kerala | 8338 | 6.54 | 6 | 1576 | 1.13 | 18 |
| 18 | Lakshadweep | 21 | 0.02 | 33 | 21 | 0.01 | 35 |
| 19 | Madhya Pradesh | 4500 | 3.53 | 12 | 5079 | 3.63 | 9 |
| 20 | Maharashtra | 19204 | 15.06 | 1 | 26820 | 19.15 | 1 |
| 21 | Manipur | 113 | 0.09 | 29 | 176 | 0.13 | 30 |
| 22 | Meghalaya | 285 | 0.22 | 26 | 268 | 0.19 | 27 |
| 23 | Mizoram | 4742 | 3.72 | 11 | 552 | 0.39 | 21 |
| 24 | Nagaland | 188 | 0.15 | 28 | 270 | 0.19 | 26 |
| 25 | Nct Of Delhi | 7384 | 5.79 | 7 | 8390 | 5.99 | 8 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 26 | Orissa | 2239 | 1.76 | 154 | 2460 | 1.76 | 14 |
| 27 | Pondicherry | 380 | 0.30 | 22 | 495 | 0.35 | 22 |
| 28 | Punjab | 2794 | 2.19 | 13 | 3853 | 2.75 | 10 |
| 29 | Rajasthan | 5037 | 3.95 | 10 | 2491 | 1.78 | 12 |
| 30 | Sikkim | 40 | 0.03 | 32 | 49 | 0.03 | 32 |
| 31 | Tamil Nadu | 12504 | 9.81 | 3 | 14532 | 10.38 | 3 |
| 32 | Tripura | 360 | 0.28 | 24 | 407 | 0.29 | 23 |
| 33 | Uttar Pradesh | 11585 | 9.09 | 4 | 19180 | 13.70 | 2 |
| 34 | Uttarakhand | 752 | 0.59 | 20 | 1013 | 0.72 | 19 |
| 35 | West Bengal | 12557 | 9.85 | 2 | 8674 | 6.19 | 7 |
| | Total | 127,485 | 100 | | 142,566 | 100 | |

**Table 1:** Solid Waste Generation State- Wise (2010 and 2015).

**Source:** Central Pollution Control Board (2010 and 2015).

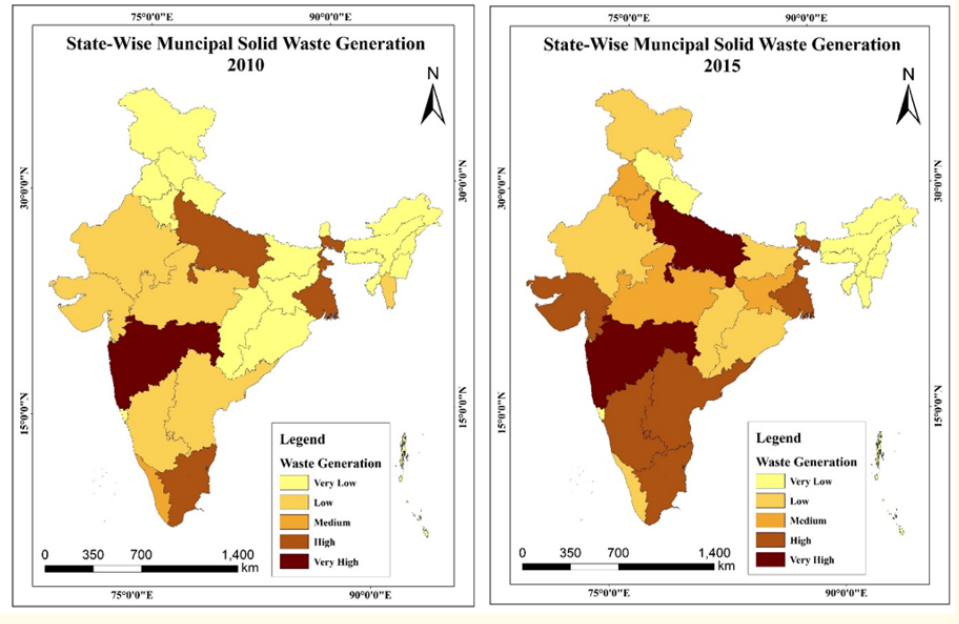


**Figure 3:** State-wise waste generation, 2010 and 2015.
(Source: Central Pollution Control Board (2010 and 2015).

## Research gap

Municipal solid waste cannot be managed with the aid of its categorisation and characterisation. Municipal Solid Waste Management has not been given a solution. The city's solid waste department uses one of the poorest management practices. To properly plan SWM, new methodologies need to be implemented. Household waste and population growth are essential issues that need careful investigation. There is still more research to be done on the topic of solid waste management transportation.

## Proposed model for sustainable solid waste management

Perceiving a vision for a city concerning solid waste generation is a vitalaspect as it would guide the key stakeholders to orient the city and development in the direction leading to the fulfilment of the aspirations of the population at large along with improving the quality of life and also improving the quality environment of the city. A vision is a statement of expectations concerning what the city wishesto achieve and what needs to be done within

a time frame. It will also identifythe town's potential for efficient and proper disposal of solid waste as per the values and preferences of the city. Thus, visions will help formulate and priorities the city's needs and aspirations. The present model and resultant strategies will help achieve the goal of a sustainable city on the one hand and restore the environment of Lucknow city on the other. This will help strike a more sustainable relationship of the town with the State, National and Global economies, restoring the city's historical legacies and maintaining its physical characteristics. Figure 6.4 presents a sustainable management model of solid waste involving environmental concerns and practices, Society having a better quality of life for everyone and the Economy, i.e., development with sustainable cities. Several measures, such as Optimised Waste Generation and a Sustainable Smart City, will eventually be achieved via effective solid waste collection, disposal, citizen involvement, and knowledge.

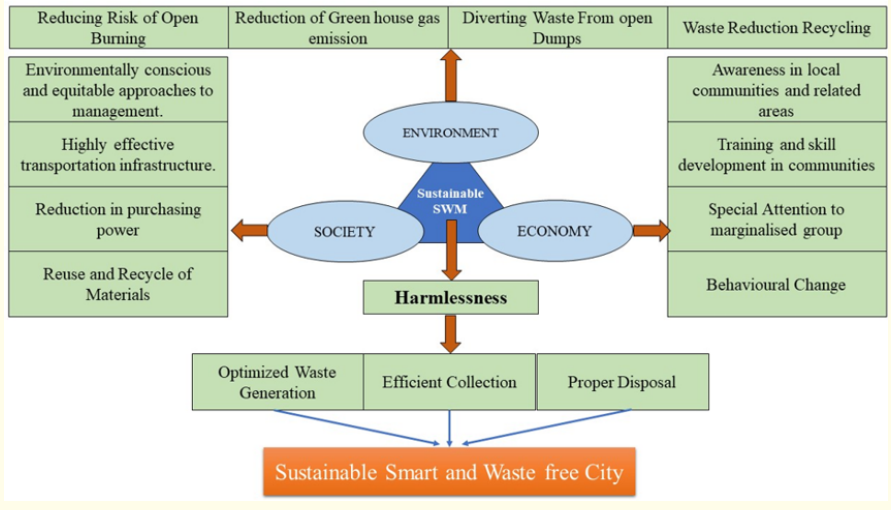


**Figure 4:** Proposed Model for Sustainable Solid Waste Management.

## Conclusion

The literature review on municipal solid waste management (MSWM) revealed significant insights into the subject matter. One key finding was the importance of adopting a comprehensive and integrated approach encompassing waste reduction, reuse, recycling, and disposal methods. This holistic approach, guided by waste hierarchy principles, such as source reduction and recycling, is crucial in minimising waste generation and promoting sustainable practices. The review also identified several challenges faced by municipalities in managing solid waste. The main hurdles were inadequate infrastructure, insufficient funding, and limited public awareness and participation. To address these challenges effectively, improved policies, regulations, and governance frameworks were deemed necessary. Municipalities can create a conducive environment for sustainable waste management by implementing these measures. Advanced technologies and innovative solutions were highlighted as potential game-changers in MSWM. Waste-to-energy systems, anaerobic digestion, and landfill gas capture were identified as valuable options that contribute to waste diversion, energy recovery, and reduction of greenhouse gas emissions. Integrating these technologies into waste management strategies can significantly enhance sustainability efforts. Community engagement, education, and awareness campaigns were emphasised in promoting responsible waste management practices. Involving all stakeholders, including residents, businesses, waste management agencies, and policymakers, is vital for developing sustainable waste management strategies. These parties' cooperation and involvement can result in a more substantial overall social impact and more efficient waste management techniques.

In conclusion, the comprehensive literature review provided valuable insights into various dimensions of municipal solid waste management. It emphasised the need for a holistic approach that integrates waste reduction, recycling, and disposal methods. The review also highlighted challenges faced by municipalities and stressed the importance of policy support, community engagement, and technological advancements. By implementing effective waste management strategies, municipalities can achieve environ-

mental sustainability, economic benefits, and an improved quality of life for their residents. Continued research, innovation, and collaboration will be vital to advancing sustainable waste management practices in the future.

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