International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 06 , June - 2026

Solid Waste Management Strategies for Developing Cities : A Case Study of Ganderbal Town, Jammu & Kashmir, India

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Abstract - Rapid urbanization in developing cities has significantly increased municipal solid waste generation, creating challenges related to collection, transportation, processing, and disposal. Developing urban centers often face inadequate infrastructure, limited financial resources, and weak institutional mechanisms for effective waste management. This study evaluates the existing solid waste management practices in Ganderbal Town, Jammu & Kashmir, India, and proposes sustainable strategies for improving system efficiency. Data were collected through field surveys, municipal records, waste characterization studies, and stakeholder interactions. The findings reveal deficiencies in source segregation, collection coverage, recycling infrastructure, and scientific disposal methods. An integrated framework consisting of source segregation, decentralized composting, Material Recovery Facilities (MRFs), GIS-based route optimization, smart monitoring systems, and sanitary landfill development is proposed. The study concludes that sustainable waste management requires technological interventions, community participation, institutional strengthening, and policy support. The proposed strategies can serve as a replicable model for other developing cities facing similar challenges.

Keywords: Solid Waste Management, Municipal Solid Waste, Developing Cities, Sustainability, Recycling, Composting, Ganderbal.

1. INTRODUCTION

Municipal Solid Waste Management (MSWM) has become one of the most critical environmental and public health issues in developing countries. Population growth, urban expansion, industrialization, and changing lifestyles have substantially increased waste generation rates. In many developing cities, municipal authorities struggle to provide efficient waste collection and disposal services due to inadequate infrastructure and limited financial resources. Improper waste management contributes to environmental degradation, groundwater contamination, greenhouse gas emissions, and health risks. Therefore, sustainable solid waste management practices are essential for achieving cleaner and healthier urban environments. This study focuses on Ganderbal Town, a rapidly developing urban center in Jammu & Kashmir, and aims to evaluate existing waste management practices and recommend sustainable strategies for future improvements.

2. OBJECTIVES OF THE STUDY

- To assess the existing solid waste management system.
- To evaluate waste generation and collection efficiency.
- To analyze transportation and disposal practices.
- To assess compliance with SWM Rules 2016.
- To propose sustainable waste management strategies.
- To develop a framework applicable to other developing cities.

3. LITERATURE REVIEW

Several studies have highlighted the growing challenges of municipal solid waste management. Wilson et al. (2015) emphasized integrated waste management approaches combining collection, recycling, and disposal

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systems. Hoornweg and Bhada-Tata (2012) reported that global waste generation is expected to exceed 2.2 billion tonnes annually due to urbanization. Sharholy et al. (2008) identified inadequate infrastructure and open dumping as major challenges in Indian cities. Kaza et al. (2018) recommended circular economy approaches and resource recovery systems for sustainable waste management. Recent studies indicate that smart technologies such as GIS, IoT-based monitoring systems, and waste-to-energy technologies can significantly improve operational efficiency and environmental performance.

4. STUDY AREA

Ganderbal Town is located approximately 18 km northeast of Srinagar in Jammu & Kashmir. The town has experienced rapid urban growth due to increasing population, commercial activities, educational institutions, and tourism development. The estimated population of the municipal area is approximately 47,000. Urban expansion and changing consumption patterns have resulted in increasing municipal solid waste generation, placing additional pressure on municipal infrastructure.

5. METHODOLOGY

Data collection involved a multi-pronged approach to assess all functional elements of the waste management system:

- Field surveys and site inspections
- Household questionnaires
- Municipal records analysis
- Waste characterization studies
- Stakeholder interviews

Waste generation was estimated using the following standard mathematical formulation:

$$\textit{Waste Generation} = \textit{Population} \times \textit{Per Capita Waste Generation Rate}$$

Collected data were analyzed using statistical methods, percentage composition analysis, and comparative assessment against national environmental standards.

6. RESULTS AND DISCUSSION

The study estimated municipal solid waste generation at approximately 480 tons per month. Waste composition analysis indicated a high proportion of organic waste, highlighting specific opportunities for recovery and diversion.

Waste Type	Percentage (%)
Biodegradable Waste	60–65
Plastic Waste	15–20
Paper Waste	7–10
Glass & Metals	3–5
Inert Waste	8–12

Biodegradable waste constitutes the largest fraction, indicating substantial potential for composting and biogas production.

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6.1 Collection Efficiency

The waste collection efficiency ranges between 75–85%. Major ongoing operational challenges include:

- Incomplete door-to-door coverage
- Lack of source segregation
- Inadequate manpower
- Irregular collection schedules

6.2 Transportation System

Transportation is currently carried out using a mixed fleet of tipper vehicles, mini collection vehicles, tractor trolleys, and hand carts. Key operational deficiencies identified include:

- Frequent vehicle breakdowns
- High fuel consumption
- Absence of GPS tracking
- Inefficient routing systems

6.3 Processing and Recycling

Current processing infrastructure is heavily inadequate to meet urban demands. Key observations include:

- Limited localized composting facilities
- Absence of formalized Material Recovery Facilities (MRFs)
- Informal recycling sector dominance with low safety standards
- Lack of waste-to-energy recovery systems

6.4 Disposal Practices

Most generated waste is unscientifically disposed of through open dumping. This results in critical environmental and social impacts:

- Leachate generation and subsequent groundwater contamination risks
- Uncontrolled methane emissions
- Odor nuisance and vectors proliferation
- Severe visual pollution

7. PROPOSED SOLID WASTE MANAGEMENT STRATEGIES

- **Source Segregation:** Mandatory segregation into wet waste, dry waste, and domestic hazardous waste at the household level.
- **Decentralized Composting:** Establishment of ward-level decentralized composting units for organic/biodegradable waste treatment.
- **Material Recovery Facilities (MRFs):** Development of centralized MRFs to improve dry waste recycling efficiency and resource recovery.
- **Smart Waste Management:** Implementation of GIS-based route optimization, GPS-enabled vehicle tracking, IoT-based smart bins, and digital monitoring dashboards.
- **Waste-to-Energy Initiatives:** Promotion of biomethanation plants, biogas production, and Refuse Derived Fuel (RDF) systems for non-recyclable high-calorific fractions.
- **Scientific Landfill Development:** Construction of engineered sanitary landfills equipped with leachate collection systems, gas recovery mechanisms, and environmental monitoring facilities.
- **Community Participation:** Aggressive public awareness campaigns and behavioral change communication to improve waste segregation and eliminate littering.

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8. CONCLUSION

The study demonstrates that developing cities face significant challenges in managing increasing quantities of municipal solid waste. The baseline assessment of Ganderbal Town revealed critical deficiencies across source segregation, collection coverage, processing infrastructure, and final disposal practices. An integrated waste management framework consisting of source segregation, decentralized composting, structured recycling infrastructure, smart technologies, and sanitary landfill development is proposed. Implementation of these strategies can significantly improve environmental quality, public health, and resource efficiency while supporting sustainable urban development. The framework developed through this study can serve as a replicable model for other developing cities facing similar waste management challenges.

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