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Original Research Article

Public Perceptions and Economic Viability of Sustainable Municipal Solid Waste Management in Gaindakot Municipality, Nepal

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Abstract

Municipal Solid Waste Management (MSWM) remains a crucial environmental and public health concern in most of the fastest urbanizing areas, even in Nepal. An exploration of public opinion and economic feasibility of MSWM using sustainable strategies in Gaindakot Municipality, an expanding urban municipality of the Nawalparasi (East) District, is carried out. Employing a mixed-methods study design that comprises household surveys, interviews with stakeholders, field observation, and qualitative waste composition analysis, the current study presents an integrated analysis of the waste management system in the municipality. The findings indicate that despite 82% of the residents citing solid waste as the major problem, organized waste management practices are not consistently followed. Although 65% of the households utilize the municipal waste collection service, 16% still follow hazardous practices such as open dumping. This behavior pattern is also sustained by infrastructural deficits, such as the absence of engineered landfill facilities and composting facilities. Field surveys indicate that the city generates approximately 16.14 metric tons of waste daily, of which more than 60% is organic in composition, representing a gigantic potential for composting as well as energy production. The estimated daily revenue from recyclable waste material is NPR 63,760, i.e., it is economically worth implementing a circular model of waste management. There are, however, institutional problems like an absent master plan for integrated waste management, no technical capacity, and poor coordination among the stakeholders. In order to fill these ambiguities, the study makes the following practical suggestions: implementation of source segregation, facilitation of public-private partnerships, provision of economic incentives, and institutional capacity building through tailor-made training and policy support. The research provides policymakers, planners, and development agencies critical findings centered on the necessity for a socially inclusive, economically feasible, and environmentally sound MSWM system responsive to the condition of secondary cities in the Global South.

Keywords: Solid Waste Management, Public Perception, Economic Viability, Resource Recovery, Nepal, Sustainable Urban Planning, Waste Segregation.

1. INTRODUCTION

One of the emerging global public health and environmental problems is solid waste management (SWM), specifically in developing nations like Nepal. Both the environment and public health have been adversely affected as a result of large-scale illegal dumping of solid waste along riverbanks [1]. Generation of municipal solid waste (MSW) has its causality associated with the expansion of urban habitation, improved standards of living, and altered consumption patterns [2]. Unsound SWM results in the release of greenhouse gases responsible for global warming, along with pollution of the environment, i.e., water, land, and air.

Local government agencies are usually constrained by institutional factors like financial resources, institutional fragmentation, and inadequate infrastructure, although their role is urban waste management [3,4]. A Nepalese citizen produces an average of one kilogram of waste daily. The public and the environment suffer due to most of the waste being dumped in an unstructured way in open spaces or water

bodies. Nepal's 2011 Solid Waste Management Act also requires municipalities to have sustainable practices, with topmost priority given to the 3Rs: Reduce, Reuse, and Recycle. Effective waste management is emerging as an essential performance measure in local governance systems [5].

The Nepal Solid Waste Management Act, 2011, also mandates municipalities to implement sustainable practices in terms of the 3Rs: Reduce, Reuse, and Recycle as a matter of priority. Effective waste management is also now a key performance indicator of a local government system [5]. Policy guidelines are there, but in all municipalities like Gaindakot, there is enforcement only in challenges due to financial, technical, as well as institutional limitations. Gaindakot Municipality, under Nawalparasi (East) District of Gandaki Province, is indicative of the aforementioned issues. With a population of over 80,000 and a geographical area of 159.93 km² [6], rapid urbanization, site, and proximity to environmentally sensitive areas like the Narayani River and Chitwan National Park necessitate efficient and timely SWM strategies. The environmental effect of waste disposal operations in Gaindakot, including dumping and riverbank deposits, has a direct bearing on biodiversity, tourism potential, and health.

It is here that the current study identifies the two key features of MSWM in Gaindakot Municipality: (1) people's attitude and (2) economic viability. Formulating behaviorally targeted policy interventions and for people's acceptability at the grassroots level requires understanding people's attitudes. At the same time, determining the economic viability of material recovery and recycling will pave the way for self-financed waste management systems. By incorporating residents' viewpoints and economic assessment of waste resources, this paper offers realistic policy suggestions to turn waste into an asset rather than a burden.

2. METHODOLOGY

A mixed-methods in-depth study design was used to collect both qualitative and quantitative data for achieving the overall picture of MSWM practices in Gaindakot Municipality. The study was conducted in January 2023 and comprised the following elements:

2.1 Study Area Selection

Three wards were chosen purposively by settlement and development profile: Ward 5 (urban), Ward 1 (semi-urban), and Ward 3 (rural). This provided the comparative analysis across different settlement patterns and waste management dynamics.

2.2 Household Survey Design and Implementation

250 families were surveyed using a standard questionnaire of 22 closed-ended questions. Data on awareness, practice of disposal, perception of responsibility, and willingness to pay for better services were collected through the survey. Respondents were selected through stratified random sampling to ensure proportional representation. Trained enumerators conducted face-to-face interviews in the local language.

2.3 Waste Characterization and Economic Assessment

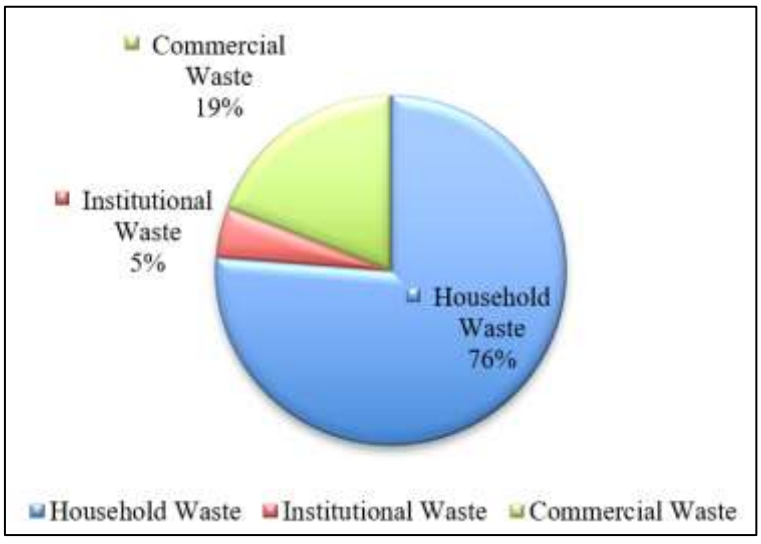

Figure 1: Composition of Overall MSW generation of Gaindakot Municipality

An in-depth seven-day waste survey was conducted in the selected wards. Waste was sorted under organic, plastic, metal, paper, glass, textiles, footwear, wood, and miscellaneous. Weights of all the categories were measured and valued at local market prices of the day, obtained from scrap buyers. The resulting data allowed calculation of the average per capita waste and estimation of economic value.

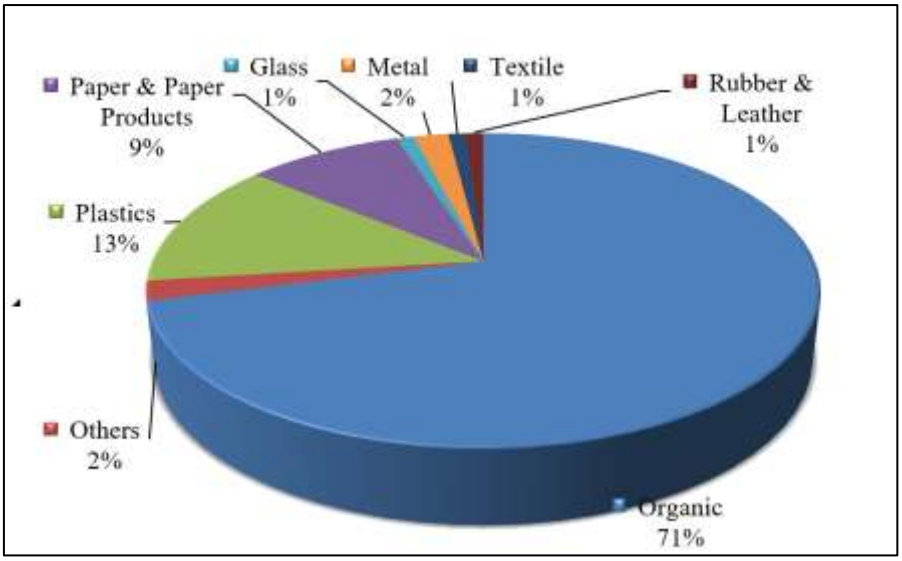

Figure 2: Total Household SW composition of Gaindakot Municipality

2.4 Key Informant Interviews and Field Observations

Semi-structured interviews with civic leaders, garbage collectors, and city officials provided information about institutional setups and operational issues. Field observations validated these observations and recorded actual waste management practices within the community.

2.5 Data Processing and Analysis

Microsoft Excel was employed to inspect quantitative data. Descriptive statistics were used to present findings, and thematic analysis was applied to explain qualitative data and to triangulate findings according to sources.

3. LITERATURE REVIEW

Gupta *et al.,* [1] highlight that uncontrolled dumping causes overflowing landfills, leading to groundwater pollution and increased greenhouse gas emissions. Open burning of waste adds to air pollution with high particulate emissions comparable to vehicular sources. Poor segregation of trash renders recycling informal and technology-obsolete, whereas the need for recycled paper and plastic is increasing. Composting, both aerobic and anaerobic, is an appropriate disposal method, but sound policy and guidelines need to support municipal waste management. Municipal corporations, despite being saddled with waste management, are plagued by a lack of infrastructure and maintenance, especially in the collection of waste, the weakest link in the chain. In general, systemic reforms are required to improve solid waste management in India.

Such rapid growth in plastics usage, with restricted product lifespan, has led to a plastics waste explosion with a sharp environmental impact. With landfilling downstream increasingly constrained by regulations and cost, alternative avenues such as recycling and energy recovery are being explored. Panda *et al.,* [2] argue that thermolysis, i.e., thermal cracking of plastic waste to yield liquid fuel, is a viable alternative option. The process exploits the high calorific value of plastics, comparable to regular fuels at about 40 MJ/kg, with waste treatment and energy generation benefits. Though chemical recycling has advanced globally with pilot and commercial-scale facilities, additional research is required to improve the efficiency, cost-effectiveness, and environmental soundness of plastic waste to fuel production [2]

Adhikari *et al.,* [3]did research to evaluate the socio-cultural aspects of residential solid waste management and its implications for public health in selected local governments of Nepal. Despite the general awareness of the waste types by dwellers, over half of the respondents (72%) disposed of waste indiscriminately, reflecting a gap between action and knowledge. There was no notable association between the level of knowledge and proper waste management practices ($p > 0.916$) or between religious/cultural practices and behavior in handling waste. Consumerism, however, and festival celebration were both significant generators of waste. Incineration, which was the preferred method in both urban and rural areas, was found to have negative health impacts. The authors conclude that awareness among the public is not enough and stress changing behavior and personal responsibility in effective waste management.

Pant [4]examined the economic contribution of recyclable waste handling in Kanchanpur Municipality, Bheemdatt Municipality, Nepal, using mixed methods including key informant interviews and questionnaires. In spite of inadequate technology and inadequate participation of the municipality, the study offers evidence for the capability of the municipality to control scrap collection and increase revenue from taxation, mainly assisted by the private sector. Principal results are the accelerating quantity of e-waste—electronic waste

and batteries—because of increased consumerism, and given the substantial value for recycling. Women workers outnumber men in the industry of the collection and handling of waste in the region. The study emphasizes the economic viability of the recycling programs but lays emphasis on the fact that correct management, market price, and technical innovation are the pillars of success. Recommendations are for continuous review of tax policies, investment in recycling plants, advocating the principles of circular economy, capacity and training of employees in waste management, and new markets for greater economic sustainability and environmental effect.

4. RESULTS AND DISCUSSION

4.1 Public Perception

While 82% of the population identifies the severe problem of solid waste, only 65% use municipal services, and 16% are still involved in open dumping. A majority of the population views MSWM as a municipally owned function, and this reflects a deficit in public ownership. Thankfully, though, there is massive enthusiasm to pay for better services and to sort waste, reflecting popular consensus behind systemic reforms.

4.2 Economic Viability

Gaindakot produces around 16.14 tons of waste per day, 60% of which is organic matter. The recyclable content, worth NPR 63,760 per day, holds significant economic value. This indicates the viability of models of resource recovery, composting units, and local business opportunities. Whereas direct revenue from recyclables is estimated in this study, a full Cost-Benefit Analysis (CBA) would add even more strength to the economic argument. Such a CBA would compare operating and investment expenses for proposed interventions (e.g., material recovery facilities, composting plants) to broader economic benefits, including job creation, public health expenditure savings from improper waste disposal, and increased landfill life.

Table 1: Economic Value of Recoverable Waste Materials in Gaindakot Municipality

SN	Waste Material Type	Market Rate (NPR per Kg/Unit)	Remarks
1	Soft Plastics	12 - 20	
2	Hard Plastics	30 - 50	
3	Heavy Metals	30 - 50	
4	Soft Metals	15 - 30	
5	Paper	12 - 20	
6	Glass Bottles	2 - 25 (per bottle)	Price varies by size/type
7	Cloth pieces	3 - 30	Based on quality
8	Shoes/Slippers	5 - 15	
9	Wood Pieces	8 - 15	
10	Compost	20 - 50	Price for processed compost

(**Source:** Current Market scenario)

This rich organic composition in Gaindakot follows national trends, whereby organic waste within the country typically accounts for over 66% of total volume of waste, reflecting a significant likelihood for recovery of resources from bio-energy conversion and composting in Nepalese cities (Bharadwa, Rai , & Nepal, 2020). The economic potential found in Gaindakot is supported by national findings, which indicate that material recovery from waste, particularly plastics, can partly recover management expenditure. For example, research shows that the material recovery of plastic alone would be able to bring in revenue equal to 1.38 times the cost of managing plastics if collection efficiency is 66.7% (Bharadwa, Rai , & Nepal, 2020). Also, the economic viability is extremely responsive to operational efficiencies: an increase in material recovery efficiency by 1% is able to fund an additional 4.64% of the cost of managing plastics in MSW, and an increase in collection efficiency by 1% is able to fund an additional 2.06% (Bharadwa, Rai , & Nepal, 2020). This emphasizes the imperative need for improvement in both aspects in Gaindakot. Even though direct income generation from recyclables has been approximated with this study, a total economic justification for eco-friendly MSWM should also encompass indirect gains. These vary from reducing oil usage, carbon dioxide emissions reduction, landfill life extension, and raw material demand reduction of virgin origin, all to contribute to higher environmental and economic gains (Bharadwa, Rai , & Nepal, 2020).

4.3 Systemic Challenges

Despite popular demand, operations are overwhelmed by a lack of sanitary landfill facilities, underdeveloped recycling plants, and inadequate institutional coordination. Dumping along riverbanks and ineffective collection logistics also undermine attempts at sustainability.

5. LIMITATIONS OF THE STUDY

This study, while providing critical insights, has certain limitations that should be acknowledged.

- **Scope:** The selection of three representative wards, while purposive, might not capture the full variation of waste management attitudes and practices in any Gaindakot Municipality section.
- **Data Collection:** Household survey data relying on self-reporting might be subject to recall bias or

social desirability bias, where subjects overreport good behavior and underreport bad behavior.

- **Economic Fluctuations:** The Market value of recyclables is determined by prevailing local market prices at the time of the study (January 2023). Prices may change, and this may impact long-term revenue expectations.
- **Temporal Snapshot:** The study provides a snapshot view of the MSWM scenario. Longitudinal data would be required to track trends in waste generation, waste composition, public attitude, and the impact of any intervention over time. Not part of the original text.
- **Technical Depth:** In determining infrastructural shortcomings, the study does not engage in detailed engineering design or site-specific feasibility study of landfills or composting facilities, which would necessitate additional special investigation.

6. RECOMMENDATIONS

Based on the findings, this study suggests the following actionable recommendations, structured to stand in a participatory, economically feasible, and environmentally sustainable MSWM framework for Gaindakot Municipality.

6.1 Policy and Strategy Development

1. **Develop a Comprehensive Integrated SWM Master Plan:** The plan has to incorporate identified long-term and short-term goals, functions and functionaries of different stakeholders (private sector, municipality, communities, NGOs), and a strategy roadmap for its execution with the 3R (Reduce, Reuse, Recycle) order and a circular economy framework of principles.
2. **Strengthen Regulatory Frameworks:** Enforce current SWM bylaws and introduce additional ones where necessary, with emphasis on obligatory source segregation, penalties for unauthorized dumping, and extended producer responsibility (EPR) for some waste streams like plastics and electronics.

6.2 Infrastructure and Technical Capacity

1. **Establish Engineered Landfill and Resource Recovery Facilities:** Be extremely cautious regarding the location and planning of an eco-friendly sanitary landfill complex. At the same time, invest in decentralized Material Recovery Facilities (MRFs) to sort the recyclables and composting facilities (aerobic composting, vermicomposting) to tackle the huge organic waste share.
2. **Improve Collection and Transportation Logistics:** Optimize waste collection routes, improve the frequency of collection in high-density areas, and transport separately collected waste to proper processing/disposal facilities. Provide waste collectors with the required safety gear and train them.
3. **Capacity Building:** Regular training of municipal staff, waste workers, and community members on best SWM practices, facility operation and maintenance, and financial management of SWM systems.

6.3 Economic and Financial Mechanisms

1. **Implement Realistic User Fee Structures:** Implement a graded user fee system (e.g., "Pay-As-You-Throw" - PAYT) in which domestic and business users pay in proportion to the quantity of waste they generate. Make the expenditures from these receipts transparent in terms of SWM services.
2. **Promote Public-Private Partnerships (PPPs):** Seek and promote collaborations with private sector firms for all aspects of MSWM, i.e., collection, transportation, recycling, composting, and waste-to-energy technology. Experiment with initiatives such as Build-Operate-Transfer (BOT) for infrastructure creation or service contracts for specific operations, with clear performance criteria and monitoring by the regulator.
3. **Provide Economic Incentives:**
   - Provide incentives (e.g., rebates on waste fees, public recognition) to residents and institutions who frequently source, segregate, and minimize their waste.
   - Create local markets for compost and recycled products by offering subsidies, tax credits for firms using recycled content, or government procurement practices favoring green products.

6.4 Public Awareness and Community Engagement

1. **Sustained Awareness Campaigns:** Launch and maintain targeted information, education, and communication (IEC) campaigns using local languages and diverse media (radio, social media, community meetings, posters) to promote waste reduction, source segregation, and responsible disposal.
2. **School and Youth Engagement:** Integrate SWM education into school curricula and involve youth groups in awareness drives and clean-up campaigns to foster long-term behavioral change.
3. **Establish Ward-Level SWM Committees**: Empower and organize local committees of residents, community leaders, and local organizations to undertake neighborhood planning, monitoring, and management of waste. It encourages ownership and tackles local concerns.
4. **Formalize and Support Informal Waste Sector:** Recognize the informal sector of waste pickers and formalize their integration into the formal SWM system by issuing identification, supplying safety gear, training, and fair access to recyclable materials.

7. Future Research

Although this study offers preliminary findings on Gaindakot Municipality's municipal solid waste

management (MSWM), future research is necessary to enhance the body of knowledge and to assist in the formulation of more sustainable and effective solutions. For future research, some suggestions are:

1. **Longitudinal Studies:** Conduct long-term studies to track changes in public perception, participation rates, waste generation, and composition over time, especially in response to implemented interventions. This will help one evaluate the MSWM strategies' sustainability and resilience.
2. **Comparative Analysis:** Carry out comparative studies with other municipalities or similar contexts in the Global South that have successfully implemented sustainable SWM models to identify transferable best practices and lessons learned.
3. **Detailed Feasibility Studies:** Carry out in-depth technical and financial feasibility studies for specific waste treatment technologies (e.g., anaerobic digestion for bio-energy, specific composting methods) suited to the socio-economic context and waste stream in Gaindakot.
4. **Impact Assessment:** Evaluate the socio-economic and environmental effects of new SWM interventions. This includes evaluation of impacts on public health, local livelihoods, ecosystem services, and community wellbeing in general, such that interventions are both equitable and effective.
5. **Behavioral Science Integration:** Explain the role played by behavioral science in adopting house-level waste management habits. Future research can investigate how nudges, rewards, publicity campaigns, and behavior interventions can be utilized to maximize waste segregation, reduce littering, and promote green practices among the citizens

8. CONCLUSION

This study highlights that Gaindakot Municipality possesses the critical mass of community support as well as the economic potential to improve its solid waste management system. Most citizens are cognizant of the seriousness of the situation and are willing to collaborate through segregation of waste and even payment for better services. This is a good basis for change. The waste produced in Gaindakot contains high organic and recyclable content, which can be used for energy production and composting. It can reduce landfill trash, support agriculture, create jobs, and boost the local economy if utilized well. There are still some problems, like there are insufficient facilities for waste, and a lack of technical capacity and coordination among different groups. Unfavorable practices like dumping rubbish by the riversides should also be stopped to guarantee that people's health and the environment are protected. Looking to the future, Gaindakot needs to have a realistic and clear waste management plan. This needs to include better policy, infrastructure, sufficient finance, and public involvement. Coordination with the private sector and development agencies will also be necessary. In summary, through proper actions and commitment, Gaindakot can transform its waste challenges into valuable opportunities and become a model for other Nepalese cities and similar environments.

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