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RESEARCH ARTICLE

SUSTAINABLE WASTE MANAGEMENT TOWARDS A GREENER FUTURE IN NEPAL: AN ESG FRAMEWORK

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ABSTRACT

This study examines the existing model's viability, scalability, and influence on waste management in Nepal with a case study of Dhangadhi Sub-Metropolitan City (SMC). The study highlights the significance of organizational openness, open communication, and feedback methods to engage all stakeholders. The degradable waste is recycled into fertilizer and gas, making the waste-to-energy operation sustainable. The study finds no landfill in the SMC, although attempts are underway to fix this. The study found that garbage disposal may be effectively managed with proper regulation, training, and awareness initiatives, reducing waste-related issues. The findings emphasize the relevance of such methods in decreasing pollution. The study found that waste management initiatives focus on worker safety and health by adhering to workplace health standards through adequate safety measures and equipment provision. It emphasizes the benefits of waste-to-energy, which minimizes air and water pollution. This sector's workers are health and safety aware, and the awareness campaigns encourage waste source segregation. Finally, the study highlights the importance of the Environmental, Social, and Governance (ESG) framework in waste management, offering insights for national initiatives.

KEYWORDS

Waste management, waste-to-energy, ESG, Dhangadhi smc, environmental impact, Nepal.

1. INTRODUCTION

Global concerns about the degradation of the environment and energy security have spurred the search for sustainable waste management solutions, especially in developing nations; an issue that varies in severity in developing countries (Karouach and El Bari, 2023; Flintoff, 1980). Developed countries generally have better control over their waste problem than developing countries. The waste management procedures in most developing countries do not match the best practices of industrialized nations in accomplishing socioeconomic goals, hence their efficiency is low (Jagun et al., 2023). The impact of poor solid waste management on human health and the environment and waste-to-resource emphasizes the role of sustainable and integrated solid waste management in mitigating climate change (Karouach and El Bari, 2023). Waste management is harder in developing countries due to limited resources and inefficient systems (Atiya et al., 2023). In Nepal, household waste generated about 1,435 tons/day and 524,000 tons/year. The generation of solid waste ranges from 0.3 kg/day to 1.0 kg/ day. The municipal composition of household waste consists of a large number of organic wastes 66%, 12% plastics, 9% paper products, 3% metals, and 5% others (ADB, 2013). Most of the generated wastes are disposed of in landfill sites (Shrestha et al., 2014). Lack of infrastructure, waste treatment plants, and recycling facilities make waste management difficult in Nepal's urban areas. Low public awareness and insufficient waste collection services exacerbate the issue. Waste is dumped and burned openly, endangering the environment and public health. These issues require infrastructure development, trash segregation and recycling promotion, waste collection service improvements, public awareness, and appropriate legislation and regulations (Bohara and Singh, 2021). Nepal's solid waste management (SWM) comprises composting, disposal, landfilling, burning, etc. However, Nepal's scientific and environmentally friendly waste management procedures are still lacking (Dangi et al., 2017). Solid waste management has low priority in many Nepalese municipalities because other public services are more in demand (ADB, 2013). Waste dumped and burned along roads and riversides poses health and environmental risks in-situ and downstream (Pokhrel and Viraraghavan, 2005). Thus, waste generation will increase and worsen the problem if not addressed early on. The growing urbanization and lack of waste management infrastructure in Nepal, especially in urban centers, have caused inappropriate trash disposal and environmental and health problems. Existing waste management models must be evaluated and assessed to handle this challenge. The major laws in Nepal related to solid waste management (Environmental Protection Act, 2019; Solid Waste Management Act, 2011; Labor Act, 2017; The Public Health Service Act, 2018; Industrial Enterprises Act, 2017; Solid Waste Management Rules, 2013). Despite the long history of the enactment of solid waste laws (e.g., before thirty years: Solid Waste and Resource Mobilization Act, 1986), the problem of solid waste management is still on the surface (Rijal and Sapkota, 2014).

Several studies in Nepal has been conducted wherein these studies provide an overview of solid waste management in Nepal, covering environmental, social, and disaster preparedness issues (Shrestha et al., 2023; Chaudhary, 2023; Khanal et al., 2023; Giri and Mainali, 2023; Gautam, 2022; Lakhe and Manandhar, 2022; Pradhananga et al, 2021). The environmental impacts of municipal solid waste management scenarios, highlighting the need for sustainable waste procedures (Shrestha et al., 2023). Khanal et al., emphasize waste prevention and recycling together with circular economy ideas in solid waste management (Khanal et al., 2023). Chaudhary, highlights informal garbage workers' recycling efforts to reduce waste and promote environmental justice (Chaudhary, 2023). Researches examine Nepali youths' at-source domestic waste segregation,

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demonstrating a grassroots drive for appropriate waste management (Khanal et al., 2023). Gautam, examines solid waste management procedures, awareness, and environmental implications in Shahidnagar Municipality (Gautam, 2022). Lakhe and Manandhar examine Banepa Municipality's middle-aged people' household trash management knowledge and practices (Lakhe and Manandhar., 2022). Furthermore, Pradhananga et al., catastrophe waste managementt in Nepal, highlighting health risks and the necessity for safe techniques (Pradhananga et al., 2021). These studies demonstrate Nepal's complex waste management issues and call for holistic solutions. However, the comprehensive perspective of ESG are with limited coverage. This study seeks to contribute to the body of knowledge waste management practices through an environmental, social, and governance (ESG) aspects of such projects, uncovering potentially unique practices, and assessing their applicability in other parts of the country.

Therefore, the study assesses the effectiveness of waste management practices in Nepal, with a case study of Dhangadhi SMC in western Nepal through the perspective of Environmental, Social, and Governance (ESG) frameworks, with a particular focus on the potential of waste-to-energy, governance aspects, stakeholder involvement, decision-making processes, social benefits and community engagement associated with the waste management practices in the selected municipality.

2. Literature Review

2.1 Current Practices of Waste Management

Environment Statistics, United Nations Statistics Division defines wastes as the materials that are not prime products (that is products produced for the market) for which the initial user has no further use in terms of his/her own purposes of production, transformation or consumption, and of which he/she wants to dispose (United Nations Statistics Division, 2019). Wastes are things we consider as unfit, unwanted and discarded due to economic reasons or ignorance of alternative technologies to re-use them (Adeyemi et al., 2001). Around the world 1.3 billion tons of solid waste is generated every year, amounting to a footprint of 1.2 kilograms per person per day (Hoornweg and Bhada, 2012). With rapid population growth and urbanization, annual waste generation is expected to increase by 73% from 2020 levels to 3.88 billion tons in 2050 (World Bank, 2022).

The current status of solid waste management (SWM) practices includes composting, disposal, landfilling, burning, etc. However, the scientific and environment friendly way of waste management practices in Nepal is still lagging (Dangi et al., 2017). In many Nepalese municipalities, managing solid waste has been given a low priority, primarily because other public services are more in demand (ADB, 2013). Waste deposited and burned along roads and riversides poses health and environmental risks in situ and downstream (Pokhrel and Viraraghavan, 2005). Due to its potential, waste-to-energy solutions in Kathmandu, solid waste climbed from 321 tons per day in 2011 to 440 tons in 2018 (Lohani et al., 2021). Since solid waste is growing, it may be transformed into energy. However, inadequate trash management, local authority apathy, and locals' lack of confidence have made it difficult. The study found that Nepal can generate energy from trash through incineration, anaerobic digestion, and landfill with gas recovery. Significant proportion, approximately 70% or more, of the solid waste generated in Nepal consists of organic materials (Pokhrel and Viraraghavan., 2005). This suggests that composting is a highly successful solid waste disposal strategy in the country. Organic waste is composted under regulated conditions to produce nutrient-rich compost. Nepal can extend landfill life by composting garbage. Compost can improve soil fertility, crop production, and chemical fertilizer use in agriculture. This sustainable waste management strategy includes solid waste disposal, agricultural sustainability, and environmental conservation. Solid Waste Management (SWM) and its challenges and practices in the Nepalese Context (Maharjan et al., 2019). Local government and public initiatives could help manage solid waste. As local governments are responsible for solid waste management, boosting their capability is crucial. The study indicates that academia may help establish and reform policy, strategy, and guidelines and strengthen concerns at all levels for environmentally friendly solid waste management.

2.2 Environmental Dimension of Waste Management

Abubakar et al., examine how waste management practices in Global South cities affect people and the environment, which is crucial for urbanization worldwide (Abubakar et al., 2022). The study found that waste management sometimes mixes regular garbage with hazardous waste when storing and handling it. Poorly maintained waste facilities and informal transportation are common. Uncontrolled dumping, open burning, and landfilling are the main waste disposal methods. These practices pollute air, water, and land, release methane and toxic liquids, and cause climate change. This harms the environment and public health, especially marginalized groups. The article concludes with ways to reduce Global South waste management risks to public health and the environment. Likewise, Ramos et al., presented an environmental evaluation of waste treatment processes in the Greater Porto area of Portugal in 2015, using life cycle assessment (LCA) software, the environmental impact of treating 1 tonne of waste was assessed for an energy recovery plant (ERP) (Ramos et al., 2018). The ERP and incineration processes performed better or at the same level as the European average due to high efficiency and electricity production. The study found that waste-to-energy technologies saved resources and reduced water and air emissions. Environmental performance improved, especially in global warming, eutrophication, and terrestrial eco-toxicity. Similarly, Dangi et al., mentioned that addressing solid waste issues in Kathmandu requires local resources, enforcement of local codes, and central government commitment to implement these policies (Dangi et al., 2017). Despite the introduction of the Solid Waste Act in 1987, Kathmandu continues to struggle with solid waste management and the implementation of policies by analyzing solid waste rules, environmental legislation, local laws, and management practices in Kathmandu.

2.3 Social Dimension of Waste Management

Waste management has a severe health impact on municipal workers (Pandey, 2009). The study found that proper management of inorganic waste and sharp objects from municipal waste and separate provisions for hospitals and other hazards for waste management can reduce waste workers' health problems, that shows Kathmandu waste management policy and practices differ. To improve waste worker health, the working environment, and the environmental impact of solid waste management in Kathmandu, suggested separate handling of hazardous waste and its immediate implementation, institutionalization of material recovery, a compost plant, and development and use of a proposed sanitary landfill. The socio-economic aspects of Integrated Solid Waste Management (ISWM) at Dhangadhi Sub-Metropolitan City and presented the real-ground situations related to the project and evaluated it from environmental and socio-economic aspects (Bohara and Singh., 2021). The ISWM project addresses waste issues through generation, recycling, and disposal, focusing on socio-economic and environmental sustainability. Successful execution and long-term effectiveness require trust in government planning, public participation, and social responsibility.

2.4 Governance Dimension of Waste Management

The public perception of waste-to-energy in China, despite strong policy support and technological maturity, waste-to-energy projects face conflicts due to public opposition (Yuan et al., 2019). There's a concern for environmental issues and a positive attitude towards waste-to-energy, awareness of benefits outweighed concerns about associated risks. The community-based waste management (CBWM) process in the region of one municipality of Tehran, Iran, mentioned despite efforts to increase community waste management participation, stakeholders are not that much included and suggested must be included simultaneously to improve regional municipal solid waste management planning, implementation, and evaluation (Ahmadi et al., 2013). Malek et al., conducted a study on waste management policies in 14 European countries from 1996 to 2018. They found that while landfill waste bans reduce garbage in landfills, they also increase waste transportation for recycling, energy recovery, and incineration (Malek et al., 2023). Conversely, landfill taxes enforce more garbage collection for energy, indicating that waste management policies play a crucial role in reducing municipal waste flow. Similarly, the landfills' wastes are mainly polymers, plastics, chemicals, electronic components, biomedical products, construction and demolition waste, household wastes, and many other substances (Gour and Singh, 2022).

3. Methods

3.1 Research design

The research adopted a mixed method approach to assesses the effectiveness of waste management practices in Nepal, with a case of Dhangadhi SMC in western Nepal through the lens of Environmental, Social, and Governance (ESG) frameworks.

3.2 Population, Sample and Data Collection

The research focuses on the population of Dhangadhi Sub-Metropolitan City in Nepal, which includes both residents and the waste management workforce and key informant within the city. Purposive sampling method was used, in terms of purposefully selected the waste management related

respondents. A semi-structured interviews were conducted with 4 nos. of higher-level officials of Dhangadhi SMC involved in waste management strategies and responsible for the governance of the sub-metropolitan city, 5 out of 7 Integrated Solid Waste Management (ISWN) Plant employees. Additionally, questionnaire and semi-structured interviews with 14 out of 37 sanitation employees involved in waste collection, transportation, and disposal were participated in the study. Local residents' perspectives were taken using 5 point Likert scale survey questionnaires, with 142 valid responses collected. The research also involved direct observations at the MRC (Micro Segregation Center) and informal discussions with community members near the ISWN Plant, providing a comprehensive approach to data collection. The demographic profile is placed in annex 1.

3.3 Instrumentations

Semi-structured interview schedule was developed of the interviews with ISWN plant and sanitation employees and key higher-level officials. Survey questionnaire for local residents using a five-point Likert scale, ranged from 1 to 5 based on the agreeableness of the statement. Where '1' is for Strongly Disagree and '5' is for Strongly Agree. A checklist for observation was developed for MRC observation, providing a comprehensive approach to primary data collection.

3.4 Data Analysis:

The qualitative data collected were arranged, coded, and presented in thematic analysis. Descriptive statistics were used to describe the quantitative data. Excel 2016 and SPSS 26 were used for the analysis of quantitative data, likewise, NVivo 10v for qualitative analysis.

4. RESULTS

Perceptions of waste management in ESG dimensions among residents, sanitation employees, key personnel of SMC

4.1 Environmental Dimension

In the environmental domain, hazardous waste handling received a positive rating (M = 4.47), while environmental impact and sustainability initiatives were viewed even more favorably (M = 4.68). There was a high level of confidence in the sanitation workers' safety and preparedness, as indicated by their responses regarding their handling of hazardous waste. On average, they indicated strong agreement for following safety procedures and being well-protected, as well as being well-equipped for the job. The majority of residents are cognizant of the environmental benefits that proper waste management provides. Residents and sanitation employees alike have a comprehensive understanding of the consequences associated with hazardous waste management. In a similar vein, it appears that *Dhangadhi* SMC is committed to fulfilling its duty of effectively managing health hazard waste and chemical waste. While the generators carry the primary responsibility for these particular types of waste, the SMC actively provides support for these endeavors. Separate collections are made for health hazards and chemical waste, with special care taken to dispose of them in designated low-lying areas. Subsequently, the waste is covered and contained using soil. To facilitate this procedure, two 400-liter autoclave machines are presently in operation. The sanitation workers and residents indicate a profound comprehension of the detrimental environmental consequences of waste mismanagement and a steadfast dedication to its mitigation. This indicates their favorable position regarding environmental consciousness and endorsement of endeavors related to sustainable waste management. Additionally, as noted by the environmental officer, SMC lacks a policy that is dedicated solely to the promotion of 3R practices. The ISWN Act, Rules, Regulations, and other primary guidance documents serve as the foundational framework for the SMC's efforts to promote waste reduction within their jurisdiction. This demonstrates the relevant authority's failure to adequately address the issue of waste reduction. In addition, the operational biogas plant necessitates appropriate deliberation to achieve sustainability. The SMC, on the other hand, is advocating for recycling practices through the Micro Segregation Center.

4.2 Social Dimension

In the social dimension, workplace health and safety has moderate to high perception (M = 4.36), while community impact (M = 3.67) and training and awareness (M = 2.95) scored lower, indicating a lesser emphasis presently. Sanitation employees exhibit strong health and safety awareness, follow procedures, feeling protected, and well-equipped, indicating a positive safety culture. Improvements in resource provision could further enhance safety. SMC has implemented measures to protect the health and safety of its waste management employees by addressing health and safety risks.

The SMC environmental officer emphasizes the need for safety equipment, vaccination plans, and health insurance policies for workers, stating that oversight falls under the Deputy Mayor's purview, without a dedicated team. The Plant's Managing Director acknowledges staff safety equipment but notes a reluctance to wear helmets. The Deputy Mayor mentions a health department and safety gear. The Ward Chairman stresses the municipality's commitment to providing and encouraging workers to use health and safety equipment.

Sanitation workers express a positive community impact on their well-being, diversity, and inclusion. Most employees feel safe and respected at work due to breaks and rest periods. Furthermore, the employees seem satisfied with their pay, indicating a high level of job respect. Additionally, employee participation in waste management decision-making may need to be increased. The findings indicate a positive but potentially enhanced community impact through sanitation employee engagement, appreciation, and decision-making.

SMC's waste management practices are also widely supported by locals, demonstrating their positive community impact. SMC develops and implements waste management with local communities. While a committee has not been formed, the SMC maintains an open dialogue with the community near the landfill site, according to its environmental officer. The Micro Segregation Center has hired community members, demonstrating their commitment to community engagement. SMC ensures socially inclusive and equitable waste management practices, particularly in providing discounts for underprivileged individuals, and SMC has contracted a private company to collect service fees, but it does not specifically identify or classify underprivileged individuals. It's worth noting that the *Chaudhari* community primarily works as sanitary workers, who play a crucial role in waste management. SMC promotes inclusivity, as these community and women's groups are provided with leaf plates and bowls manufacturing machines to produce plastic substitutes and encouraged to engage in fiber bag production.

Likewise, the residents exhibit moderate awareness of SMC's efforts to promote recycling and composting but have lower knowledge regarding training programs for proper waste segregation, highlighting the need for increased awareness and education in waste management practices. SMC has transformed its solid waste management approach, focusing on source segregation. Community engagement, awareness programs, and two tractors are employed for waste collection, educating over 20,000 households about waste segregation. The establishment of a Micro Segregation Center for disposing of inorganic waste, segregating similar types of inorganic waste, and compressing it for sale in the market. These initiatives promote understanding of the importance of waste segregation within the local community.

4.3 Governance Dimension

Residents are moderately satisfied with the municipality's service fee and services. In assessing the effectiveness of waste management practices in the SMC, both the Plant Manager and Environmental Officer highlight a commitment to transparency and accountability. The organization uses KPIs for success, engages with the community, and uses real-time GPS for waste collection. It also adheres to strict tariff regulations for outsourcing waste collection to external companies. The SMC is transparent in its actions, terminating contracts for irregularities, and involving locals and students in site visits, demonstrating accountability and promoting community participation in waste management. SMC strives for efficient waste management practices through a transparent and accountable approach, actively involving and informing the concerned community.

Likewise, sanitation workers reported a moderate level of involvement in the waste management decision-making process. As stated by the environmental officer, ward chairman & plant manager of the SMC states that they employ a collaborative approach to coordinate with stakeholders in waste management. The ISWN Plant in *Dhangadhi*, operated through a Public-Private Partnership, is an inclusive model that encourages community participation in waste management practices. It also collaborates with educational institutions and regularly meets with stakeholders to gather feedback and improve waste management practices.

4.4 Landfill Site Support

SMC has implemented various programs to address the financial, economic, social, physical, and environmental impacts of the landfill site affected area, in line with Section 22 of the Solid Waste Management Act in Nepal. The SMC's initiatives address landfill-affected areas by implementing social, economic, and environmental measures. These

include establishing a football ground for socio-economic upliftment and upgrading the *Tharu* Museum for cultural preservation. Park management also contributes to local environmental conservation. The ward chairman emphasizes continuity in planning for both landfill sites.

Table 1: Perceptions of ESG Dimensions in Waste Management

Dimensions	Variables	Mean	SD
Environmental (E)	Hazardous Waste Handling	4.47	0.95
	Environmental Impact and Sustainability Initiatives	4.68	1.25
Social (S)	Workplace Health and Safety	4.36	0.47
	Community Impact (Wellbeing, Inclusivity, and Diversity)	3.67	0.87
	Training and Awareness	2.95	0.85
Governance (G)	Accountability and Transparency:	2.97	1.02
	Stakeholder Engagement	2.78	0.65

5. Key Challenges Explored

5.1 Environmental Challenges

After conducting interviews with several key stakeholders in study site waste management practices and speaking with residents, plant employees, and sanitation workers. The ISWN plant faces several meat processing byproduct management challenges, according to the KIIs. The tough composition of byproducts like chicken feathers makes processing difficult. The ISWN plan does not process such products, making it difficult to separate them from regular waste. ISWN Plant worries about the waste collection area, suggesting expanding it could be difficult. This suggests that an expanded waste collection area may require logistical and resource allocation considerations. Building a landfill to support the project was sought. However, the construction process poses logistics, resource allocation, and environmental issues. The KIIs highlight the ISWN plant's operational and logistical challenges in managing and disposing of meat processing by-products and the infrastructure needed to sustain the project.

> *"Managing byproducts of meat products is still a big challenge. The feathers of the chicken are very hard to digest without cutting. ISWN plan refuses to process these kinds of products, it is challenging to segregate these from normal waste. We need to have a centralized meat cutting system to manage this issue."* – Environmental Officer

> *"Currently collecting in a limited area so expanding area can be another challenge"* – Managing Director of ISWN Plant

> *"Building a Landfill site for sustaining the project is necessary. Constructing becomes challenging"*- Managing Director of ISWN Plant

5.2 Social Challenges

KIIs highlight community waste management issues. Lack of waste management responsibility raises concerns. Littering persists despite efforts to promote waste ownership. Additionally, waste collection times present a logistical challenge. Working people may find it difficult to dispose of their waste during 9 AM to 4 PM collection hours. However, urban pedestrian dustbins are maintained. Some households still dump their waste in these bins overnight, despite awareness campaigns. Overall, the need for community-wide efforts to foster waste management ownership and responsibility and the importance of considering collection timings and infrastructure placement in waste management system design.

> *"There is a lack of feeling that this is my waste and I should be responsible for managing this waste. Still, people are littering anywhere." – Environmental officer*

> *"Waste collection is done in-between 9 AM to 4 PM. It is very much challenging for working people to be in a house for disposing waste into the waste collection vehicle during that time."* – Environmental Officer

> *"There are dustbins in the cities for pedestrians. Despite frequently making the residents aware, some households disposed their waste on those dustbins at night."* – Deputy Mayor

5.3 Governance Challenges

It has been found that, despite efforts to give priority to waste management within the SMC, certain officials are facing difficulties in recognizing this change in focus. The hesitancy of officials to fully prioritize waste management poses a substantial governance challenge. The presence of deeply rooted mindsets and reluctance to adapt within the bureaucratic framework may impede the successful execution of waste management endeavors. It is essential to overcome this resistance and establish a consensus among officials regarding the significance of waste management in order to achieve effective governance and sustainable waste management practices in the SMC.

> *"Still some officials had difficulties accepting the fact that Waste Management is the most prioritized sector of Dhangadhi SMC now. This mentality is the biggest governance challenge for officials."* – Environmental Officer

6. Discussion

Through the perspective of the Environmental, Social, and Governance (ESG) framework, the main objective of the study assesses the effectiveness of waste management practices in Nepal, with a case study of Dhangadhi SMC in western Nepal. Based on the findings of the study, it was determined that the SMC's initiative to implement waste management practices is effective. This study found that the staff members who are engaged in waste management procedures are provided with the appropriate safety measures and equipment by the organization. Workers are provided with a setting that is both safe and conducive to their health. According to Pandey, to make the working environment healthier, a separate segregation area that is equipped with a required health and safety environment is established (Pandey, 2009). Similarly, two autoclave machines are currently in operation to remove chemical waste and health hazards. It was found that the locals, employees, and other stakeholders had a good understanding of the positive impact that effective waste management has on the environment about the environment. Based on their findings, the researchers discovered that the waste-to-energy project contributed to the reduction of emissions to water and air, as well as the mitigation of environmental impacts. The results of this study are in line with the findings of Ramos et al., who found that waste-to-energy technologies saved resources and reduced water and air emissions (Ramos et al., 2018).

Furthermore, it was discovered that the workers possessed a high level of awareness regarding health and safety within the workplace. The employees do not deviate from the safety procedures and believe that they are adequately prepared for the assigned task. To protect its employees from the possibility of experiencing health issues as a result of waste management, the SMC has implemented several different safety measures. According to the findings of the study, the majority of this industry's workforce is comprised of members of the *Tharu* community. There are a significant number of people from *Tharu* communities who are employed by the municipal government, the plant, and the segregation center.

The findings of the study, the awareness program that is being carried out by the SMC is also very effective. A proper awareness program and the beginning of the source segregation of waste are both things that SMC can provide, despite the many challenges that were encountered during the initial phase. Many different awareness programs are carried out at the local level. Source segregation is one of the most important factors in the case of waste-to-energy projects, and the SMC has been able to be able to provide the local people with the appropriate training and awareness regarding source segregation.

Additionally, it was found that both the SMC and the plant place a strong emphasis on open communication and transparency in their work. To make communication between the various stakeholders more straightforward, feedback boxes are made available in a variety of locations. One hundred percent of the waste that can be broken down into fertilizer and biogas is recycled at the plant that was established as part of the waste-to-energy project. It assists in the appropriate utilization of waste, and the revenue generated from the sale of such products is sufficient for the plant to continue operating, ensuring its continued viability. However, Taelman stated that the recovery of energy from waste is ranked lower, with landfilling being the least preferable choice (Taelman, 2018).

It is clear from the findings of the study that there is adequate coordination and communication between the various stakeholders, even though there are not enough specific committees. Through the use of regular meetings, all of the interests of the stakeholders are effectively managed. These meetings also serve as an essential platform for engaging all of the stakeholders and collecting meaningful feedback. Nevertheless, the findings of the study indicated that SMC does not possess a suitable landfill site. Discussions are still taking place regarding the location of the landfill site. For the establishment of the landfill site, the only thing that is required is approval from the forest department. All of the preliminary works have been finished before this point. Additionally, the SMC has planned to initiate a variety of programs and address the challenges that are posed by areas that have been affected by landfills, all while emphasizing the well-being of the community and sustainable development.

It was also found that few challenges in managing meat processing byproducts, including separating them from regular waste and expanding waste collection areas. Community waste management issues include littering and collection times, and officials face resistance to prioritizing waste management. Addressing these issues and fostering responsibility and a consensus among officials is crucial for sustainable waste management practices. This aligned with the findings by Khanal et al., of common challenges related to waste collection, transportation, sorting, processing, and final disposal identified in Nepal mentioned (Khanal et al., 2023).

As an additional finding, the study indicated that effective waste management practices can be achieved by implementing appropriate regulations, appropriate training and awareness programs, and appropriate utilization of available human resources. Khanal et al., also emphasize inclusive waste management policies, improved waste collection and segregation systems, recycling infrastructure investment, and government, waste management, and informal waste worker collaboration (Khanal et al., 2023). In the beginning, it is a difficult task; however, if the appropriate resources are utilized in conjunction with the appropriate regulations, waste management can be accomplished. As in the Khanal et al., study; also mentioned that the lack of appropriate legislation addressing their involvement serves as a major hindrance and it can contribute to the reduction of the waste-related problem that exists in the country (Khanal et al., 2023). Similarly, Wang and Geng, the main obstacles to implementing integrated municipal solid waste (MSW) management are a fragmented management structure, ineffective and inefficient enforcement of regulations, outdated technologies, limited financial resources, and a lack of public participation (Wang and Geng., 2011).

7. Conclusion

In conclusion, the highly efficient waste management practices are employed by the SMC, in both efficiency and local resident awareness. Key elements such as the waste-to-energy project and segregation areas have played significant roles in managing biodegradable and non-biodegradable waste effectively. It can highlight the importance of community awareness and engagement, which can greatly contribute to the success of waste management practices. The high level of consciousness among employees and residents, particularly regarding source segregation, has been instrumental in achieving positive outcomes. The implementation of appropriate regulations, comprehensive training, and awareness programs are essential for sustaining and further enhancing waste management practices. By optimizing existing human resources and fostering community involvement can serve as a model for sustainable waste management. Ultimately, efficient waste management practices not only benefit the environment but also address various pollution-related issues, contributing to overall environmental sustainability.

Implications

Nepal struggles with waste management, and poorly managed in many parts of our country, causing serious health issues and other issues. The SMC's waste-to-energy project's waste management method could improve Nepal's waste management. Waste management is addressed by using organic degradable waste to produce fertilizer and CNG gas and recycling inorganic waste for sale. This multifaceted waste management strategy generates income and solves problems. It represents a sustainable waste management method that could be implemented nationwide. Employees have made valuable waste management health and safety suggestions. We must address several critical areas they identified. To protect employees, SMC must provide health insurance. Lack of vaccines for serious diseases that can be spread during waste management is another major issue that needs immediate attention. First aid facilities are needed to treat workplace injuries quickly. Low-quality gloves and delays in getting boots and gloves must be improved for employee safety and efficiency. The lack of hand sanitizers and the need for aprons emphasize the need for comprehensive safety measures to protect employees' health and well-being. It's clear that these suggestions are essential for waste management safety. Residents have important waste management suggestions for sanitation workers and municipal officials. First, increasing waste collection frequency, especially for degradable waste, highlights the need for a more responsive waste disposal approach to meet community needs. Waste collection could be extended to reduce missed pickups and boost efficiency. The request to collect waste visible on roadsides emphasizes the need for a comprehensive waste collection strategy that covers all areas to ensure no waste is left unattended. These demands require more resources, including collection vehicles, to support enhanced collection efforts. Additionally, sanitation workers must be properly trained and equipped to ensure their safety. Finally, while the community supports plastic bans, effective management of alternative packaging materials is needed to minimize unintended consequences.

Future researchers should prioritize this type of study in different regions of the country to provide more research perspectives. This research only examined a small area to evaluate waste management practices, so more studies with a larger sample size can extrapolate the findings. The plant's business model must be examined in detail to determine its financial stability since it is still in its infancy and has not yet generated significant revenue. This study selected a small sample of residents and employees for this study due to convenience. However, including diverse SMC residents from different regions may have improved results. The ESG framework dominated this study. Additional variables can be examined to determine waste management strategy efficacy. The findings of this study can help manage waste across the nation.

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Annexure 1

Demographics of local residents			
Demographics	**Category**	**Numbers**	**Percentage**
Gender	**Male**	**78**	**54.93**
	Female	**64**	**45.07**
Age	**Upto 20**	**7**	**4.76**
	20 to 25	**27**	**19.05**
	25 to 30	**34**	**23.81**
	30 above	**74**	**52.38**
Family Size	**Upto 2**	**7**	**4.76**
	2-May	**74**	**52.38**
	Above 5	**61**	**42.86**
Residency Duration	**below 6 Months**	**7**	**4.76**
	0.5 to 1 year	**3**	**2.38**
	1-2 Year	**10**	**7.14**
	Above 2 year	**122**	**85.71**
Education	**No Education**	**2**	**1.41**
	Below SLC	**30**	**21.29**
	SLC Pass	**24**	**17.04**
	+2 Pass	**18**	**12.68**
	Bachelor Pass	**60**	**42.59**
	Masters Pass	**7**	**4.93**
Demographics of sanitation workers			
Demographics	**Category**	**Numbers**	**Percentage**
Gender	**Male**	**12**	**85.71**
	Female	**2**	**14.29**
Age	**Upto 20**	**0**	**0.00**
	20 to 30	**5**	**35.71**
	30 to 40	**7**	**50.00**
	40 above	**2**	**14.29**
Working Duration	**Below 6 Months**	**3**	**21.43**
	0.5 to 1 year	**0**	**0.00**
	1-2 Year	**0**	**0.00**
	Above 2 year	**11**	**78.57**
Education	**No Education**	**2**	**14.29**
	Below SLC	**8**	**57.14**
	SLC Pass	**1**	**7.14**
	+2 Pass	**4**	**28.57**
	Bachelor Pass	**1**	**7.14**
	Masters Pass	**0**	**0.00**
Demographics of key informant			
Organisation/dept.	**Position**	**Gender**	**Experience in present organisation**
Environment, drinking water and sanitation Dept.	**Environmental Officer**	**Male**	**5**
Waste to Energy Project	**Managing Director**	**Male**	**5**
Dhangadhi SMC	**Deputy Mayor**	**Female**	**1st Term**
Dhangadhi SMC	**Ward Chairman**	**Male**	**1st term**