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Article

Sustainable solid waste management in municipalities: Experiences of selected settlements in Engcobo local municipality

Musa Nqwitha[1,*], Modeni Mudzamba Michael Sibanda[1], Tafadzwa Clementine Maramura[2]

[1] University of Fort Hare, Dikeni 5700, South Africa
[2] University of the Free State, Bloemfontein 9301, South Africa
*** Corresponding author:** Musa Nqwitha, 201805925@ufh.ac.za

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Abstract: South Africa has a variety of regulations on the provision of solid waste management services in municipalities because of the apartheid legacy. Nonetheless, discrepancies in waste management services persist despite new laws, legislative reforms and strategies. Those who live in marginalized and impoverished communities are the most susceptible and severely affected by improper waste management. This demonstrates a lack of integrated and sustainable waste management systems. This study aims to recommend a sustainable solid waste management system in Engcobo Local Municipality. Data was gathered through focus group discussions, documents, and semi structured interviews. Findings revealed that there has been improvements in the sustainable management of solid waste. The municipality is experimenting with novel approaches to deal with the problem of solid waste, particularly in remote locations where people's trash is difficult to pick up and collect. Through the focus group discussions, it was shown that some participants still need more information on waste management, there is a need for thorough educational initiatives on sanitation management, not particularly wastewater and sanitation.

Keywords: Engcobo local municipality; sustainable solid waste management; sustainable service delivery; municipality; waste collection

1. Introduction and background

Solid Waste (SW) is the universal phenomenon directly affecting every individual. Around the globe governments and citizens are making decisions on the utilization and management of waste that affect the daily hygiene of citizens and communities (Kaza et al., 2018). Solid Waste has detrimental effects on the environment, though efficient Solid Waste Management (SWM) can have positive effects on the environmental ecosystems. Solid waste creation causes environmental concerns, which are exacerbated when enterprises prioritize expansion and economic growth (Das et al., 2019). The terrestrial ecology is negatively influenced by open dumps, which are more prevalent in developing and underdeveloped countries since it is simple to run and inexpensive; this is particularly prevalent in rural and low economies (Das et al., 2019).

SWM is a series of ongoing and logical regulations that govern waste generation, storage, collection, transportation, processing and landfilling according to the best public health practices, economy, resource preservation, aesthetics, environmental necessities and what the public cares about (Akbarpour et al., 2016). Environmental challenges in South Africa, including SWM, have been generally managed by Command-and-Control regulations which penalize poor waste management by implementing and enforcing various legislations (Nahman and Godfrey, 2010).

Sustainable Solid Waste Management (SSWM) is a contemporary sophisticated approach that utilizes technology and new techniques to improve SWM in a socially and environmentally acceptable manner (Simatele and Kubanza, 2018). Asefi et al., (2020) further provide that ensuring sustainability in SWM is predicated on the promotion of solid waste to be eco-friendly while being socially and legally abode to SWM management. Maintaining SSWM requires practices that include effective systems as well as tangible characteristics of the system component, which cannot be limited to the areas' waste processing plants. It must minimize the greenhouse gases of incarnation plants to promote eco-friendly environments. Simatele and Kubanza (2018) posit that people in informal settlements are often negatively affected by unsustainable waste management practices because they often lack waste management services, unlike their formally settled urban counterparts.

Based on the empirical literature, Municipal Solid Waste Management (MSWM) is one of the most expensive local government obligations in many cities. In underdeveloped nations, for example, the money necessary for waste management might account for up to half of the overall municipal budget. MSW collection is insufficient in many underdeveloped nations due to resource restrictions (Kabera, 2020; Rai et al., 2019). As a result, different finance methods are required to extend the coverage of municipal waste collection. To enhance self-reliant curb-side recycling of recyclables and remaining trash, the European Union (EU) implemented restrictions in the waste industry. Moreover, low-income nations worldwide have focused on increasing accessibility, while the EU has redirected its attention from trash disposal towards recycling and reuse (Rai et al., 2019).

Officials in the United States of America (USA) are obliged to identify other venues for municipal trash disposal owing to the rapidly shrinking capacity of metropolitan landfills. As a result, rural towns now have strong financial incentives to absorb waste from metropolitan regions (Moser and Korstjens, 2018). The location of these rural facilities may require the transportation of large amounts of trash by truck, rail or barge, among other methods while other individuals are anxious about the hazards associated with trash transportation through their areas (Shrestha et al., 2020).

Moreover, the Australian governments have worked together for a very long time on waste policy and efforts. The Council of Australian Governments agreed on the first comprehensive domestic waste management strategy in 1992 when they adopted the National Strategy for Ecologically Sustainable Development (also known as the National Strategy for ESD). This strategy committed Australia to increasing resource efficiency, lowering the environmental impact of waste disposal, improving the management of hazardous wastes, preventing their formation and addressing significant clean-up problems. This dedication has been the cornerstone for contemporary government initiatives and programs, as well as the ground for cooperation between environmental ministers on matters about waste management nationwide (Diesendorf and Hamilton, 2020).

However, many Sub-Saharan African nations have ineffective policies and regulations in place to stimulate and expand investments in waste management and recycling. Where waste management laws and regulations exist, they are applied inconsistently (Mohee and Simelane, 2015). Mbah and Nzeadibe (2017) note that unlike in Asia and Latin America, the African waste sector is plagued by a lack of

socioeconomic and environmental planning and policy intervention. Despite the relevance of dealing with municipal waste issues, the Nigerian informal sector does not remain unrecognized by law, with no legal responsibilities and obligations in waste management, regulations/plans included in social safety net programs or the creation and execution of MSWM policy (Gumbo and Simelane, 2015).

While South Africa has been driving growth through the Fourth Industrial Revolution (4IR), the country's development still faces various service delivery problems, including SSWM. However, there are various approaches that municipalities may use to bring waste management under control. Such approaches are not limited to the implementation of technology when recycling, but also enforcing the existing legislation and collaborating with the private sector and Non-Government Organizations (NGOs) in SWM. To successfully manage solid waste, resources must be devoted to leveraging a change in public attitudes and behavior towards waste reduction, waste management and recovery, in alignment with the local government's daily waste operation. Efficient community-based recycling and waste management, within the context of New Public Management, may require municipal waste sector restructuring to include Private Public Partnerships (PPP) and compliance with Broad-base Black Economic Empowerment (BEE) principles to effectively drive sustainable municipal waste management. Thus, the purpose of this study was to recommend a sustainable SWM system for managing municipal waste.

2. Research methods

This study adopted the paradigm of naturalistic interpretive research. Using the interpretivism paradigm, the data collectors collected substantial exploratory data on municipal stakeholders' and people's experiences with SSWM in the Municipality. As a result, interpretivists embrace a relativist ontology in which a single phenomenon might have several interpretations rather than a truth that can be determined by a measurement process. Non-probability sampling was used by the researchers since this study is grounded in the interpretivism paradigm and qualitative research methodology. According to Bhardwaj (2019), nonprobability sampling involves selecting a sample without guaranteeing a member of the population will be chosen. Purposeful sampling was also used in non-probability sampling. The best way to match the sample to the goals and objectives of the research is through purposeful sampling, which enhances the quality of the study and guarantees the reliability of the findings. It was used since the study had a small number of participants and the researchers recognized that the target group fit the objectives of the SWM study goal; in that case, purposive/judgmental sampling was the best sample.

To collect data, in-depth, semi-structured interviews with community service municipal officials from Municipal officials (Community Service-SWM) (No = 5) were conducted. Documents were employed to strengthen the trustworthiness of the data. Focus groups were utilized to gather qualitative information on the experiences of participants from formal settlements (No = 10), informal rural areas (No = 10), and informal settlements (No = 10) up until a point of saturation which made the sample size to be (No = 35). In this study, the researchers gathered information through interviews, documents, and focus group discussions. Participants provided insights on

sustainable solid waste management in selected Engcobo Local Municipality based on their experiences, views, and feelings. To analyze data, thematic data analysis was employed to analyze the data and outcomes acquired from participants for this study, which must correspond with the research goals. Also, this study has considered and applied ethical consideration and practices. Before data collection, all ethical standards were properly observed.

3. Results and discussions

3.1. Introduction

While this section deals with the analysis, interpretation and presentation of data that was collected from the Municipality about SSWM, the data collected was underpinned by the research objectives of the study. Further, data was collected using semi-structured interviews with municipal officials and focus group discussions with citizens from formal settlements, informal settlements, and rural areas of Engcobo Local Municipality. The data analysis yielded themes that were ordinated: sustainable solid waste management system, factors, and experiences of municipal stakeholders on sustainable waste management in the municipality. Every superordinate theme that emerged was examined, as were the resulting sub-themes.

3.2. Employment status in waste management

One of the most significant SWM components affecting sustainable waste management is employment. The amount of waste generated by individuals is also influenced by their employment; certain people's earnings and income may need to be supplemented by side hustles for them to feed their families; hence, you will notice specific people collecting bottles and cans from where they work. According to Gardiner and Hajek (2020), the relationship between economic growth and trash generation is a critical global issue. Gardiner and Hajek (2020) found that varied regional economic settings have a significant influence on the link between economic development and environmental quality. Increases in production factors (such as employment and capital) boost not just output but also workplace pollution consumption.

3.3. Evaluation of sustainable solid waste management for managing solid waste in the municipality

3.3.1. Actions of managing waste in the municipality

SWM agencies in industrialized nations have benefited from the use of systems analysis engineering models, analysis platforms, and evaluation techniques since the 1960s, with a primary focus on highly defined system design (Marshall and Farahbakhsh, 2013). Although small groups may bury solid waste close to their villages or dispose of it in adjacent rivers or bodies of water, these methods proved ineffective in stopping the spread of disease or offensive odors when population densities increased (Marshall and Farahbakhsh, 2013). Moreover, research by Parfitt, Barthel and Macnaughton (2010) and Kaza et al. (2018) shows that changes in consumption patterns are reflected in the composition of garbage in low-income

nations. The percentage of organic waste in all rubbish dropped from 64% to 56%. The requirement for sufficient trash collection in towns and nations is demonstrated by the fact that waste collection increased dramatically in low-income countries, from about 22% to 39%. The global trend toward more recycling and composting has facilitated this breakthrough. Lastly, from 0.1 to 10%, waste-to-energy incineration increased dramatically in upper-middle-income countries.

Per the officials questioned, there have been advances and changes in the sustainable management of waste. The municipality is embarking on new methods to deal with the problem of SWM, particularly in remote areas where it is challenging to pick up and collect rubbish generated by residents. Residents' attitudes toward waste management have changed because previously, citizens refused to attend the "General Mbizo" about waste. After all, it is where the municipality gets a chance to converse about waste with citizens and the economic benefits that are available if waste is properly managed. Participants emphasized that the Municipal Systems Act (Act 32 of 2000) and the Hazardous Substances Act (Act 5 of 1973) are used to manage waste. Participants indicated that dealing with individuals when it comes to trash management is tough since it is what is produced daily and, if left unmanaged, can cause health problems. The data shows that the most vulnerable members of society are disproportionately affected by all the negative effects of poorly managed trash, with individuals losing their lives and homes as a result of waste dump floods and those who work in the fields in hazardous garbage-picking situations having serious health implications. Participants in the interview have given such information.

In as much as the municipality tries to manage waste, they are not doing enough, particularly in informal settlements and rural areas where it is difficult to find waste in one area (collected) for municipal trucks to take waste on recycling site in Forest View (focus group).

Another municipal official question has noted the actions they have taken in tackling the poor management of solid waste.

> "*The municipality has placed some skim bins in the settlement entrances so that when our services (waste trucks) are unavailable, people can throw their waste in those bins, allowing the town to remain clean at all times (municipal official).*"

The researchers have noted that the officials are displaying positive outcomes regarding solid waste management in the municipality. Even though there are many gaps in municipal jurisdiction since the municipality is solely focused on the Central Business District (CBD) rather than providing the same treatment to all people if such exists in South Africa. According to what was observed during data collection, those who live in informal settlements live in an unhealthy environment full of waste, and they simply throw it anywhere. Others gather it together in the same place and burn it, but if there is a blowing wind before they can burn it, it spreads everywhere. Finance plays a significant part in the trash disposal since people who pay for municipal services, i.e., those who live in suburbs, are well taken care of, and they also know how to handle and dispose the garbage they generate.

The findings are substantiated by Marshall and Farahbakhsh's (2013) study, which found that public concern and awareness are also SWM drivers in high-income countries. Poor previous practices, such as landfill burning and the use of toxic incinerators, have created negative opinions of current SWM initiatives among the

public. Although most people are aware of the need for SWM facilities, their overall disapproval of them and tendency to think of them as "Not in My Backyard" (NIMBY) indicates that they would rather see them somewhere else. It is also shown how, regardless of how clean or sustainable a new SWM facility may be, proposals for them have almost always been met with the pretty standard NIMBY opposition from prior negative facility perceptions.

3.3.2. Technological development in waste management

An increasing number of innovative companies are exploring alternative SWM methods and technologies to create a more sustainable waste management industry. These technologies take several forms and address a variety of issues affecting the waste management industry. They all have the same goal: to reduce pollution, streamline the rubbish collection system, and protect the environment. Many of the most recent solid waste management technologies making headlines are directed at businesses. This is because enterprises create more waste than people. Making sustainable waste management easier and less expensive for businesses will encourage more individuals to recycle. With 75% of all rubbish produced being recyclable, this might have a substantial impact on pollution, landfill levels, and climate change (RTS, 2023). While the reduction of solid waste, energy consumption, and carbon emissions are all coordinated, they all require financial investment and technical support. Technology and investments in pollution control have directly benefited solid waste reduction, and technological advances can minimize investment to some extent. To address the environmental challenges generated by solid waste, policymakers should consider economic and social growth (Guo et al., 2021).

Based on the data supplied by the participants, the municipality is far behind when it comes to technical improvement in SWM. One reason for this is that municipalities, which include rural areas, need time to grow. That sums up the municipality's lack of technological progress as indicated by a participant below.

> *South Africa as a developing country, currently implemented the use of 4IR, but the country is far behind in technological advancement as a country in general, so it will be difficult for the local municipality to be technologically advanced, while technology is a problem throughout the South Africa* (municipal official).

The findings of the participants are consistent with those of Fletcher et al. (2021). "In many developing nations, such as Pakistan and India, technologically sophisticated waste management solutions are expensive, and uncontrolled dumping of rubbish in unregulated landfills is nevertheless common practice for waste disposal."

> *Just as it is difficult to maintain and repair the waste vehicle, it must be more difficult to maintain the electrical equipment that can be used to mitigate waste* (municipal official).

Another municipal official has highlighted.

> *The local government needs to invest in waste management because it can benefit the municipalities. This has always been an area of fascination for the municipal* (municipal official).

As human proclivity fades, technology steps in. It augments traditional human efforts, also changing traditional waste disposal methods. Innovation is crucial for the waste management industry since it is not only improving the environment but also

creates new prospects for advancement. Current waste management processes are growing more expensive as a result of rising demand and expense, however,

> *The municipalities are not ready to fully adopt technology for waste management* (focus group).

The study notes, that it will be difficult for South African municipalities to implement waste-to-energy projects because their primary focus is on technological development that will make it easier for them to collect waste rather than find ways to convert waste into energy so that they can use the income generated from that project to purchase more waste-treatment materials rather than waiting for national investment in the waste sector.

The responses from respondents align with a study by Shekdar (2019); the present technological system's equipment and machinery are either designed and developed for general use or adapted from other industries. The application of such equipment for solid waste results in underutilization and loss of efficiency. Because the properties of solid waste and local conditions vary so significantly, current handling and treatment technologies from other countries are typically inadequate for South Africa (Shekdar, 2019). Another important hurdle is the misapplication of technology, which has been recorded several times in underdeveloped nations where complicated and costly technological recycling and composting operations, as well as other waste management approaches, have failed. Failure to include the public and relevant stakeholders, acceptance of outdated technology that includes imported mechanical and electrical parts that are too expensive to replace or too difficult to maintain, failure to conduct economic and financial assessments, limited development of a recyclables market, financial constraints, and a lack of skilled technical personnel to manage these systems are all factors that contribute properly and thoroughly to a breakdown (Nahman and Godfrey, 2010).

3.3.3. Measures to mitigate improper disposal of solid waste

It has been noted that 50% of the officials interviewed indicated that they can significantly reduce solid waste by minimizing trash output, reusing goods that would otherwise be wasted, recycling products, and using recycled materials. The Municipality has set non-statutory guidelines prioritizing domestic trash collection and recycling, street cleaning, bin-tipped garbage, and commercial waste. The trash produced in different regions is categorized as high, medium, or low priority, and potential fallout and mitigation during service interruption are mentioned. Waste collection is necessary to keep the environment less affected, boost the economy, and preserve hygienic conditions (Tripathi et al., 2020).

> *The municipality is effectively implementing national waste management standards, as well as encouraging citizens to re-use recyclable waste material, and the majority of people in rural areas and informal settlements are showing positive results in terms of recycling* (municipal official).

All the authorities that were questioned agreed that solid involvement, coordination, and focused efforts towards successful distribution across several interrelated institutions are necessary for SWM since it encompasses waste creation, waste composition, collection, recycling, pre-treatment and treatment, and ultimately disposal.

> *For the past years, the municipality have always installed waste bins in areas around town, the reason for this is for citizens to throw waste in those bins so that the municipality can come to clean and pick it up, this serves as one of our waste management strategies, but there are some challenges in townships (informal settlement) whereby the municipality installs those bins but you disappear within two weeks-time, because citizens take them to their house* (municipal official).

Based on the study, the municipality does not have an effective waste management strategy to mitigate poor solid waste disposal; they are using all the old-known strategies rather than developing new methods as the world changes. As per the respondents' remarks, open dumping and landfilling are the most common methods of disposing of MSW in poor economies due to their low cost, especially when social and environmental consequences are taken into consideration. Due to a lack of supportive laws, norms, and regulations as well as a lack of public knowledge of the necessity of separating materials at the place of origin, recycling and material recovery operations are still in their early stages. Incineration and energy recovery are severely limited because of the high cost of investment and the incorrect composition of mostly undetectable and biodegradable waste with high water content, which negatively affects the calorific value of waste. Composting has long been promoted as a method of dealing with recyclable garbage while simultaneously creating new job opportunities and earning extra revenue for communities. However, composting systems have several drawbacks. Municipal composting commonly confronts technical challenges due to a lack of understanding and know-how, as well as the use of mixed MSW, which produces low-quality compost.

3.4. A sustainable waste management system in the municipality

3.4.1. Legal aspects of SWM

The legal aspects pillar of SWM is driven by the need for the environmental manager to use financial and legal laws to educate the public and impose legal consequences on disobedient parties. The unbalanced state of the ecosystem demands, among other things, actions that might impact public participation in environmental conservation and culture for present and future generations (Rodić and Wilson, 2017). Therefore, based on organizational, financial, economic, and legal help, laws must be unified at many levels of economic management, such as in the fields of creative activity and energy conservation, among others (Batista et al., 2021).

The officials interviewed mentioned a lack of legal action on unsustainable SWM, which is primarily due to the failure of other departments to execute their primary tasks. The waste department cannot combat or mitigate the issue of poor solid waste disposal alone; if one department fails, it is difficult for other departments to proceed effectively without destruction. As a result, each department must carry out its responsibilities.

> *The municipality draft the by-laws to control solid waste management, but enforcing those by-laws is no longer the responsibility of their department since it has included more government departments including SAPS* (municipal official).

Whereas other officials suggested:

It is high time that the municipality introduce a waste enforcement department that deals with negative waste activities, as there are those who still sell certain things like electrical wires to scrap yards, having this law enforcement that will focus on waste management can help the poor waste management activities (municipal official).

Citizens are observed to be reckless when it comes to obeying waste laws hence other focus groups suggested that government must enforce the waste policies and laws.

While citizens may be perceived to have a negative attitude toward waste, if the government can enforce waste by-laws and ensure that all policies that govern waste are effectively implemented, the way citizens manage their waste may change, as they will be afraid of the consequences (focus group).

All the officials questioned said that the barrier of limited funding sources and linear risk management may be lowered when properly implemented by existing financial and economic aid measures and legislative aspects that have been worked on and adjusted to municipal management plans. One element that promotes communication between public and private powers is the Public Private Partnerships (PPP). Adhering to waste management regulations may also help to establish an environment free of contaminants and modify specific waste standards.

Policies serve as a guideline for public service delivery; they may assist in determining the likely threat to occur in the future, while also assisting in preparing to avoid those threats that may have a negative impact on the environment (municipal official).

Hence, legal proceedings, laws, and policies can create a common ground which can bring people together to work towards the common goal of promoting sustainable solid waste management.

3.4.2. Stakeholders' cooperation

In terms of public policies, the government must emphasize the employment of new technologies to benefit individuals and communities through rational, ecologically fair, solidary, and inclusive production. In terms of disposal, it is important to increase the utilization and reuse of combusted waste ashes in the concrete, asphalt, and pottery industries. Although there are inadequately monitored governance structures in place to maximize MSW energy recovery, it is a realistic implementation mechanism (Batista et al., 2021). The involvement of the private sector in waste management systems often improves system efficiency (Elsaid and Aghezzaf, 2015).

Officials who were interviewed shared their thoughts. NGOs play a limited role in SWM, most of their initiatives are aimed at improving the livelihoods of trash collectors and supporting ecologically friendly recycling practices. Recently, certain Non-Governmental-Organisations, in collaboration with the Department of Environment, have been working on an effort to separate solid trash at the source. This campaign is still in the works; the goal is to encourage homes to separate their garbage into only two waste bags, namely organic and non-organic waste separation. Because organic garbage will be delivered straight to composting plants, this technique will

make sorting operations easier. Non-organic trash will be further segregated by material, processed, and recycled. A modest amount of non-recyclable waste is projected to be landfilled.

> *Cooperation should foster trust among relevant stakeholders in government policies, as well as social stability, which may aid in crisis recovery plans for communities. Also, ensuring coordination and cooperation should open the door to transparency, open communication, and improved conflict resolution between municipalities and waste stakeholders because they will be working together towards the common goal of preserving the environment, which is the goal of sustainability* (municipal official).
>
> *Involving citizens in decision making as a valuable stakeholder in the municipality may limit our complaints and provide a clear direction on waste management, monitoring, and evaluation* (focus group).

In the study by Tseng et al. (2021), stakeholders such as Provincial government agencies, municipalities, and commercial service providers might contribute to SSWM by building waste management regulatory frameworks. Changes in national policy may motivate practitioners to rethink and reinvent SSWM in socially acceptable ways that have a direct influence on employment and leadership issues. Environmental problems should also be addressed in policies, as should raising awareness among SSWM stakeholders.

> *The municipality and political parties must not come to citizens only when an election time is approaching; they must come to us constantly to ask for the challenges we are facing, and if they have made any changes to the challenges, they must come and update us on what to expect next, as well as evaluate those changes, so that the government can regain public trust* (focus group).
>
> *As we are interconnected, there must be a strong relationship between all municipal departments such as supply chain procurement, and finance. For example, the finance department must be aware of the challenges we are facing so that when they are making the budget, they can see the need for budget increase* (municipal official).
>
> *As previously stated, we need more campaigns, which means collaborating with more departments such as education can help the municipality reach out to more people to educate them about sustainable waste management and change their attitudes toward waste management* (municipal official).

The municipal officials have emphasized the importance of collaboration with the relevant stakeholders in mitigating waste challenges.

3.4.3. Employment standards intervention and infrastructure investment

Maintaining SSWM in times of crisis requires a strong foundation of employment norms and occupational intervention in the form of benefits for human resources. As a tabled in **Table 1** below, investment in human resource development is stressed as vital to successful performance and organizational expenditure of resources, as well as strengthening companies' position and competitiveness. Organizing and improving human resources is essential for crisis response due to employees' lack of experience with SSWM (Tseng et al., 2021).

Table 1. Summary of findings.

Municipal official 2	Municipal official 1	Municipal official 4	Focus group
The municipality must collaborate or work with some engineers starting from the mechanic for transport services and breakdown instead of taking it to those auto services with unskilled labours because the waste trucks are heavy and they need someone who is trained for them, also need the help of engineers and Information Technology (IT) to update the waste systems so that municipality can be able to use technology to manage the waste that is generated (municipal official).	The infrastructure that we have is not in good condition; by investing in infrastructure, purchasing different boiler machines, and updating Weigh Bridge, we will be able to manage more waste than we are now and have accurate statistics on the waste that we collect monthly.	The municipality may be in rural areas, but we have many areas that we must cover in the waste collection, but we are unable to do so because there are few waste trucks, then the municipality must purchase the trucks that will deal with rural areas but before that, the road must be maintained to accommodate waste trucks as they are heavy.	The municipality must install at least one skim bin per village where people will throw their waste, and they can come to collect it no matter how often they come and employ one person to guard the waste area to avoid illegal waste activity and someone who can tell citizens to dump the waste according to their categories.

3.5. Summary and conclusion

3.5.1. Evaluation of sustainable solid waste management for solid waste

One of the sub-objectives was to examine the sustainable waste management that the municipalities had adopted. The study aim was met by demonstrating that the SSWM is capable of handling waste-generating processes and recognizing correlations between various factors from a technological, sociological, and economic standpoint. However, designing applications is difficult since the essential assumptions are unrealistic; evaluating complexity necessitates an examination of the interface. SSWM is seen as not only a crucial player in supporting resource transformation on a large scale but by approaching resource management in a novel way, it may also open new economic opportunities. Enhancing the assessment and choice of SWM solutions is essential for an SSWM implementation to be successful. It is necessary to identify the obstacles to resolve the negative features of SSWM. Moreover, a long-term, distinctive strategy for providing efficient management solutions to close the MSW-energy supply gap is successful MSW conversion.

Secondly, the maintenance of the SWM is also significantly influenced by operational and financial requirements, as well as cost-recovery plans for financial reasons. Reduced supplementary costs while boosting efficiency would result in more sustainable resource management and suitable socioeconomic service delivery. The municipality has emphasized that they apply a Waste management hierarchy. Lastly, the municipality significantly reduced solid waste by implementing several essential ideas such as restricting waste creation, reusing goods that would otherwise be wasted, recycling products, and reusing recycled materials. “Reduce, Reuse, and Recycle” is a popular three- letter phrase to express this concept. Due to a lack of laws, standards, and regulations that encourage recycling and material recovery, as well as a lack of public knowledge of the need to separate materials at the site of origin, these operations are still in their early phases. The high expense of investment and the waste’s inappropriate composition, which mostly consists of inert and biodegradable garbage with a high-water content that lowers the waste’s calorific value, make incineration and energy recovery extremely difficult. The practice of composting has

long been marketed to get rid of recyclable waste while also generating income for local communities and new job possibilities.

It is recommended that the municipality should not set lofty goals for technical improvement, even innovation is critical for the waste management business since it not only benefits the environment but also opens new opportunities for advancement. Expanding demand and expenditure of current waste management techniques are becoming more expensive. This requires South African municipalities to transition from waste to energy; if this is accomplished, all waste expenditures will be compensated by waste profits, and it will not only create a clean environment but job possibilities; this is referred to as sustainability.

3.5.2. Best practices of waste management system

Enforcing waste regulations necessitates a combination of legislative measures, efficient monitoring and enforcement systems, public awareness, and the participation of stakeholders. The following can be used to enforce waste policies:

Establish clear and well-defined waste management rules that include a wide range of subject matter, including waste reduction, recycling, disposal, and hazardous waste management. These must adhere to national and international trash regulations and norms. Strong legislations and regulations are needed to support waste management policies. This includes setting goals, defining roles, and implementing sanctions for noncompliance. Waste generators, waste transporters, and waste treatment and disposal facilities should all be covered by the legislation.

Create a solid monitoring and reporting system to keep track of trash creation, collection, recycling rates, and disposal. This might include frequent waste management facility inspections, audits, and reporting requirements. Improve monitoring efficiency and accuracy by utilizing technology and data analytics. Guarantee that adequate enforcement procedures are in place to ensure that waste management rules are followed. Inspections, audits, and fines for noncompliant persons or corporations are possible. To enforce rules and investigate unlawful waste operations, work with law enforcement authorities or designated waste enforcement agents.

Conduct public awareness and education programs to educate individuals, companies, and communities on waste management policies, as well as the necessity of trash reduction, recycling, and proper disposal techniques. Education, training, and community outreach activities should be used to promote sustainable waste management strategies. Offer incentives or awards to individuals and organizations who implement environmentally friendly waste management strategies. This can promote involvement and adherence to waste rules. Tax breaks, subsidies, and reward programs for excellent trash reduction or recycling activities are examples.

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