International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 8s, 2025
https://www.theaspd.com/ijes.php

Mediating Factors Of Efficiency In Municipal Solid Waste Management

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Abstract: *A study was conducted in the Moses Kotane Municipality (MKM) in the North-West Province of South Africa in order to identify and quantify factors that affect efficiency in the management of municipal solid waste generated by households and businesses. Data was collected from a combination of 471 households and businesses on 24 socioeconomic, sanitary and environmental indicators of efficiency in the management of municipal solid waste in developing municipalities. The specific objectives of study were to assess the current level of efficiency in the collection and disposal of municipal solid waste, and to construct a framework that could be used for improving the current level of efficiency in the management of municipal solid waste. Efficiency in the management of municipal solid waste was assessed by using ISO 14000 and ISO 14031 standards defined by the Canadian Standards Association. The results showed that about 67% of businesses selected for the study were inefficient in municipal solid waste management, whereas about 33% of them were efficient. Efficiency in the management of municipal solid waste was significantly influenced by 3 predictor variables (lack of adherence to municipal bylaws on waste management, inability to enforce municipal bylaws on municipal solid waste management, and wrong perception on the potential benefits of proper waste management.*

Keywords: *ISO standards, Managerial efficiency, Moses Kotane Municipality, Municipal bylaws, Solid waste management*

INTRODUCTION

The purpose of study was to identify and quantify key predictors of efficiency in the management of municipal solid waste at the Moses Kotane Municipality (MKM) in the North-West Province of South Africa. The study covers 32 villages that constitute about 300,000 inhabitants of the Bakgatla-Ba-Kgafela (BBK) community of MKM. The research was conducted in order to identify indicators of performance that could be used for enhancing efficiency in the management and disposal of municipal solid waste in Moses Kotane Municipality as a way of enhancing the quality of municipal services that are provided to residents of Bakgatla-Ba-Kgafela (BBK).

Moses Kotane Local Municipality is a local municipality in Bojanala Platinum District Municipality, North-West Province, South Africa. It is named in memory of Moses Kotane, who was the Secretary-General of the South African Communist Party from 1939 until his death in 1978 [1]. The seat of local municipality is Mogwase. According to Statistics South Africa (2024), Moses Kotane Municipality (MKM) has a total population size of 242, 554, a total area of 5, 719 square km, a total number of 75, 193 households, and a population density of MKM is 42 inhabitants per square km. About 98.3% of the population living in MKM is black, 0.8% is white, 0.5% is Indian, and 0.3% is coloured. Languages spoken at MKM are Tswana (81.6%), Zulu (4.1%), Xhosa (3.4%), English (3%) and other languages (7.9%). Moses Kotane Municipality (MKM) consists of 34 electoral Wards in which the African National Congress (ANC) holds 42.649% of seats, the Economic Freedom Fighters (EFF) holds 12.945% of seats, and the Democratic Alliance holds 3.324% of seats in the North-West Provincial Legislature [2].

The annual report issued for the financial year 2022/2023 by Moses Kotane Municipality (2024) shows that the MKM is mostly rural and consists of 107 villages and two formal townships of Mogwase and Madikwe. The Municipality has predominantly African population, with fewer Indian, coloured and white groups. Moses Kotane Local Municipality is one of five constituent local municipalities of Bojanala Platinum District Municipality in North-West Province of South Africa. It shares borders with Rustenburg, Kgetleng Rivier, Ramotshere Moiloa and Thaba Zimbi Local Municipalities. Its headquarters are based in Mogwase Township with satellite offices in Madikwe Township [3].

The economy of Moses Kotane Municipality (MKM) is based on tourism, mining and agriculture. MKM is fairly close to Pilanesberg and Sun City, which are major tourist attractions to local and international visitors. Table 1, below, shows general economic indicators that are used by the World Bank (2024) for assessing economic growth rates in Sub-Saharan African countries. It can be seen from the table that Moses Kotane Municipality is a typical

developing municipality based on ISO 14031 benchmarks that are used by the Canadian Standards Association (2024) that are used for environmental assessment worldwide [4].

Table 1: General economic indicators of Moses

Kotane Municipality in 2024

Total population size of local municipality	243, 648
Total area of local municipality in square km	5, 719
Annual population growth rate	0.22%
Unemployment rate	37.9%
Youth unemployment rate (Unemployment among people with ages of 15 to 34 years)	47.4%
Annual economic growth rate	0.38%
Total number of households	75, 600
Total number of households with electricity	61, 800
Number of households with piped water inside their yards	10, 900
Number of households with weekly waste removal services	63, 200

Source: Statistics South Africa (2024)

Table 2, below, shows demographic indicators that are used by the World Bank (2024) for assessing population and fertility growth rates in Sub-Saharan African countries. It can be seen from the table that Moses Kotane Municipality is fairly similar to any other developing municipality in Sub-Saharan African countries. The figures shown in Table 2 suggest that the economy of Moses Kotane Municipality needs to grow at a much faster pace in order for the Municipality to alleviate poverty, lack of skills and unemployment.

Table 2: Demographic indicators of Moses Kotane Municipality in 2024

Percentage of population under 15 years of age	33.2%
Percentage of population between 15 and 64 years of age	59.5%
Percentage of population over 65 years of age	7.3%
Number of males per 100 females	99.3
Percentage of illiterate population	7.5%
Percentage of population with Grade 12 level education	30.9%
Percentage of population with tertiary level education	4.2%
Total number of households	80, 654
Average number of people living in a household	3.0
Percentage of female-headed households	41.0%
Percentage of formal dwellings	85.6%
Percentage of people owning their dwellings	79.9%
Percentage of dwellings with flush toilets connected to sewerage	10.5%
Percentage of households with weekly waste removal services	75.5%
Percentage of households with piped water inside dwelling	9.0%
Percentage of dwellings with electricity connection	92.5%

Source: Statistics South Africa (2024)

BACKGROUND TO STUDY

The annual report published by the Moses Kotane Municipality (2024) for the financial year 2022/2023 shows that one of the top strategic priorities of the Municipality is to create employment opportunities for the unemployed youth in the Moses by way of initiating and creating community-based projects in collaboration with the private sector and individual entrepreneurs. In this regard, the key role player is the mining industry. By using advanced methods of municipal solid waste management, it is possible to transform plastic waste into usable products. Very few tangible results have been achieved in this respect. The study aimed to fill the gap by identifying feasible methods in which efficiency in the management of municipal solid waste could be enhanced. Municipal solid waste could be processed,

engineered, recycled and commercialised by using modern technological methods of municipal solid waste management that are used in cities such as Amsterdam, Kuala Lumpur and Singapore [5]. The study was aimed at laying the foundation for a framework that could enhance cleanliness and environmental sanitation in Moses Kotane Municipality. The construction of a feasible and affordable framework for the efficient management of waste is a key priority for people living and working in Moses Kotane Municipality.

The study has the potential for equipping the unemployed youth living in Moses Kotane Municipality with practical skills that could create livelihoods. The project is relevant to the needs of the community. Similar projects have succeeded in cities such as Amsterdam, Kuala Lumpur, Singapore and Maputo [6].

LITERATURE REVIEW

Moses Kotane Municipality is part of Bojanala Platinum District Municipality [3]. Bojanala Platinum District Municipality (BPDM) has a population of 1.67 million or 44.1% of the total population of the North-West Province. In the year 2016, the BPDM had a GDP of R137 billion (BPDM, 2019). This figure amounted to 52.14% of the GDP of the North-West Province or 3.16% of the South African GDP of R4.35 trillion in the year 2016. This shows the relative significance of Moses Kotane Municipality to the South African national economy.

Asah, Fatoki and Rungani (2015) have shown that it is essential to train municipal managers on the planning, implementation and assessment of integrated service delivery programmes on a regular basis as a means of ensuring satisfactory service delivery [7]. Asefi and Lim (2017) have proposed a multi-dimensional model that is suitable for developing municipalities such as Moses Kotane Local Municipality. The proposed model recommends the provision of economic incentives to private waste collectors and the reduction of municipal waste at source level [8].

In all developing municipalities of Sub-Saharan African countries, efficiency in the management of municipal solid waste is undermined due to lack of awareness about environmental sanitation, lack of respect for the general environment, failure to enforce municipal bylaws and legislation, and failure to utilise modern waste collection, processing and recycling techniques [4, 9, 10]. The study conducted by Bongwe (2017) has found that mining companies and industries operating in the Bojanala Platinum District of the North-West Province must invest much more on the environmental and municipal needs of local communities in order to mitigate the consequences of pollution, environmental degradation and poverty among local communities. The author has highlighted the need to promote community-based awareness campaigns and poverty alleviation programmes [11].

Brownson (2014) has proposed a community-based poverty alleviation programme that could be used by developing municipalities such as Moses Kotane Local Municipality for alleviating poverty and unemployment. The author has proposed a framework in which local municipalities need to attract entrepreneurs into their local communities by creating an enabling environment for investors and entrepreneurs [12]. Based on a community-based study conducted in the Suzhou region of China, Fei, Qu, Wen, Xue and Zhang (2016) have suggested the provision of economic incentives to private waste collectors and recyclers as a means of ensuring cleanliness, conservation and creating employment opportunities for the youth [13].

According to Cilliers, Siebert, Du Toit, Barthel, Mishra, Cornelius and Davoren (2018), local municipalities in all Sub-Saharan African nations can improve their ability to protect ecological systems by actively providing professional garden services to households, businesses and local communities in collaboration with the private sector and entrepreneurs [14]. Nguyen-Trong, Nguyen-Thi-Ngoc, Nguyen-Ngoc and Dinh-Thi-Hai (2017) have shown the benefit of using an integrated municipal solid waste management plan by optimising the transportation of municipal solid waste [15].

Mirdar Harijani, Mansour and Karimi (2017) state that the use of an integrated municipal solid waste management system is essential for ensuring value for money in the provision of essential municipal services [16]. Based on a study conducted in the Moses Kotane Local Municipality, Bongwe (2017) has found that any successful integrated developmental plan of action must include all stakeholders in the local municipality, and that tangible economic incentives must be provided to the private mining sector as a means of funding infrastructural projects adequately. Based on a study conducted in Italy, Ranieri, Ionescu, Fedele, Palmieri, Ranieri and Campanaro (2017) have shown that it is strategically beneficial for resource-constrained local municipalities to provide tangible economic incentives to industry and business as a means of ensuring economic and administrative efficiency as well as service quality

standards that are applicable to municipal solid waste [17].

Ionescu, Rada, Ragazzi, Marculescu, Badea and Apostol (2013) have shown how an integrated municipal solid waste management model can be used for transforming waste into energy and useful products by utilising advanced technological applications. The authors have shown that waste can be transformed into energy by building the capacity for modern transformation of waste [18]. Bernstad, Jansen and Aspegren (2012) have shown the benefits of minimising and sorting waste at source level by promoting health and sanitary education in developing municipalities [10]. Li, He, Fan, Chen and Lu (2017) state that the ability of rural households to minimise and sort waste at source level requires community-based education on proper waste management, motivation and economic incentives [19]. Mearns and Boshoff (2017) state that optimisation of waste management in developing municipalities requires the identification of key indicators of efficiency and the application of performance monitoring and evaluation techniques. The ability to do so is a requirement for assessing efficiency and the degree of compliance with municipal bylaws on waste management [20].

Collaboration and partnership with advanced global waste management institutions is a key strategy that should be exploited as a means of improving efficiency in municipal solid waste management. Plastic waste is a key cause of contamination in Moses Kotane Local Municipality. The task of transforming plastic waste into a usable product requires advanced waste management technology. Denmark is one of the global leaders in advanced municipal solid waste management technologies. Tornaes (2019) and Horodytska, Valdes and Fullana (2018) state that the Government of Denmark supports several development projects on municipal solid waste management in developing nations [21, 22], and that Moses Kotane Local Municipality should consider collaborating with waste management institutions in Denmark with a view to build capacity for transforming plastic waste into usable products.

The aim of study was to construct a framework that could be used for improving overall efficiency in the management of municipal solid waste at the Moses Kotane Municipality. Municipal solid waste produced in Moses Kotane Municipality includes trash or garbage such as wood, product packaging, empty bottles, used tyres and car parts, and cans, garden refuse, furniture, clothing, leftover food, newspapers, wires, grease, appliances, paint, pieces of metal, broken containers, sheet metal, used medicine, and the like. Businesses and individual households generate large volumes of solid and liquid waste on a daily basis. Taxi ranks, bus stations, open flea markets, food outlets, and small businesses located in Mogwase are synonymous with litter, uncontrolled solid and liquid waste, as well as lack of capacity in the efficient management of waste. Massive waste is accumulated during strike action by municipal workers responsible for the removal of waste from households and businesses. The collection, disposal and processing of waste produced by businesses and households is regulated by legislative policies set out and enforced by Moses Kotane Municipality and the South African National Department of Environmental Affairs and Tourism. The use of an integrated municipal solid waste management system has been shown to be essential for improving overall efficiency in municipal waste management in almost all developed nations of the world. In order for an integrated waste management system to perform efficiently, all relevant stakeholders of the waste chain must play a mutually collaborative role in the collection, disposal, processing and management of municipal solid waste.

The study conducted by Mnwana (2015) shows that the mining industry generates large volumes and varieties of municipal solid waste in Moses Kotane Municipality [23]. The author has highlighted the need for maintaining overall cleanliness, the proper management of municipal solid waste and environmental sanitation in the municipality. According to the author, efficiency in the proper management of municipal solid waste is undermined due to lack of awareness about environmental values, limited infrastructural capacity, lack of socioeconomic incentives to private waste collectors, failure to vigorously enforce municipal bylaws, and inability to use an integrated waste management system.

The study conducted by Mohono (2017) in the region has found that the efficiency with which municipal solid waste is being managed and processed at the Moses Kotane Municipality could be enhanced by way of utilising modern waste management techniques, and by promoting active collaboration and partnership with the private sector [24].

The study aims to test the veracity, relevance and potential benefits of the theory proposed by Wang, Chen, Xiong and Wu (2018) in which the authors have shown the benefits of public-private partnerships in municipal development projects [25]. According to the authors, developing communities that lack funds for capital projects and

advanced expertise that are required for the successful implementation of strategic municipal projects should provide tangible economic incentives to the private sector as a means of minimising their degree of dependence on national governments for funding infrastructural projects.

OBJECTIVES OF STUDY

The objective of study was to identify and quantify barriers to efficiency in the management of municipal solid waste in Moses Kotane Municipality. The study has the following specific objectives:

• To assess and evaluate the current level of efficiency in municipal solid waste management in Moses Kotane Municipality; and

• To construct a framework that could be used for enhancing efficiency in the management of municipal solid waste generated by households and businesses that operate in Moses Kotane Municipality.

METHODS AND MATERIALS OF STUDY

The aim of study was to assess and evaluate socio-economic factors that affect efficiency in the management of municipal solid waste at Moses Kotane Municipality in the North-West Province of South Africa. The study was based on data collected from a stratified random sample of size n=471 residents of Moses Kotane Municipality.

Data was collected on a total of 24 socioeconomic variables that are known to affect the ability of local municipalities to ensure efficiency in the management of municipal solid waste by using a pre-tested, validated and standardised questionnaire of study. A combination of quantitative and qualitative methods of data collection and analyses were used in the study. As part of the qualitative aspect of study, individual in-depth interviews were conducted with 14 respondents living and working in the town of Mogwase of Moses Kotane Municipality.

Data was collected from a stratified random sample of size 471 residents of Moses Kotane Municipality by the Pretoria-based research company Leap Specialist Strategic and Planning Solutions (PTY) Ltd (LEAP). The Business Register of Statistics South Africa (2024) was used for making comparison with data collected from the survey [2]. Frequency tables and Pearson's chi-square tests of associations (Denis, 2021) were used for obtaining summary and descriptive estimates [26]. Ordered logit analysis (Hosmer and Lemeshow, 2013) was performed for estimating epidemiological measures of effect such as odds ratios [27]. Confirmatory factor analysis (Rogers, 2024) was performed to perform data reduction [28]. Structural equations modelling (Newsom, 2023) was performed to identify influential predictors of efficiency in municipal solid waste management [29]. A 5-point Likert scale is also used for measuring subjective variables such as perception. Standard goodness-of-fit tests were used for assessing the theoretical reliability of all fitted models.

Table 3 shows estimates obtained from principal components analysis in which the percentage of variance explained by each one of the 3 predictor variables was estimated.

Table 3: Percentage of variance explained by key predictors (n=471)

Predictors of efficiency in municipal solid waste management	Number of retained factors	Percentage of explained variation
Lack of adherence to municipal bylaws	2	78.8%
Inability to enforce municipal bylaws	2	76.1%
Wrong perception about the potential benefits of proper waste management	2	75.2%

According to Rigamonti, Sterpi and Grosso (2016), it is essential for developing municipalities to ensure adequate compliance with municipal bylaws on municipal waste management, the strict enforcement of municipal bylaws on

waste management and the promotion of health and environmental campaigns in order to achieve sustained efficiency in municipal solid waste management [30]. Accordingly, the following three research hypotheses were tested as part of the study:

H1: Sustained efficiency in municipal solid waste management (Y) is significantly undermined by failure to adhere to municipal bylaws on municipal solid waste management (X1)

H2: Sustained efficiency in municipal solid waste management (Y) is significantly undermined by inability to enforce municipal bylaws on municipal solid waste management (X2)

H3: Sustained efficiency in municipal solid waste management (Y) is significantly undermined by wrong perception about the potential benefits of proper waste management (X3)

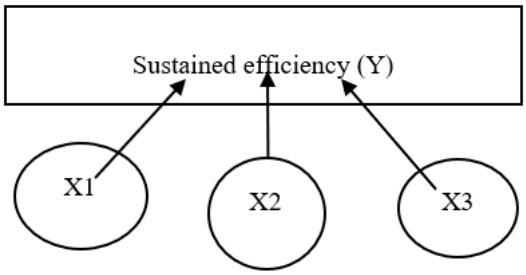

Figure 1: Theoretical framework of study

RESULTS OF DATA ANALYSES

In this section, results obtained from univariate, bivariate and multivariate data analyses shall be presented in a sequential order. These are results obtained from frequency tables, two-by-two crosstab associations, ordered logit analysis, confirmatory factor analysis and structural equations modelling.

Table 4 shows the general characteristics of the 471 respondents of study who took part in the study. It can be seen from the table that 154 of the 471 respondents (33%) were efficient in the management of municipal solid waste by the standards of the Canadian Standards Association (2019), whereas the remaining 317 (67%) were not efficient enough by the same standards.

About 89% of respondents were male, whereas the remaining 11% were female. This shows that the tourism business is dominated by male operators. About 14% of operators had ages of 30 years or less. About 46% of them had ages of 31 to 40 years. About 27% of operators had ages of 41 to 50 years. About 12% of operators had ages of 51 years or more. About 29% of operators had certificates or less as formal academic qualification. About 29% of operators had Diplomas. About 35% of respondents had bachelor's degrees. About 7% of respondents had Honour's degrees or better academic qualifications. About 88% of respondents were actual owners of the businesses they operated, whereas the remaining 12% of respondents were employed managers. About 16% of businesses had been in operation for three years or less at the time of the study. About 69% of businesses were in operation for four to 7 years. About 15% of them were in business operation for more than 7 years at the time of the study.

Table 4: Personal characteristics (n=471)

General characteristics of respondents	Frequency (Percentage)
Efficiency in the management of municipal solid waste	Efficient: 154 (33%) Inefficient: 317 (67%)
Gender of respondents	Male: 89.3% Female: 10.7%
Age category of respondents in years	30 years or less: 14.3% 31 to 40 years: 45.9% 41 to 50 years: 27.4% 51 years or more: 12.5%

Highest level of formal education of respondents	Certificate or less: 28.7% Diploma: 29.2% Bachelor's degree: 35.2% Honour's degree or above: 6.9%
Duration of residence in years	Three or less: 16.0% Four to seven: 68.8% More than seven: 15.1%
Marital status of respondent	Single: 16.2% Married: 53.8% Divorced: 15.1% Widowed: 6.5% Living together: 8.4%

Table 5 shows percentages for basic indicators of the ability of respondents to manage municipal solid waste properly at household level. It can be seen from the table that just above 15% of respondents separated household waste at home on a daily basis. About 13% of respondents minimised waste at source level on a daily basis. About 25% of respondents attended at least one health education session in the past. About 19% of respondents attended at least one sanitary education session in the past. About 59% of respondents were public servants working in various Government Departments. About 19% of respondents were employed by private companies. About 12% of respondents were involved in community-based leaderships at least once in the past. About 74% of respondents had religious backgrounds. About 66% of households had 6 family members or more. About 87% of households had tap water inside their yards. About 71% of households had flush toilets. These figures are in agreement with those reported by Sirovha (2018) in the North-West Province of South Africa.

Table 5: Determinants of ability to manage waste at household level (n=471)

Indicator of ability to manage waste at household level	Frequency (Percentage)
Separation of household waste at home on a daily basis	Yes: 15.2% No: 84.8%
Minimisation of household waste at source level on a daily basis	Yes: 13.5% No: 86.5%
Attendance of at least one health education session in the past	Yes: 24.6% No: 75.4%
Attendance of at least one sanitary education session in the past	Yes: 19.3% No: 80.7%
Employment status of respondent	Government employee: 59.1% Employee of a private company: 18.7% Self-employed: 8.2% Unemployed person: 7.0% Pensioner: 4.1% Person living on a social grant: 1.8% Others: 1.2%
Community leadership in at least one area in the past or present	Yes: 12.3% No: 87.7%
Membership of faith-based institution	Yes: 74.3% No: 25.7%

Family size	5 or fewer: 34.5% 6 or more: 65.5%
Tap water in yard	Yes: 87.1% No: 12.9%
Flush toilet inside home	Yes: 70.8% No: 29.2%

Table 6 shows frequency counts and percentages for the characteristics of dwellings in which respondents live. The table shows that just under 51% of respondents were homeowners. About 44% of respondents lived in traditional dwellings. About 36% of respondents lived in rented flats or rooms. About 6% of respondents lived in blocks of flats or apartments. About 4% of respondents lived in backyard dwellings. About 52% of dwellings had walls made of bricks. About 31% of dwellings had walls made of concrete. The table shows that about 8% of respondents had an estimated average monthly income of R5, 000 or less. About 52% of respondents had an estimated average monthly income of between R10, 001 to R20, 000. These figures are fairly similar to those reported by Bongwe (2017).

Table 6: Home ownership (n=471)

Variable of study	Frequency (Percentage)
Ownership of home	Yes: 50.9% No: 49.1%
Type of dwelling	Traditional dwelling: 44.4% Room or flat let on a property: 36.3% Flat or apartment in a block of flats: 6.4% Dwelling in the backyard: 4.1% Semi-detached house: 5.3% Cluster house in complex: 2.3% Others: 1.2%
Structure of wall of dwelling	Brick: 52.1% Concrete: 30.1% Corrugated iron: 11.1% Wood and mud: 9.4% Others: 2.3%
Estimated average monthly household income in Rand	R5, 000 or less: 8.2% R5, 001 to R10, 000: 19.3% R10, 001 to R20, 000: 52.1% R20, 001 to R50, 000: 14.0% R50, 001 or more: 6.4%

Table 7 shows significant two-by-two crosstab associations obtained from data analyses. The table shows 7 significant two-by-two crosstab associations involving efficiency in the management of municipal solid waste at the household level. At the 1% of significance, significant two-way associations are characterised by large chi-square values and P-values that are lesser than 0.01. The table below shows that all 7 factors are significantly associated with inefficiency in the management of municipal solid waste at the household level.

Table 7: Results from crosstab analyses (n=471)

Factors that undermine efficiency in waste management	Observed chi-squared value	P-value
Failure to adhere to municipal bylaws on municipal solid waste management	102.27	0.0000
Inability to enforce municipal bylaws on municipal solid waste management	94.71	0.0000
Wrong perception about the potential benefits of proper waste management	82.07	0.0000

Low level of formal education	58.68	0.0000
Low level of household income	32.44	0.0000
Large family size	23.39	0.0000
Failure to separate waste at the household level	11.46	0.0000

Data analysis was performed by using confirmatory factor analysis (Kline, 2014) and ordered logit regression analysis (Hosmer and Lemeshow, 2013) in order to identify key predictors of lack of efficiency in the management of municipal solid waste [28, 27]. The two procedures identified similar predictor variables. Table 8 shows odds ratios estimated from ordered logit analysis [27] for 3 influential predictors of efficiency in the management of municipal solid waste.

Table 8: Results from ordered logit analysis (n=471)

Predictor of lack of efficiency	P-value	Odds Ratio	95% C. I.
Failure to adhere to municipal bylaws on municipal solid waste management	0.0000	8.1	(5.1, 11.5)
Inability to enforce municipal bylaws on municipal solid waste management	0.0000	7.4	(4.9, 9.9)
Wrong perception about the potential benefits of proper waste management	0.0000	5.2	(3.9, 7.1)

Each one of the above 3 predictor variables shown above in Table 8 is highly significant at the 0.01 level of significance. The overall percentage of correct classification for the fitted logit model was 81.46%. The P-value from the Hosmer-Lemeshow goodness-of-fit test was 0.1107 > 0.05. As such, the fitted logit model is theoretically reliable enough [27].

Factor analysis (Rogers, 2024) was used for identifying influential predictor variables that influenced efficiency in the management of municipal solid waste at the household level [28]. The results showed that efficiency in the management of municipal household was significantly influenced by 3 predictor variables. These influential predictor variables were failure to adhere to municipal bylaws on municipal solid waste management, inability to enforce municipal bylaws on municipal solid waste management, and wrong perception about the potential benefits of proper waste management. These findings were similar to those obtained from ordered logit analysis [27]. Table 9 shows that the factor analysis model fitted for the data set explains 82.887% of the total variability in the dependent variable of study (efficiency in the management of municipal solid waste). The Eigen values estimated in the model have magnitudes that are greater than 1.

Table 9: Eigen values (n=471)

Extracted factor	Eigen value	Percentage of explained variance	Cumulative percentage of explained variance
Failure to adhere to municipal bylaws on municipal solid waste management	6.2	38.1	38.1
Inability to enforce municipal bylaws on municipal solid waste management	5.9	26.3	64.4
Wrong perception about the potential benefits of proper waste management	4.7	18.5	82.9

Structural Equations Modelling (O'Rourke and Hatcher, 2013) was used for estimating regression coefficients for the top 3 influential predictors of viability [29]. The procedure identified 3 predictor variables. These predictor variables were failure to adhere to municipal bylaws on municipal solid waste management, inability to enforce municipal bylaws on municipal solid waste management, and wrong perception about the potential benefits of proper waste management. In structural equations modelling, linear regression coefficients are estimated. The linear regression coefficients are a function of odds ratios estimated from logit regression analysis. That is,

$$Odds\ Ratio = \exp(\hat{\beta})$$

Table 10: Regression coefficients estimated from structural equations modelling (n=471)

Barriers to efficiency in waste management	$\hat{\beta}$	P-value	95% C. I.
Failure to adhere to municipal bylaws onmunicipal solid waste management	2.1	0.000	(1.6, 2.9)
Inability to enforce municipal bylaws on municipal solid waste management	2.0	0.000	(1.6, 2.7)
Wrong perception about the potential benefits of proper waste management	1.7	0.000	(0.9, 2.2)

Standard diagnostic procedures were used for assessing the degree of reliability of the fitted structural equations model. The diagnostic measures shown in Table 11 below show that the fitted model is theoretically reliable.

Table 11: Diagnostic measures for structural equations model (n=471)

Diagnostic test used for assessment	Estimates obtained from data analysis	Interpretation of results
P-value from the likelihood ratio test used for comparing conceptual model with saturated model	P = 0.000; Observed chi-square value = 113.5 (P-value is smaller than 0.05; the observed chi-square value is large)	The conceptual model differs significantly from the saturated model at the 5% level of significance
P-value from the likelihood ratio test used for comparing baseline model with saturated model	P = 0.000; Observed chi-square value = 40.7 (P-value is smaller than 0.05; the observed chi-square value is large)	The baseline model differs significantly from the saturated model at the 5% level of significance
AIC (Akaike Information Criterion)	26.6 (Small)	The fitted model is fairly similar to the true model
BIC (Bayesian Information Criterion)	24.6 (Small)	The fitted model is fairly similar to the true model
CFI (Comparative Fit Index)	0.9 (Large)	The fitted model is theoretically reliable
TLI (Tucker-Lewis Index)	0.9 (Large)	The fitted model is theoretically reliable

SRMSEA (Error of estimation)	0.02 (SRMSEA value is smaller than 0.05)	The error of estimation of the fitted model is small
CD (Coefficient of Determination)	76.2% (The percentage of explained variation is above 75%)	The fitted model is good in explaining variability in the viability of businesses

DISCUSSION OF RESULTS

The key objective of research was to identify and quantify factors that affect efficiency in the management of municipal solid waste generated by residents and businesses that operate in Moses Kotane Municipality. The study has shown that efficiency in the management of municipal solid waste was significantly influenced by failure to adhere to municipal bylaws on municipal solid waste management, inability to enforce municipal bylaws on municipal solid waste management, and wrong perception about the potential benefits of proper waste management, in a decreasing order of importance. According to the South African National Department of Environmental Affairs (2018), the disposal and combustion of municipal solid waste is conducted by the use of landfills, the conversion of non-recyclable waste materials into useable heat, electricity, or fuel, combustion, and transfer stations. Although the use of such mechanisms is consistent with the municipal bylaw in Moses Kotane Municipality, the mechanisms have been poorly utilised mostly due to lack of infrastructural development and technical skills.

Filatova and Davidson (2017) state that the establishment of community-based poverty alleviation projects in collaboration with the private sector will be mutually beneficial to local communities living in and around Moses Kotane Municipality as well as private sector participants and individual entrepreneurs [31]. Suman, Thys, Mfoukou-Ntsakala, Ali, Ouedraogo, Van den Bossche, Van Huylenbroeck, Berkvens and Speybroeck (2015), the USEPA (2024), and the South African National Department of Environmental Affairs (2024) recommend that emphasis should be placed on the promotion of community-based health awareness campaigns, the maintenance and expansion of infrastructure, and the application of technologies that are helpful for efficient waste management [32, 33, 34].

Li, He, Fan, Chen and Lu (2017) have shown that failure to dispose of municipal waste properly often causes groundwater contamination in developing municipalities [19]. Wagland, Veltre and Longhurst state that refuse disposed of in storm drains often causes blockages and the breeding of mosquitoes and flies [35]. It follows that all businesses operating in Moses Kotane Municipality must be inspected for environmental sanitation and cleanliness regularly with a view to encourage and reward good practice, and to penalise irresponsible behaviour. Municipal bylaws on the collection, disposal and management of waste must be enforced with enough vigour and commitment. Hurlbut and Robert (2012) have shown that good leadership at municipal level is essential for enforcing municipal bylaws on the proper disposal and management of municipal solid waste [36]. Studies conducted by Sirovha (2018) and Jordan and Maharaj (2018) have shown that two of the underlying causes of the failure of local municipalities to provide satisfactory municipal solid waste removal services is lack of modern technological methods of waste management and the failure of local municipalities to use performance monitoring systems [37, 38].

Khale and Worku (2015) have identified predictors of efficiency in municipal solid waste management by conducting a survey in Pretoria and have found that failure to enforce municipal bylaws has the potential for fuelling frustration and poor compliance among businesses that obey municipal guidelines and regulations on waste management [39]. Mathonsi and Sithole (2017) have found that the use of a community based participatory approach in which all relevant stakeholders are involved is quite helpful for bringing about long-lasting change in terms of harmful traditional and cultural practices and wrong attitudes and beliefs [40]. This could be done by encouraging community leaders at Moses Kotane Local Municipality to take the lead on the promotion of awareness campaigns and attracting private sector entrepreneurs to invest in the local economy. Sun, Fujii, Tasaki, Dong and Ohnishi (2018) and Mir, Ghazvinei, Sulaiman, Basri, Saheri, Mahmood, ... & Aghamohammadi (2016) have proposed integrated plans of municipal solid waste management that are based on utilisation of technologically advanced methods of municipal solid waste management, a vigorous enforcement of municipal bylaws and the provision of economic incentives to the private sector [41, 42].

International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 8s, 2025
https://www.theaspd.com/ijes.php

FRAMEWORK OF STUDY

Based on findings obtained from the study, a framework has been proposed for Moses Kotane Municipality with a view to enhance the current degree of efficiency in municipal solid waste management. The framework enables all relevant stakeholders to work together based on clearly defined roles, contribution and expected output.

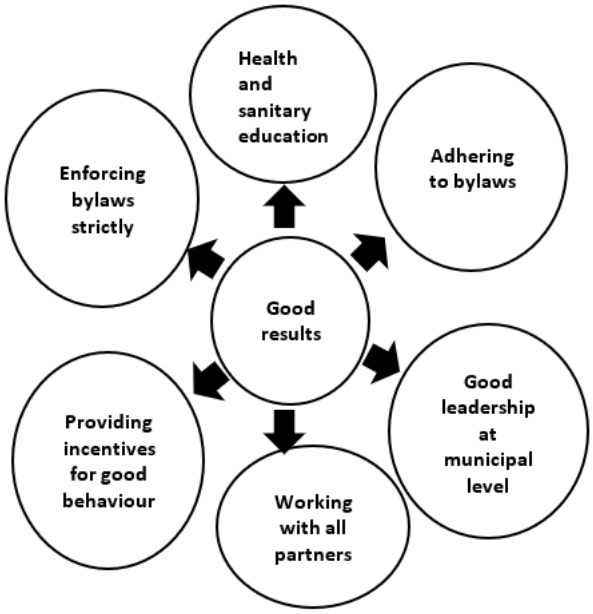

Figure 1: Framework for ensuring efficiency in municipal solid waste management

CONCLUSION

The framework displayed in Figure 1 above could be used for enhancing efficiency in the collection, disposal, processing and recycling of municipal solid waste. The key stakeholders of the framework are Moses Kotane Municipality, businesses and institutions that operate in the area, ratepayers who pay for waste removal services, the Department of Environmental Affairs, the Department of Health, Civil Society, academic and research institutions, and non-governmental organisations.

The study has shown that efficiency in the management of municipal solid waste was undermined by failure to adhere to municipal bylaws on municipal solid waste management, inability to enforce municipal bylaws on municipal solid waste management, and wrong perception about the potential benefits of proper waste management. Based on findings of this particular study, the following recommendations are made to Moses Kotane Municipality in order to improve overall efficiency in the management of solid waste that is generated by residents and businesses operating in the local municipality:

• Moses Kotane Local Municipality must produce and implement an integrated plan for the management of solid waste in collaboration and partnership with the relevant stakeholders in the municipality so that each of the role players in the waste management chain can investment adequately in basic environmental sanitation. Studies conducted by Bernstad, Jansen and Aspegren (2012) and Hurlbut and Robert (2012) have shown that forging strategic partnerships and collaborations between local municipalities and stakeholders are vital for cutting down operational cost in the management of municipal solid waste [10, 36].

• An initial infrastructural investment needs to be made by Moses Kotane Municipality in order to build adequate capacity for commercial composting. This should be done in collaboration with business enterprises so that they can share the financial burden at the initial stage, and benefit from compost-related business opportunities in the long-run. Studies conducted by Khale (2015), Khale and Worku (2015) and Brownson (2014) have shown that it is strategically beneficial for developing municipalities to invest on infrastructural maintenance and expansion as a means of ensuring sustained growth and development in small, micro and medium-sized enterprises that conduct business in Moses Kotane Municipality [43, 39, 12].

• Moses Kotane Municipality must strive to increase awareness about the potential benefits of proper waste collection and disposal by promoting health education on environmental sanitation and techniques that are useful for collecting and sorting waste as has been recommended by Snyman and Vorster (2011) based on a similar study conducted in the City of Tshwane [44].

• Incentives should be provided to businesses that do a good job in terms of the proper collection and disposal of solid waste. Moses Kotane Municipality must support community-based health promotion activities undertaken by non-governmental organisations. Support should also be provided to research initiatives conducted by academic and research institutions in areas that are related to waste management, environmental sanitation, and personal hygiene by funding them partially or fully. The study conducted by Sharma and Chandel (2017) in Mumbai, India has shown that providing economic incentives to the private sector has the potential for creating job opportunities for the unemployed [45].

• Moses Kotane Municipality must improve the conditions of employment of municipal workers responsible for waste collection and disposal. The study conducted by Marivate (2014) has shown the potential benefits of using private waste collectors as a means of ensuring environmental cleanliness and sanitation [46].

• Moses Kotane Local Municipality must provide technical assistance to businesses that do not have their own waste management plans so that such businesses can contribute for overall efficiency in environmental sanitation as has been recommended by Rigamonti, Sterpi and Grosso (2016) based on a similar ecological study [30].

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