

# An Empirical Application of Structural Time based Modelling for the Efficient Management of Municipal Solid Waste

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## **Abstract:**

The aim of study was to explore factors that undermine efficiency in municipal waste management in the Tshwane region of South Africa by assessing and evaluating basic indicators of efficiency in municipal waste management in densely populated urban centers. The ability of businesses to optimally manage waste was measured by using criterion stipulated by Tchobanoglous, Theisen and Vigil (1993) in their structural time-based model. Compliance with municipal bylaws was assessed by using ISO 14032 standards as a benchmark. The study found that about 82% of businesses in the study managed their own waste optimally. Based on regression estimates obtained from ordered probit regression analysis, the management of waste by businesses was undermined by disregard to municipal bylaws by businesses, inability to enforce municipal bylaws, and the management of businesses by outside employees.

**Keywords:** Tshwane municipalities, Waste management, Ordered probit regression.

## **I. INTRODUCTION**

The research work was aimed at exploring the underlying causes of inability to optimally utilize modern technological techniques of waste minimization, recycling, processing, sorting and aggregating in Tshwane municipalities in Gauteng, South Africa. Inability to utilize advanced and integrated techniques of waste minimization and recycling undermine overall environmental sanitation and contribute to pollution and the accumulation of litter in urban centers of Tshwane (Snyman & Vorster, 2011). Failure to enforce municipal bylaws on urban waste, disregard for environmental sanitation, inability to recycle and minimize waste generation is a phenomenon synonymous with local communities and municipalities in and around the Tshwane geographical region (Worku & Muchie, 2018). Municipal workers whose job is to pick up and sort waste are often seen taking strike actions due to poor wages, the absence of work-related incentives and harsh working conditions. Failure to provide sanitary education, breakdown in community based

awareness campaigns, the scarcity of health promotion programmes with focus on environmental sanitation and awareness programmes has led to failure in enhancing the current level of efficiency in waste collection, disposal and processing. Tshwane is home to a large number of migrants from rural areas as well as taxi and bus ranks. Rural people migrate into Tshwane looking for job opportunities and livelihood (Worku & Muchie, 2019).

The other chronic problem of Tshwane is the population explosion that has taken place since the early 1990s. The municipal infrastructure in Tshwane municipalities is adequate only for a population of 1 million or less as this was the population size of Tshwane before 1990. As of 1990, various restrictions on migration into urban areas were lifted as a result of political transformation. In light of this transformation, rural communities steadily flew into urban centers in large numbers. This phenomenon led to congestion and overcrowding in city centers in various sections of Tshwane municipalities. Tshwane is home to over

five thousand small, micro and medium-sized enterprises. Out of this figure, a thousand six hundred and three enterprises are located in overcrowded centers of Tshwane. Nearly two million tons of rubbish is generated annually in Tshwane by business enterprises (Worku & Muchie, 2019).

Ensuring adequate sanitation and cleanliness in all zones of the city is the responsibility of employees of the city who work on sanitation duties. The city depends upon an integrated municipal solid waste management system that links up sanitation services to water, electricity, road maintenance, public health, disaster management, safety and security services, capacity building, rescue and emergency services, financial and general administrative duties. The performance of all employees working on sanitation duties is evaluated on a quarterly basis by line function managers. However, a study conducted by Pooe, Worku and Van Rooyen (2016) has shown that service quality is undermined due to lack of specialized skills and failure to implement the integrated development plan of the City of Tshwane with enough vigor. The integrated development plan allows stakeholders such as residents, ratepayers, researchers and community members to comment on the quality of sanitary services on a regular basis. One of the perceived shortcomings of the City of Tshwane is the apparent inability to enforce bylaws that apply to sanitation to the letter of the law with adequate commitment. The second shortcoming is failure to utilize modern technological techniques of waste management, mostly due to lack of capacity and specialized skills (Maphoroma, 2019).

## II. OBJECTIVE OF STUDY

The aim of study was to determine socioeconomic and systemic factors that influence efficiency and productivity in sanitation and waste services that are provided to inhabitants and local communities in Tshwane municipalities.

## III. METHODS

The survey was conducted by gathering information on waste, hygiene and sanitation from 1, 123 business enterprises in Tshwane municipalities including the central business district of Tshwane. At each business enterprise, assessment was made by using standard indicators of adequate performance in environmental health and sanitation, personal hygiene and waste management. Data was gathered by using a structured questionnaire in which personal experience, views and perceptions held by respondents were measured. Odds ratios from ordered logit regression (Machin, Campbell, Tan and Tan, 2018) and multilevel regression (Austin, 2017) were used for ranking variables affecting efficiency. ISO 14032 standards were used for assessing the degree of compliance of businesses with sanitation benchmarks (Canadian Standards Association, 1999). The ability of businesses to manage waste optimally was measured by using a structural time based composite index developed by Tchobanoglous, Theisen and Vigil (1993).

## IV. RESULTS OF STUDY

Table 1 shows the profile of respondents of the study. About 82% of businesses were capable of managing waste optimally based on criteria stipulated by Tchobanoglous, Theisen and Vigil (1993) in their structural time-based model. The majority of business operators were involved in retail and industrial activities. Sixty-one percent of respondents were in business operation for six years or more. Ninety-four percent of respondents complied with waste-related and sanitation guidelines and regulations issued by the City of Tshwane satisfactorily. Eighty-one percent of respondents practiced waste minimization at source level on a regular basis. Eighty-five percent of businesses were visited by health or sanitation experts on a regular basis. About 49% of businesses produced between 1, 001 and 2, 000 kg of waste per week in the course of conducting business operations.

**Table 1: Profiles of business enterprises in the study (n=1123)**

Characteristic	Percentages
The ability of business to manage waste optimally based on criteria stipulated by Tchobanoglous, Theisen and Vigil (1993)	Yes: 82% No: 18%
Economic sector of business enterprise	Agricultural enterprises: 2% Retail or commercial: 70% Building and construction: 5% Industrial productions: 10% Institutional agencies: 3% Municipal service providers: 7% Manufacturing enterprises: 3%
Number of years of business operation	Less than a year: 6% 1 to 2 years: 5% 3 to 5 years: 28% 6 years or more: 61%
Utilisation of private waste collectors on a regular basis	Yes: 22% No: 78%
Sorting in-house waste at source level on a regular basis	Yes: 75% No: 25%
Satisfactory compliance with waste regulations issued to businesses by the City of Tshwane	Yes: 94% No: 6%
Perception of business operator on the importance of health, sanitation and hygiene messages	Highly positive: 4% Positive: 55% As expected: 36% Negative: 4% Highly negative: 1%
The practice of waste minimisation at source level on a regular basis	Yes: 81% No: 19%
Volume of waste produced by business per week	Less than or equal to 1, 000 kg: 22% 1, 001 to 2, 000 kg: 49% 2, 001 to 5, 000 kg: 25% 5, 001 to 10, 000 kg: 3% 10, 0001 kg or more: 1%
Visit to business premises by sanitation inspectors working for the City of Tshwane on a regular basis	Yes: 85% No: 15%

Table 2 provides regression estimates obtained from ordered probit regression analysis. The estimates show that the management of waste by businesses was undermined by disregard to municipal bylaws by businesses, inability to enforce municipal bylaws, and the management of businesses by outside employees.

**Table 2: Regression coefficients estimated from ordered probit regression (n=1123)**

Variable	Regression coefficient	P-value	95% C.I.
Disregard to municipal bylaws	2.22	0.000	(1.86, 2.53)
Inability to enforce municipal bylaws	2.18	0.000	(0.78, 2.43)
Management of businesses with outside employees	1.15	0.000	(0.38, 1.77)

Multilevel analysis (Austin, 2017) was used for assessing the extent to which efficiency in waste management varied by suburb of Tshwane and economic sector of business. The results showed that about suburbs were responsible for about 23% of the total variability in efficiency. The results showed that businesses in Pretoria East were relatively more efficient in comparison with businesses in other suburbs of Pretoria. The results also showed that type of business operation was responsible for about 19% of the total variability in efficiency. Retail businesses were least efficient in waste management in comparison with other types of businesses.

## V. DISCUSSION OF RESULTS

The study has found that about 82% of businesses were efficient enough in waste management by benchmarks defined by Tchobanoglous, Theisen and Vigil (1993) as well as ISO 14032 standards defined by the Canadian Standards Association (1999). Secondly, results obtained from ordered probit regression analysis have shown that the management of waste by businesses was undermined by disregard to municipal bylaws by businesses, inability to enforce municipal bylaws, and the management of businesses by outside employees. Thirdly, the study has found that efficiency in waste management varies significantly by suburb and type of business. Businesses operating in Pretoria East were found to be relatively more efficient in comparison with businesses in other suburbs of Pretoria with regards to waste management. Retail businesses were found to be least efficient in comparison with other types of business.

The City of Tshwane (2019) needs to implement the integrated development plan for ensuring satisfactory compliance with waste management and sanitation guidelines and regulations that are applicable to businesses operating in Tshwane municipalities. This suggestion is in line with the recommendation made by the South African Auditor-General (2019) to the City of Tshwane. Health and sanitary education should be provided to business enterprises operating in the various suburbs of Tshwane in order to improve the degree of awareness of business operators about the importance of ensuring adequate compliance with municipal bylaws on environmental sanitation, cleanliness and responsible business management.

According to Statistics South Africa (2017), Tshwane municipalities are overwhelmed by a massive influx of migrants who come to Tshwane in search of livelihood, employment opportunities and improved municipal service delivery. In almost all Tshwane municipalities, underground water pipes and sewerage lines need to be repaired, replaced and maintained in order to minimise the loss of water and to enhance the current level of municipal service delivery (Khale, 2015). The research work conducted in Tshwane municipalities by Maphoroma (2019) has found that there is a dire need for the provision of skills based training opportunities to employees of Tshwane municipalities who are responsible for providing essential services to residents and ratepayers. Studies conducted by Khale (2015) and Maphoroma (2019) have shown that there is a priority need in Tshwane municipalities to maintain and expand the infrastructure required for



efficient service delivery including the management of waste produced by businesses operating in Tshwane municipalities.

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