



## Research Article

# The Experience of Waste Management in Wad Medani, the Capital of Gezira State Sudan Between Success and Failure

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## Abstract

This paper aimed to shed light on the experiences that Wad Medani city, Sudan, went through in the waste transfer project during the first quarter of the current century. The paper evaluates four successive waste management models implemented in the studied area between 2000 and 2025, ranging from local authority control to private sector and corporate management. Criteria such as transport efficiency, cost per ton, and community interaction, management efficiency...etc. were utilized to compare these periods. Performance during these experiments varied between success and failure. These four successive experiments are: the private sector experiment (the Turkish company), Wad Medani City Development and Elegance Corporation, Gezira State Cleaning and Development Authority, and Greater Wad Medani Locality experiment before and after these three experiments. The study concludes that the corporate model was the most effective, whereas recent conflict and lack of budget have led to significant environmental deterioration, the waste transportation experience by corporations is the best, with the percentage of waste transported by the Wad Medani City Development and Elegance Corporation and the Gezira State Cleaning and Development Authority reaching 98% and 67.8%. The paper recommended that, establishment of a special authority for waste management in Wad Medani, along with intensifying community awareness programs, allocating a special site for a waste dump and registering it officially in the land registry, and diversifying the transport fleet are necessary to have an ideal model. It also recommended that it's prefer to establish a special structure to accommodate male and female cleaning workers in permanent positions.

## Keywords

Waste Management, Local Authority, Private Sector, Corporation

## 1. Introduction

Waste management or waste disposal includes the processes and actions required to manage waste from its inception to its final disposal [1], is necessary to be studied in Wad Medani, city, southeast-central Sudan, which has been subjected to the outbreak of violent fighting between the Sudanese people and rebels, forcing thousands of its residents to flee to neighboring

areas to escape the conflict. [2]

Wad Medani lies on the west bank of the Blue Nile 85 miles (136 km) southeast of Khartoum, at an elevation of 1,348 feet (411 meters). [3]

The rebels replaced the residents, seizing control of the city,

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Sudan's second-largest, by December 16, 2023. They continued to occupy it until mid-January 2025, when the state was liberated from the clutches of the rebellion.

During the course of a year and a month, the rebellious and destructive Rapid Support Forces militiamen took lives, violated honor, looted public and private property, and extensively destroyed infrastructure and service facilities.

They left behind an environment congested with waste, hazardous pollutants, pests, and disease vectors to an unimaginable degree.

This calls for concerted efforts to overcome this environ-

mental disaster, especially since the commendable efforts exerted by the Greater Wad Medani local government are being hindered by weak capabilities and a lack of the necessary budgets to address this horrific environmental deterioration.

Furthermore, previous experiences in waste management in the city over the past quarter century, ranging from success to failure, should be considered, their positives recognized, and their negatives addressed.

This paper, titled "Waste Management Experiences in Wad Medani: Between Success and Failure," aims to contribute to this endeavor.



*Figure 1. Environmental situation of Wad Medani City immediately after the war [7].*



*Figure 2. Governmental and nongovernmental organizations in Wad Medani Cy warning immediately after the war.*

## 2. Literature Review

### 2.1. Definitions

#### 2.1.1. Hygiene

Hygiene is the science of maintaining health, encompassing all aspects that affect the physical and mental well-being of humans. From a personal perspective, it includes the examination and inspection of food, water, other beverages, clothing, work, sleep, exercise, personal hygiene, and mental health. From a public perspective, it deals with soil, climate, materials, waste disposal, medical care, and disease prevention. Together,

these constitute the general concept that complements the concept of environmental management, at the forefront of which is waste management.

#### 2.1.2. Wastes, Garbage

This term is commonly used for waste produced by human activities, including all types of garbage specially plastics which represents the biggest part of wastes in the world. In 2019, 6.1 million tonnes (Mt) of plastic waste leaked into aquatic environments and 1.7 Mt flowed into oceans. There is now an estimated 30 Mt of plastic waste in seas and oceans, and a further 109 Mt has accumulated in rivers. The build-up of plastics in rivers implies that leakage into the ocean will continue for decades to come, even if mismanaged plastic

waste could be significantly reduced. [11]

### 2.1.3. Waste Management

Waste management is defined as the handling of discarded materials with the aim of eliminating their potential hazards. Waste can be converted into useful products, for example, through recycling, composting, or landfilling. Waste management could be also defined as the process of monitoring, collecting, transporting, treating, recycling, and disposing of or reusing discarded materials.

Countries undertake this process to mitigate the negative impacts of waste on the environment, health, and overall appearance.

### 2.1.4. Waste Per Capita

Waste per capita is the amount of waste generated by an average person, calculated as total waste divided by population. Globally, the average is around 0.74 kg per person per day, but this varies significantly by income level, with high-income countries generating much more. For example, in the U.S., the average is 951 kg per year, while the EU average (excluding major mineral waste) was 1.8 tons in 2022.

Globally, the average per capita production in urban areas is estimated at 352 kg per year, equivalent to approximately 1 kg per person per day.

### 2.1.5. Landfill

One solution to dealing with waste is to put it into landfill sites. However, landfill produces around 5 per cent of the world's greenhouse gas emissions. It is estimated that 1.6 billion tonnes of carbon dioxide equivalent (CO<sub>2</sub>e) such as methane and landfill gases were generated in 2016. In the same year, the world generated 242 million tonnes of plastic waste. This means that landfill causes BIG problems for our environment.

### 2.1.6. Zero Waste

A Zero waste approach is a key of sustainable production and consumption. [5]. The term means conservation of all re-

sources by means of responsible production, consumption, re-use, and recovery of products, packaging, and materials without burning and with no discharges to land, water, or air that threaten the environment or human health. [11].

### 2.1.7. Environmental Awareness

Environmental awareness is having an understanding of the environment, the impacts of human behaviors on it, and the importance of its protection. [14, 16].

### 2.1.8. Environmental Protection

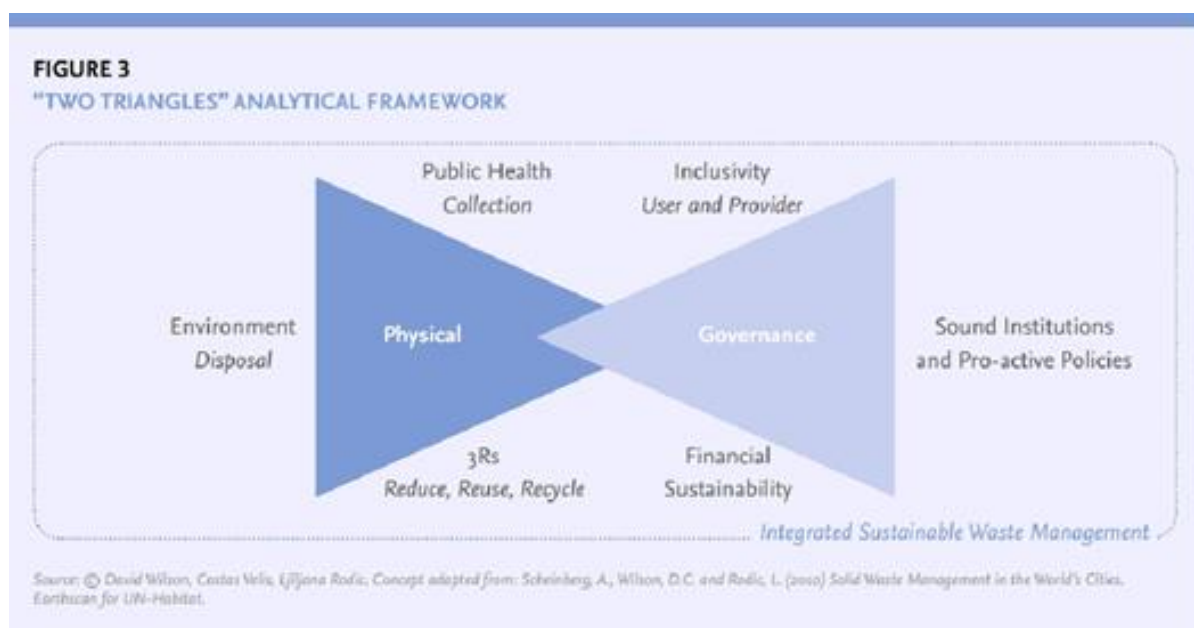
Proper waste management reduces pollution of air, water, and soil. It helps in curbing greenhouse gas emissions, especially methane from landfills, and minimizes the impact of hazardous substances [8].

## 2.2. Waste Management: Goals

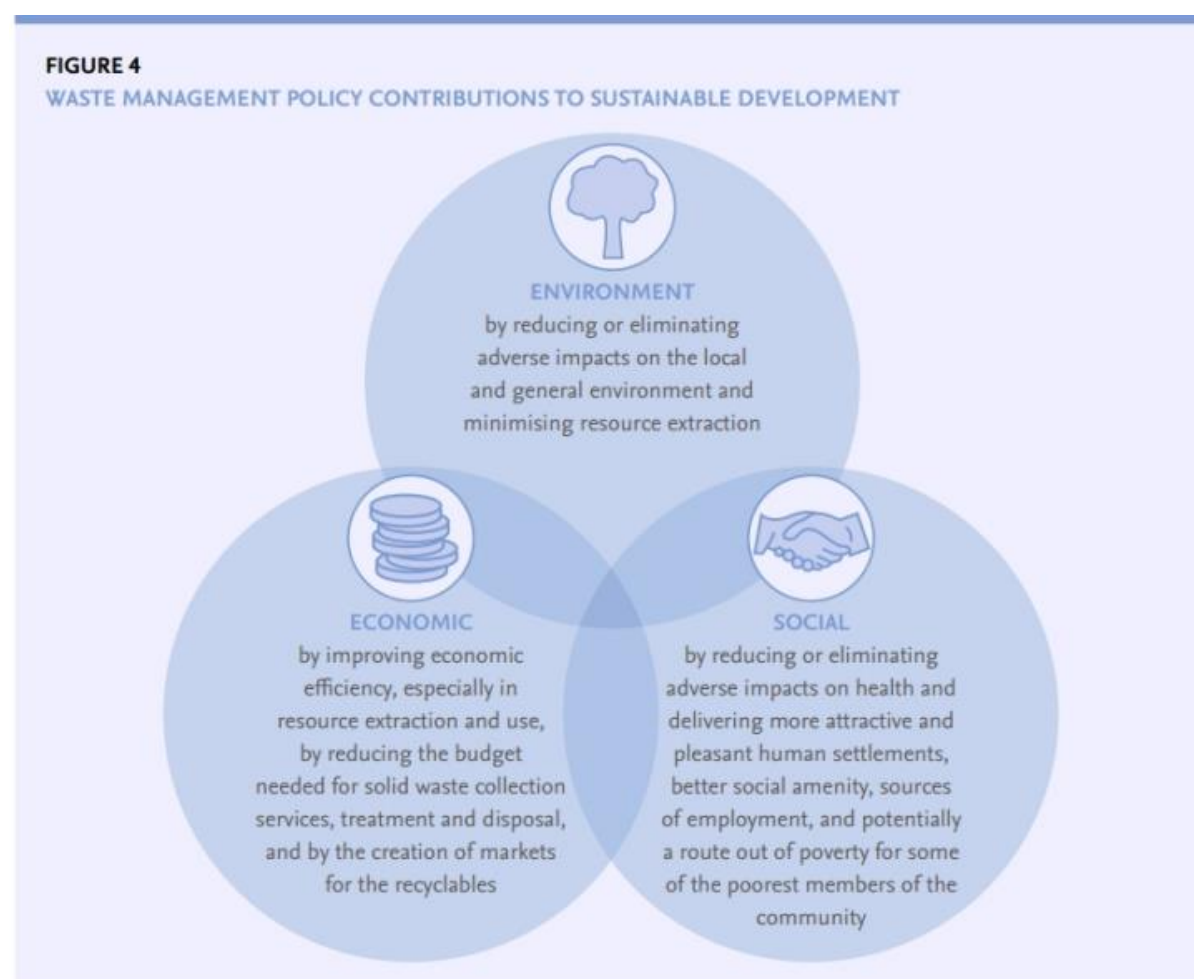
- 1) The primary goal of waste management is to protect individuals and the environment from the potentially harmful effects of waste. Some materials can pose a health threat if not handled properly.
- 2) Other goals of waste management are as follows:
  - a) Creating a better environment, as waste disposal units indirectly contribute to people's well-being by helping them eliminate diseases resulting from the random accumulation of waste.
  - b) Conserving energy, as recycling some types of waste helps us reduce the use of various energy sources in implementing other types of waste disposal methods.
  - c) Creating job opportunities, as the recycling industry creates numerous job opportunities to complete the industrial process, with many people adopting this environmentally friendly practice. i.e. Sustainable Solid Waste Management: A Systems Engineering Approach [9]
  - d) Following as possible the mandate of IETC, as agreed in Decision 16/34 of UNEP Governing Council, is the transfer of environmentally sound technologies (EST) to developing countries and countries with economies in transition. [12]



Figure 3. A diagram represents the processes of Waste Management.



*Figure 4. A diagram represents the two triangles analytical framework.*



*Figure 5. A diagram represents how waste management policy contribute sustainable development [10].*



**Figure 6.** A diagram represents environmental awareness according to Dreamflower [13, 15].

### 3. Materials and Methods

Since 1999, the World Health Organization (WHO) handbook Safe management of waste from health-care activities (commonly known as "the Blue Book") has been the definitive information source on how to deal with these wastes, particularly in low and middle income countries. [6]

Waste management effectiveness could be evaluated according to the following criteria:

- 1) Quantity of waste transported and its percentage of the total waste in the area
- 2) Transportation mechanism (efficiency, speed, discipline, comprehensiveness, environmental impact)
- 3) Program sustainability and management efficiency and discipline
- 4) Community interaction (awareness, conviction, payment of fees)
- 5) Environment and general appearance as a result of program effectiveness
- 6) Public health (reduced disease rates)
- 7) Cost per ton transported (SDG per ton or USD per ton)
- 8) Budget availability

## 4. Results and Discussions

### 4.1. Wad Medani City

Wad Medani currently covers an area of 65 square kilometers (Northwestern Medani and the popular market - Central Wad Medani - East Wad Medani - the central market). It includes a number of important institutions such as the Ministry of Irrigation, the Agricultural Research Authority, Gezira Scheme, and University of Gezira. It also includes a number of factories and markets (the large market, the small market, the popular market, the central market, and the neighborhood markets). Wad Medani city is a part of Greater Wad Medani Locality, one of the eight localities in Gezira State.



**Figure 7.** The main feature in Wad Medani City: Qubat AlSunnī.



**Figure 8.** Wad Medani Location Map – Gezira State – Sudan.

## 4.2. Estimating the Total Weight of Waste in Wad Medani

**Table 1.** Shows total weight of waste in Wad Medani at different periods.

| Daily waste weight in tons | Population (1000 habitants) | Year |
|----------------------------|-----------------------------|------|
| 220                        | 368                         | 2008 |
| 228                        | 380                         | 2011 |
| 256                        | 427                         | 2016 |
| 280                        | 467                         | 2020 |
| 316                        | 525                         | 2025 |

Globally, the average per capita production in urban areas is estimated at 352 kg per year, equivalent to approximately 1 kg per person per day. This includes commercial, industrial, and agricultural activities. This rate is directly proportional to the degree of urbanization of the area. Therefore, in Sudanese cities, it is estimated at approximately 0.65 kg per person per

day.

Municipal solid waste generation is predicted to grow from 2.1 billion tons in 2023 to 3.8 billion tonnes by 2050. In 2020, the global direct cost of waste management was an estimated USD 252 billion. [4]

## 4.3. Stages of Waste Management in Wad Medani During the Period (2000-2025)

**Table 2.** Shows waste management stages in Wad Medani.

| No. | Responsible party                                                                              | Period               | Stage        |
|-----|------------------------------------------------------------------------------------------------|----------------------|--------------|
| 1   | The experience of transporting waste by the Locality                                           | 2005 – 2000          | First stage  |
| 2   | The experience of transporting waste by the Turkish company Tamika Kamin Tamzlak (TKTC)        | 2010 – 2006          | Second stage |
| 3   | Waste transport experiment by the Wad Medani City Development and Elegancy Corporation (WMDEC) | 2015 – 2011          | Third stage  |
| 4   | Waste transport experiment by the Gezira State Cleaning and Development Authority (GSCDA)      | 2020 – 2016          | Fourth stage |
| 5   | Waste transport experiment Greater Wad Medani Locality (GWML)                                  | 2020 still continued | Fifth stage  |

### 4.3.1. The First Phase 2000-2005

The experience of transporting waste by local authorities. as shown in Table 3.

The total waste production during this period was less than 239 tons per day.

**Table 3.** Shows performance of first stage in Wad Medani city.

| No. | Criteria                                                                                          | Performance                       | Evaluation |
|-----|---------------------------------------------------------------------------------------------------|-----------------------------------|------------|
| 1   | Quantity of waste transported and its percentage of the total waste in the area                   | 10÷239                            | %5         |
| 2   | Transportation mechanism (efficiency, speed, discipline, comprehensiveness, environmental impact) | 3 – 4 old trucks                  | %4         |
| 3   | Program sustainability and management efficiency and discipline                                   | There was no separated department | 0          |

| No. | Criteria                                                                | Performance         | Evaluation |
|-----|-------------------------------------------------------------------------|---------------------|------------|
| 4   | Community interaction (awareness, conviction, payment of fees)          | Weak                | Weak       |
| 5   | Environment and general appearance as a result of program effectiveness | Bad                 | Bad        |
| 6   | Public health (reduced disease rates)                                   | Malaria and typhoid | Bad        |
| 7   | Cost per ton transported (SDG per ton)                                  | Weak                | Weak       |
| 8   | Budget availability                                                     | Weak                | Weak       |

Work during that period was traditional, with intermediate dumps (kush) spread throughout all neighborhoods, and their removal times spaced out until they piled up and emitted foul odors. They were often burned by citizens or local authorities.

Waste transport experiment by the Turkish company Tamika Kamin Tazlak.

Total waste production during this period was 239 tons.

#### 4.3.2. Phase II 2006-2010

*Table 4. Shows performance of second stage in Wad Medani city.*

| No. | Criteria                                                                                          | Performance Per day           | Evaluation     |
|-----|---------------------------------------------------------------------------------------------------|-------------------------------|----------------|
| 1   | Quantity of waste transported and its percentage of the total waste in the area                   | 100 ton                       | %42            |
| 2   | Transportation mechanism (efficiency, speed, discipline, comprehensiveness, environmental impact) | Low capacities compactors     | %40            |
| 3   | Program sustainability and management efficiency and discipline                                   | There was a separated dept.   | %50            |
| 4   | Community interaction (awareness, conviction, payment of fees)                                    | Fees included in water tariff | Weak           |
| 5   | Environment and general appearance as a result of program effectiveness                           | Medium                        | Medium         |
| 6   | Public health (reduced disease rates)                                                             | Medium                        | Medium         |
| 7   | Cost per ton transported (SDG per ton)                                                            | 6000 SDG /Ton                 | Highly costive |
| 8   | Budget availability                                                                               | incurring heavy debts         | Weak           |

This is the only time the private sector has participated in a waste disposal project, not only as a participant but also as a full responsibility. However, the profit objective overshadowed the company's performance, and the contract ended with major legal problems that remained unresolved, and with the state incurring heavy debts that took some time to repay.

#### 4.3.3. Phase III 2011-2015

Waste Transport Experiment by Wad Medani City Development and Elegance Corporation.

Total waste production during this period was 254 tons.

*Table 5. Shows performance of third stage in Wad Medani city.*

| No. | Criteria                                                                                          | Performance               | Evaluation                  |
|-----|---------------------------------------------------------------------------------------------------|---------------------------|-----------------------------|
| 1   | Quantity of waste transported and its percentage of the total waste in the area                   | 250 ton                   | %98                         |
| 2   | Transportation mechanism (efficiency, speed, discipline, comprehensiveness, environmental impact) | 40 kantars + 3 compactors | Excellent and comprehensive |

| No. | Criteria                                                                | Performance                                                                       | Evaluation                |
|-----|-------------------------------------------------------------------------|-----------------------------------------------------------------------------------|---------------------------|
| 3   | Program sustainability and management efficiency and discipline         | Board of Directors + General Administration + Executive manager + Technical Staff | Disciplined and efficient |
| 4   | Community interaction (awareness, conviction, payment of fees)          | Good                                                                              | Good                      |
| 5   | Environment and general appearance as a result of program effectiveness | Excellent                                                                         | Excellent                 |
| 6   | Public health (reduced disease rates)                                   | Good                                                                              | Good                      |
| 7   | Cost per ton transported (SDG per ton)                                  | 1200 SDG TON                                                                      | SUITABLE                  |
| 8   | Budget availability                                                     | Available                                                                         | Available                 |

The work during that period was disciplined and comprehensive, as the phenomenon of intermediate landfills (kush) disappeared from all neighborhoods, private sector offices participated extensively, and women participated for the first time. The city won the Cleanest City Award more than once.

#### 4.3.4. Phase IV 2016-2020

Waste Transport Experiment by Gezira State Cleaning and Development Authority.

Total waste production during this period was 295 tons.

*Table 6. Shows performance of fourth stage in Wad Medani city.*

| No. | Criteria                                                                                          | Performance                  | Evaluation                                                          |
|-----|---------------------------------------------------------------------------------------------------|------------------------------|---------------------------------------------------------------------|
| 1   | Quantity of waste transported and its percentage of the total waste in the area                   | %67.8                        | 200 ton                                                             |
| 2   | Transportation mechanism (efficiency, speed, discipline, comprehensiveness, environmental impact) | Not including the whole city | Limited capacity - frequently breaks down - only 1-2 floors per day |
| 3   | Program sustainability and management efficiency and discipline                                   | Disciplined                  | Disciplined                                                         |
| 4   | Community interaction (awareness, conviction, payment of fees)                                    | Good                         | Good                                                                |
| 5   | Environment and general appearance as a result of program effectiveness                           | Good                         | Good                                                                |
| 6   | Public health (reduced disease rates)                                                             | Good                         | Good                                                                |
| 7   | Cost per ton transported (SDG per ton)                                                            | Costive                      | 4000 SDG per ton                                                    |
| 8   | Budget availability                                                                               |                              | Available                                                           |

During this period, the Port Sudan copy-paste experiment was transferred, and 1-ton trailers pulled by tractors were brought in. The experiment succeeded in cleaning the market, but the neighborhoods were once again plagued with intermediate dumpsters due to irregularity, the slowness of the transporter, and its inability to enter narrow streets.

#### 4.3.5. Current Stage from 2020 Till Now

Total waste production during this period was 330 tons + the war remains.

*Table 7. Shows performance of the current stage in Wad Medani city.*

| No. | Criteria                                                                        | Performance                                                              | Evaluation    |
|-----|---------------------------------------------------------------------------------|--------------------------------------------------------------------------|---------------|
| 1   | Quantity of waste transported and its percentage of the total waste in the area | Compressors x 7 tons (18 m <sup>3</sup> ) x 2 floors (56 tons + efforts) | Less than 30% |

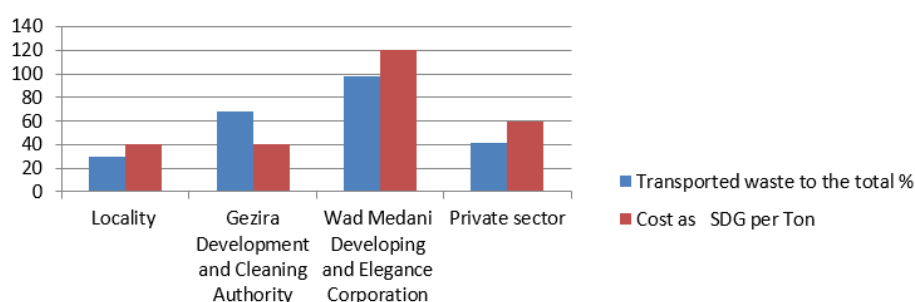
| No. | Criteria                                                                                          | Performance                     | Evaluation                |
|-----|---------------------------------------------------------------------------------------------------|---------------------------------|---------------------------|
| 2   | Transportation mechanism (efficiency, speed, discipline, comprehensiveness, environmental impact) | 7 compressors 2 floors          | Good - not comprehensive  |
| 3   | Program sustainability and management efficiency and discipline                                   | Effective and disciplined       | Effective and disciplined |
| 4   | Community interaction (awareness, conviction, payment of fees)                                    | Very good                       | Very good                 |
| 5   | Environment and general appearance as a result of program effectiveness                           | Fevers, flies mosquitos ... etc | Bad                       |
| 6   | Public health (reduced disease rates)                                                             | Fevers, flies mosquitos ... etc | Bad                       |
| 7   | Cost per ton transported (SDG per ton)                                                            | Unknown                         | But High                  |
| 8   | Budget availability                                                                               | Partially available             | Not available             |

The city's environmental situation has deteriorated to a dangerous degree, with garbage spreading uncontrollably and being dumped anywhere. There are no designated places for waste disposal, and only four compactor trucks are operating in this program.

#### 4.4. Comparisons

**Table 8.** The comparison between the four stages of waste management in Wad Medani city.

| The Experiment                   | GWML the Locality | GSDCA: Gezira Development and Cleaning Authority | WMDEC: Wad Medani Developing and Elegance Corporation | TKTC: Tamika Kamin Tamzrak Co. |
|----------------------------------|-------------------|--------------------------------------------------|-------------------------------------------------------|--------------------------------|
| Transported waste to the total % | 30                | 67, 8                                            | 98                                                    | 42                             |
| Cost as SDG per Ton              | 4000              | 4000                                             | 1200                                                  | 6000                           |



**Figure 9.** A comparison between the four experiments of waste transportation in the percentage of transported waste to the total and the cost per ton for each.

#### 4.5. Wad Medani Development and Elegance Corp. Experience: Pros and Cons

##### 4.5.1. Positives

- 1) Increased waste transfer rate to 250 tons per day, instead of 100 tons.
- 2) Reduced project cost to SDG 300,000 per month, down

- from SDG 600,000 per month in the previous pilot and SDG 800,000 per month in the subsequent pilot.
- 3) Comprehensive cleaning program for all neighborhoods and a consistent schedule.
- 4) Using the small private sector (dumpers), which has stimulated the market economy and reduced vehicle maintenance costs.
- 5) Involving women in a first-of-its-kind pilot.
- 6) Provided the necessary budgets, which has prevented the

project from being halted.

- 7) Full coordination with the Petroleum Administration to secure the required daily fuel quota.

#### 4.5.2. Negatives

- 1) Resistance to the formation of the authority and insistence on placing obstacles in its way.
- 2) Lack of permanent employment for waste workers, who are only employed in temporary positions.
- 3) Overlapping jurisdictions between the authority and some state institutions.
- 4) The condition of the landfill and the inability to implement its vision.

## 5. Conclusion and Recommendations

### 5.1. Conclusion

The paper aimed to shed light on the experiences that Wad Medani city went through in the waste transfer project during the first quarter of the current century (2000-2025), its positives and negatives, and the comparison between them.

The paper concluded that the city had gone through four successive experiments: the private sector experiment (the Turkish company), the Wad Medani Development and Elegance Corporation, the Gezira State Cleaning and Development Authority, and the waste management experiment by the local authority before and after these three experiments. Performance varied between success and failure during these experiments.

The paper adopted unified criteria to evaluate the performance of each of these experiments, including: ratio of transported waste to total product, conveyor efficiency, comprehensiveness of the experiment, project management efficiency, community interaction, budget availability and cost per ton.

The paper concluded that the waste transportation experience by agencies is the best, with the percentage of waste transported by the Wad Medani City Development and Elegance Corporation WMDEC and the Gezira State Cleaning and Development Authority GSDCA reaching 98% and 67.8%, respectively. However, the transportation experience by the locality is the worst due to the lack of budgets.

As for the private sector TKTC, the percentage of transfers through it reached only 42%, and the reason is attributed to the fact that the profit goal overshadowed the company's performance, and the contract ended with major legal problems that remained pending and high debts on the shoulders of the state, the repayment of which took a period of time.

### 5.2. Recommendations

- 1) Establish a dedicated waste management state corporation in Wad Medani.

- 2) Intensify community awareness programs.
- 3) Allocate a dedicated site for a landfill and officially register it in the land registry.
- 4) Diversify the transportation fleet, including compactor trucks, dump trucks, and small tuk-tuks capable of navigating narrow streets.
- 5) Activate the waste transportation program (house-to-house).
- 6) combat the phenomenon of intermediate landfills.
- 7) Improving waste management to include all stages and processes, from monitoring, collection, transportation, treatment, recycling, disposal, or reuse.
- 8) Establishing a dedicated structure to accommodate male and female sanitation workers in permanent positions.
- 9) Preparing a specific schedule for neighborhoods, two days a week per each, with commitment and discipline in its implementation and Intensifying cleaning in markets.

## Abbreviations

|       |                                                |
|-------|------------------------------------------------|
| GWML  | Greater Wad Medani Locality                    |
| GSDCA | Gezira Development and Cleaning Authority      |
| WMDEC | Wad Medani Developing and Elegance Corporation |
| TKTC  | Tamika Kamin Tamzlak Co                        |
| 3 Rs  | (Reduce, Reuse and Recycle)                    |
| UNEP  | United Nations Environment Program             |
| IPCC  | Intergovernmental Panel on Climate Change      |
| EST   | Environmentally Sound Technologies             |
| IETC  | International Environment Technologies Council |

## Conflicts of Interest

The authors declare no conflicts of interest.

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