Optimal Design of Sustainable Municipal Solid Waste Management Framework Multi-criteria: Environmental and Socio-economic Analysis Using LCA, in KSA

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Introduction

Municipal Solid Waste (MSW) management is currently receiving attention world-wide. The Saudi Arabian government and decision-makers are increasingly concerned about waste management and practices in the country. As a result, a dedicated center for managing waste was established, the National Centre for Waste Management (MWAN), in 2019.

The Saudi authorities consider municipal solid waste management a serious matter, due to the negative impact they have both the environment and economy, in addition to the current waste management practices in Saudi Arabia (e.g., simple dumping in landfill) that are primitive and associated with social and human health problems. Such negative impact could be avoided, or at least, reduced by using the waste into energy (WtE) approaches. Shifting to the approaches that focus on resource recovery can not only be beneficial to the environment but also valuable to the economy in terms of energy and value-added products. Saudi Arabia faces a big challenge to reduce and treat the MSW.

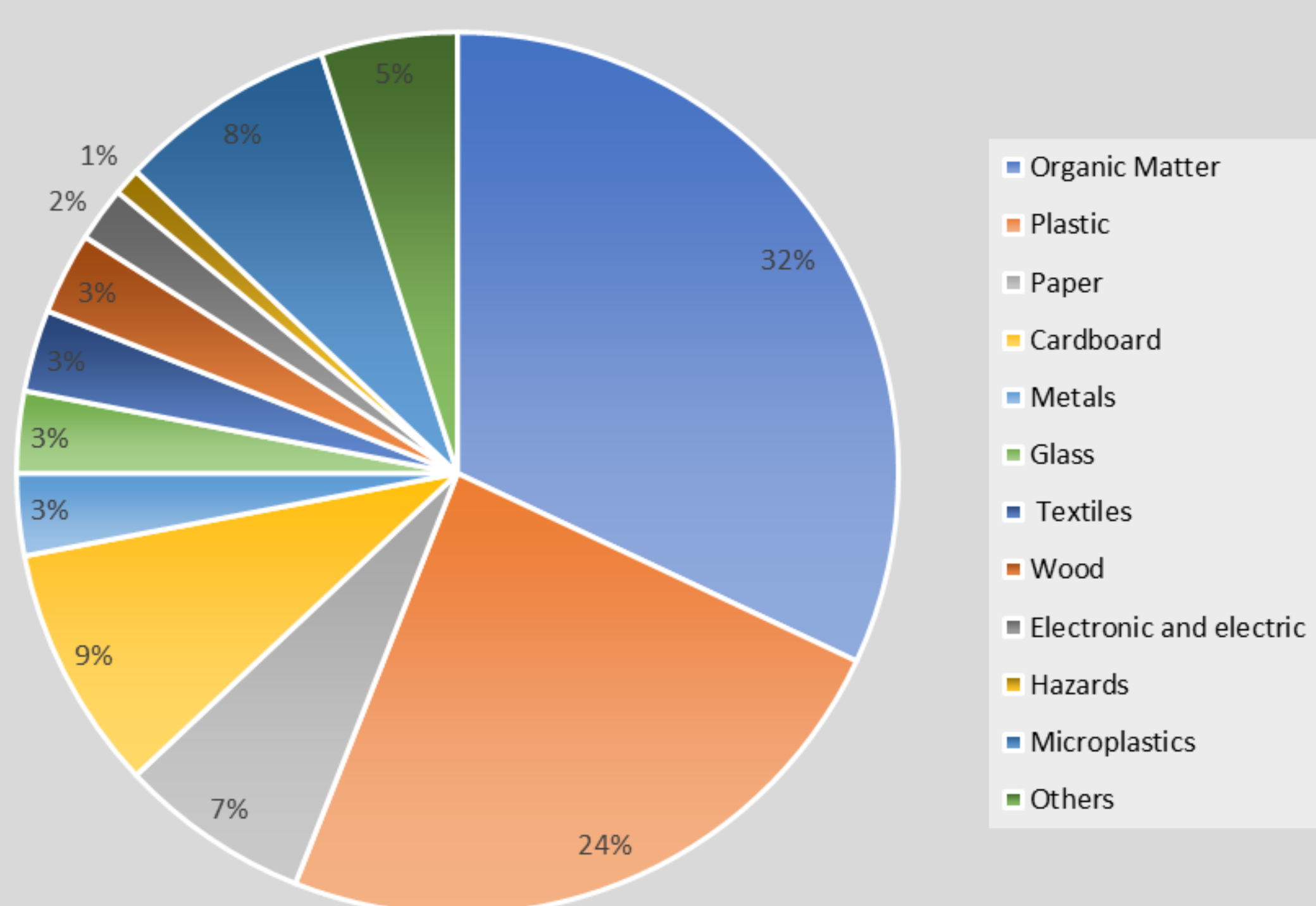2020 Total MSW generated by material before recycling

Figure 1: Breakdown of municipal solid waste generated in the Riyadh, Saudi Arabia in 2020
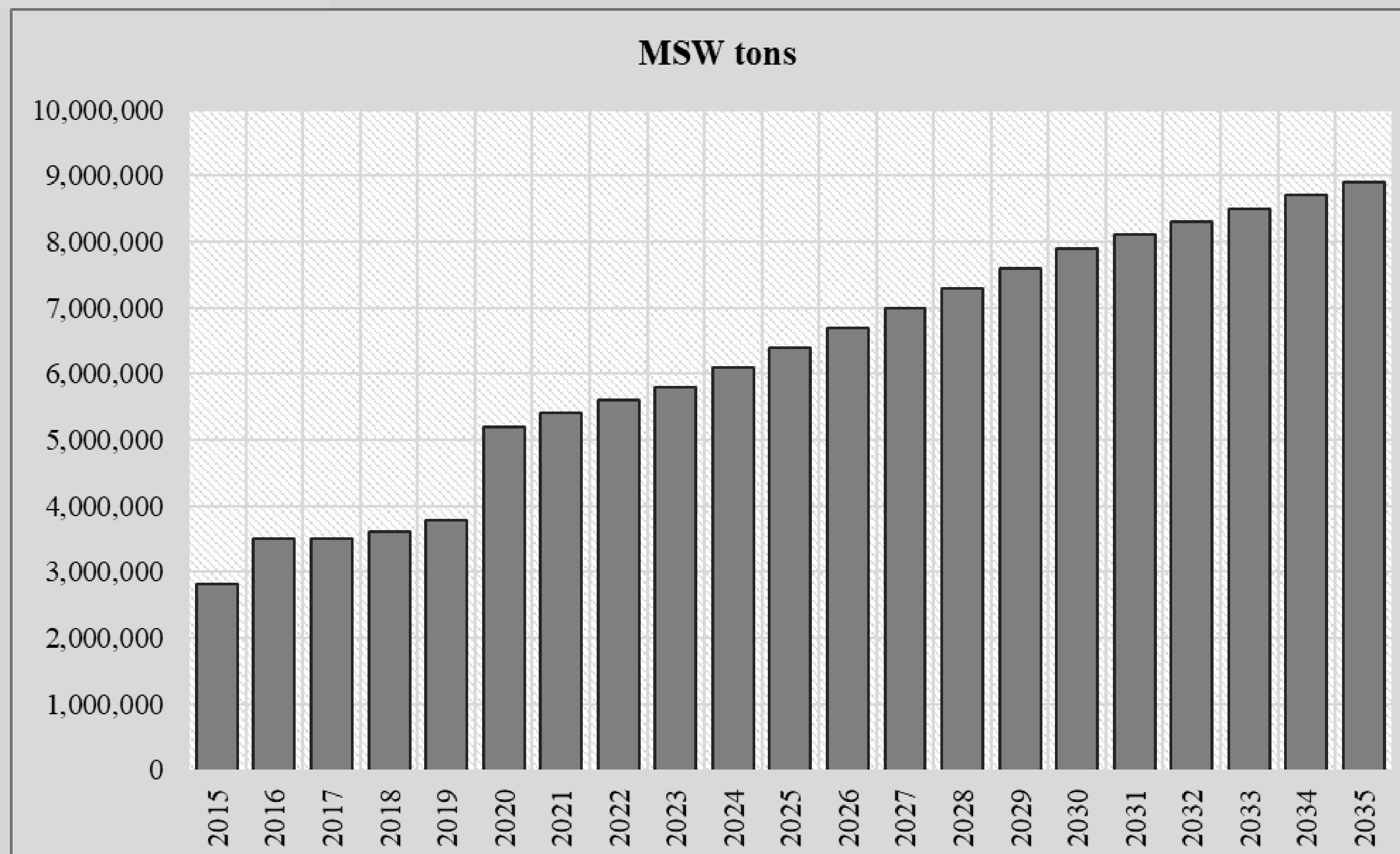

Figure 2: Municipal waste generated in the city of Riyadh during the years shown

The national center for waste management in Saudi Arabia, which was founded only in 2019, has estimated the waste generated from households and commercial businesses will reach approximately 106 million tons in 2035. In 2020 the MSW in Riyadh was about 5.2 millions tons and in 2035 it will reach around 8.9 millions tons.

The country plans to benefit from MSW through using it as energy. In addition, the plans also include reducing waste, reuse, and recycling before going through the treatment phase. Riyadh are among the fastest developing in the Middle East, more waste is generated continuously as a result, and the need to build a sustainable waste system to manage and control such volumes and diversity of MSW is a necessity.

However, the total amount of recycled waste is extremely limited and usually is performed informally by the private sector. Unfortunately, the country lacks a system to manage the waste and they solely depend on traditional approaches such as landfill dumping and incineration.

Methodology

This study aims to enhance Riyadh's waste management system, which has reached a substantial increase in the amount of generated waste. The analysis and evaluation methodology are based on Life-Cycle Assessment (LCA) using specialist software such as SimaPro. In addition, it is to assess the effects of various waste management treatment choices and technologies, such as pyrolysis, gasification, composting and anaerobic digestion (AD) plants in the country.

Research Data

- Waste composition (type of solid waste such as plastic, organic, paper, etc.) in Saudi Arabia, Riyadh.
- Waste amount in Saudi Arabia, Riyadh. (tons)
- Waste physical and chemical characteristics (water content, substance concentration and calorific value of individual waste fraction).
- Energy uses, raw materials, emissions, and waste and if there is (transportation of waste) and its cost in kilometers. (Type and quantity)
- Cost of materials, unit(s) and weight for each product and production quantities and current, future plan and strategies.

Table.1 Data analysis methods and software tools.

Method	Software Tool	Outcome measurement
LCA	SimaPro software	Environment and economic effect
MCDM (AHP)	ExpertChoice software	Environment, economic, and social criteria
Descriptive statistics	SPSS	Mean, Standard deviation, and standard errors for different data.

Data Collection methods
Expert interview, previous academic research paper data extraction, public/governmental reports data extraction.
Data Analysis methods
Descriptive statistics, LCA, Multi-Criteria Decision Making (MCDM) using SPSS, SimaPro, and ExpertChoice software respectively.

Aims

The main aim of this research is to determine the most effective, sustainable approach for waste management (waste-to-energy approach) in Riyadh, Saudi Arabia. An approach that leads to the most environmental benefit, economically affordable, and by accounting for social factors through assessing different waste treatment techniques and scenarios.

Results

This is still in-going work, and we are in the data collection phase. Results will be presented afterwards for descriptive statistics, LCA, and MCDM to measure the outcome of MSW effect on environment, economic, and social aspects.

Conclusions

To address the challenges and meet its forecasted energy and green environment demands; Saudi Arabia needs to plan a sustainable strategy and to give the private sector opportunities to invest in solid waste management instead of being run by the governmental sector. The current practices of waste treatment in the country lack planning, practicality, and sustainable methodology. The traditional treatment methods are used, which have enormous well-known consequences on the environment, economy, and the quality of life. Thus, it is crucial to produce a sustainable strategy to manage waste using a systematic approach thorough analysis such as LCA and MCDM.