UNIVERSITY of York

School of Physics, Engineering & Technology

MSc in Engineering Management
Project Report
2022/2023

Student Name: Ajay Varghese

Project Title: Review of York's Municipal Solid Waste Management Practices Concerning Sustainable Development Goals

Supervisors: Dr. Martin Robinson & Prof. Yongbing Xu

School of Physics, Engineering & Technology,

University of York, Heslington,
York
YO10 5DD

Acknowledgement

Foremost, I would like to thank the Lord Almighty God for his grace and favour for seeing me through this course. I would like to take this opportunity to express my most profound appreciation and gratitude to the faculty and the Department of Physics, Engineering and Technology for their support. This research paper would not have been possible without the help and support of many individuals, including my parents, teachers, family, friends, and all who have been part of my journey. I would like to extend a special acknowledgement of gratitude to the following significant advisors and contributors:

Firstly, I wish to express my profound gratitude to my supervisors, Dr. Martin Robinson and Prof.Yongbing Xu, for the most support and encouragement. The weekly meetings with Dr. Martin Robinson and his advice and suggestions helped my team and me to progress well in our research. Also, the weekly feedback from Prof.Yongbing Xu helped me track my progress and improve. Second, I would like to thank the Engineering management lectures staff for supporting us and clarifying our concerns throughout the project. Thirdly, I would like to thank the team members I have worked with for their immense support and contribution towards the research project. Finally, I sincerely thank my parents, family, and friends, who provide advice and financial support.

Thank you,

Ajay Varghese.

Abstract

Municipal solid waste management is essential to urban sustainability, encompassing the responsible collection, transportation, processing, recovery, and disposal of waste materials in cities. This research project delves into York's municipal solid waste management practices, evaluating their alignment with the Sustainable Development Goals (SDGs). The study begins with giving a background about the research, group work and a brief of technical aspects. The mixed-methods approach combines quantitative and qualitative data from literature sources, surveys, and interviews to comprehensively analyse waste management practices through environmental, social, and economic sustainability. Along with identifying the SDGs related to these dimensions, specific indicators were also pinpointed to assess the practices' congruence with the relevant SDGs.

The study used a cross-sectional time horizon to collect data from residents, waste management companies, and relevant authorities. The research evaluates York's waste management practices' environmental impact, social engagement, and economic viability through statistical analysis. Thematic analysis of interview data provides valuable insights into public perceptions, perspectives of waste management companies, prevalent challenges, and potential barriers. The study uncovers awareness gaps among the public and businesses, leading to recommendations for policy enhancements and technological implementations to foster more sustainable waste management practices.

By fulfilling its objectives and addressing research questions comprehensively, the study thoroughly assesses strengths, weaknesses, opportunities, and threats (SWOT) associated with waste management in York. Furthermore, considering the potential for future research, the study contributes to the discourse on effective waste management strategies. This research is valuable for policymakers, waste management professionals, and researchers interested in promoting sustainable urban development through refined waste management practices.

List of Abbreviations

MSW - *Municipal Solid Waste,* IOT - *Internet of Things,* MSWM - *Municipal Solid Waste Management,* SDGs - *Sustainable Development Goals,* HTC - *Hydrothermal Carbonisation,* AD - *Anaerobic Digestion,* WtE - *Waste-to-Energy,* LIBS - *Laser-Induced Breakdown Spectroscopy,* GIS - *Geographic Information System,* RFID - *Radio-Frequency Identification,* GPS - *Global Positioning System,* GSM - *Global System for Mobile Communications,* MCDM - *Multi-Criteria Decision Making* PMI - *Plus, Minus, Interesting,* AWRP - *Allerton Waste Recovery Park,* HWRCs - *Household Waste Recycling Centres,* SECR - *Streamlined Energy and Carbon Reporting,* TCV - *The Conservation Volunteers,* MRF - *Material Recovery Facility.*

Table of Contents

List of Figures

List of Tables

Chapter 1 : Introduction

1.1 Overview

In recent years, the global community has witnessed a growing concern for environmental sustainability and the urgent need to address the challenges posed by escalating waste generation. Various factors, including population growth, economic progress, better living conditions, and urbanisation, cause an increase in waste production. This trend is observed in all countries, regardless of their development level or classification as developed or developing nations (Permana et al., 2015). Waste generation is an inevitable outcome of human actions, and how it is handled adversely affects human well-being and the environment. (Khan et al., 2022). The rate of solid waste produced worldwide has increased significantly over time. In 1900, it was less than 0.3 million tonnes per day, but by 2010, it had risen to over 3.5 million tonnes per day. It is predicted to double by 2025 and triple by 2100 (Hoornweg & Bhada-Tata, 2012; Zhang et al., 2022). Solid waste encompasses a range of discarded materials, such as household, commercial, and industrial waste that are no longer useful. Solid waste, particularly municipal solid waste (MSW), is a critical environmental issue that poses significant challenges to sustainable development. Proper management is necessary to reduce negative environmental and human health impacts (WHO,2023). Waste Management is a complex sustainability issue due to its inherent connection to numerous environmental, social and economic factors (Ikhlayel, 2018).

Municipal Solid Waste (MSW) is the collective waste generated from residential, commercial, and institutional sources. This waste differs significantly in composition and classification between municipalities globally, even though it contains both biodegradable and non-biodegradable fractions derived from organic and inorganic components (Nanda & Berruti, 2020). Municipal Solid Waste Management (MSWM) is a comprehensive process involving several steps: collection, transportation, processing, and disposal of waste materials, aiming to adopt environmentally-friendly practices (Ye et al., 2023). However, MSWM faces numerous challenges, such as inadequate technology and inappropriate implementation of government policies and these challenges can hinder effective waste management and lead to environmental and social consequences. (Mandpe et al., 2022). Therefore, ensuring the entire waste management process is conducted sustainably is paramount. The waste hierarchy system shows different options for managing the waste according to which is the best for the Environment to address these challenges and promote a more sustainable approach, from the most preferred to least preferred option (Ismwaste, 2021), as shown in Figure 1.

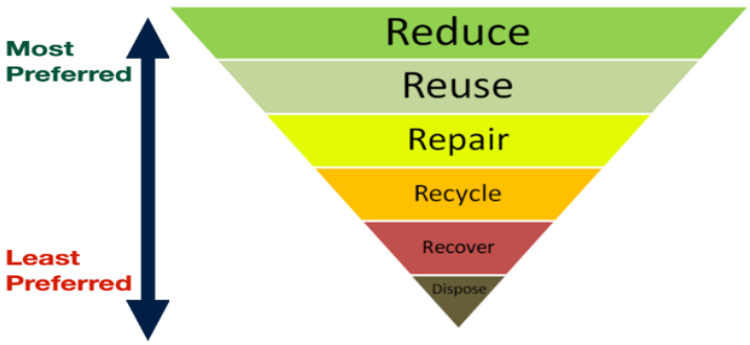

Figure 1:The Waste Hierarchy (CromwellPolythene, 2021)

1.2 Background of the Research

This study focuses on the York City Council's jurisdiction, which is a part of North Yorkshire, as shown in Figure 2. The city has a population of 202,821 people, of which 172,945 adults, according to the ONS - 2021 Census, reside in an area of 27232 hectares (ONS, 2021). The council is committed to implementing environmentally friendly actions that provide economic and social benefits, such as creating new green jobs, saving money, opening up market opportunities, and improving the well-being of York residents (york.gov, 2023). The research will analyse waste management practices, which are also an environmental concern, and assess their alignment with SDG goals.

Figure 2:Area under the authority of York city council (OpenStreetMap, 2023)

The City of York Council is responsible for overseeing waste management in York. They provide various waste and recycling collection services, including household waste recycling centres and street care and cleaning services (york.gov, 2023b). According to the Waste Management strategy report published by the council in 2021, which assesses waste generation from 2002 to 2020, it is stated that the continuous increase in household waste at a rate of 3% is not sustainable. This growth will lead to higher costs and make it difficult for the city to achieve its recycling and recovery targets. It is necessary to implement measures to slow down this growth. If the current waste management services are maintained, they will not meet the required performance standards or landfill directive targets (Walton, 2021). To support environmental preservation and work towards their goal of making York a net-zero-carbon city by 2030, the council has implemented various waste strategies and recycling standards. One such initiative is the "Let's Talk Less Rubbish" campaign, adopted in July 2006, which outlines a Joint Municipal Waste Management Strategy developed by the City of York Council, North Yorkshire Council, and regional district councils. This strategy aims to address waste management in the area for the next 20 to 25 years. According to the report, continuing landfill operations over 25 years, starting from 2011/12, would cost approximately £1.7 billion (York.gov, 2020).

Such a hefty bill would ultimately be borne by the residents of North Yorkshire and the City of York, potentially resulting in a 15% increase in Council Tax. However, transitioning from landfills and adopting more sustainable waste treatment technologies could save £307 million (york.gov, 2023b).

Chapter 4 : Data Analysis & Findings

This chapter provides a detailed and systematic analysis of the data collected through literature, surveys, and interviews. The findings are presented in subsequent sections, along with in-depth discussions and interpretations of the results. Based on the outcomes of the analysis, both management and technical recommendations are provided to address the issues identified.

4.1 Data Presentation

In line with the objectives and research questions, specific indicators have been identified to analyse the sustainability aspects of waste management, considering the three pillars of sustainability: environmental, social, and economic, as shown in Table 3. The focus is on key indicators that directly influence waste management. For each sub-aspect, numerical scores (0, 0.5, or 1) were assigned based on data analysis from available literature, public surveys, interviews, and expert interviews. The Score sheet is attached in Appendix IV, and the generated statical graph is shown in Figure 8. The provided scores in the figure represent the performance of various waste management sub-aspects. A score of "1" indicates good practices, supported by evidence and agreement from the data sources. A score of "0.5" suggests potential for improvement, while a score of "0" highlights areas requiring attention. The "-" symbol indicates insufficient data for evaluation.

The scoring system will give a slight insight into the analysed indicators in each pillar of sustainability from the available resources. In-depth analysis will be given in the qualitative and quantitative data analysis.

Aspects	**Sub aspects**
Environment	Reduction & Reuse (Sharma et al., 2021a)
	Resource conservation (Sharma et al., 2021b)
	Energy recovery (Tan et al., 2015)
	Recycling efforts (Rafael M.D et al., 2019a)
	Biodiversity (Sharma et al., 2021c)
	Climate change (Sharma et al., 2021d)
	Eco-friendly/Green Technologies (Tanveer et al., 2022)
	Greenhouse gas emission (Tan et al., 2015)
	Disposal/Landfill (Rafael M.D et al., 2019b)
Social	Perceived convenience and effort (Schwab et al., 2012)
	Public Awareness (Loan et al., 2017)
	Influence of Others (Knickmeyer, 2019a)
	System trust (Knickmeyer, 2019b)
	Transparency and Traceability (Sharma et al., 2021d)
	Community Engagement (Jesson et al., 2014)
Economic	Cost Effectiveness (Di Foggia & Beccarello, 2020a)
	Revenue Generation (Di Foggia & Beccarello, 2020b)
	Funding Availability (Di Foggia & Beccarello, 2020c)
	Regulatory Compliance effort (Tobin & Zaman, 2022)
	Waste disposal/Landfill tax (Prabawati et al., 2023)
	Public-Private Partnerships (Kruljac, 2012)
	Investment in innovations (Salmenperä et al., 2021)
	Employment Opportunities (Zurbrügg et al., 2014)

Table 3:Identified indicators for the Three Pillars of Sustainability

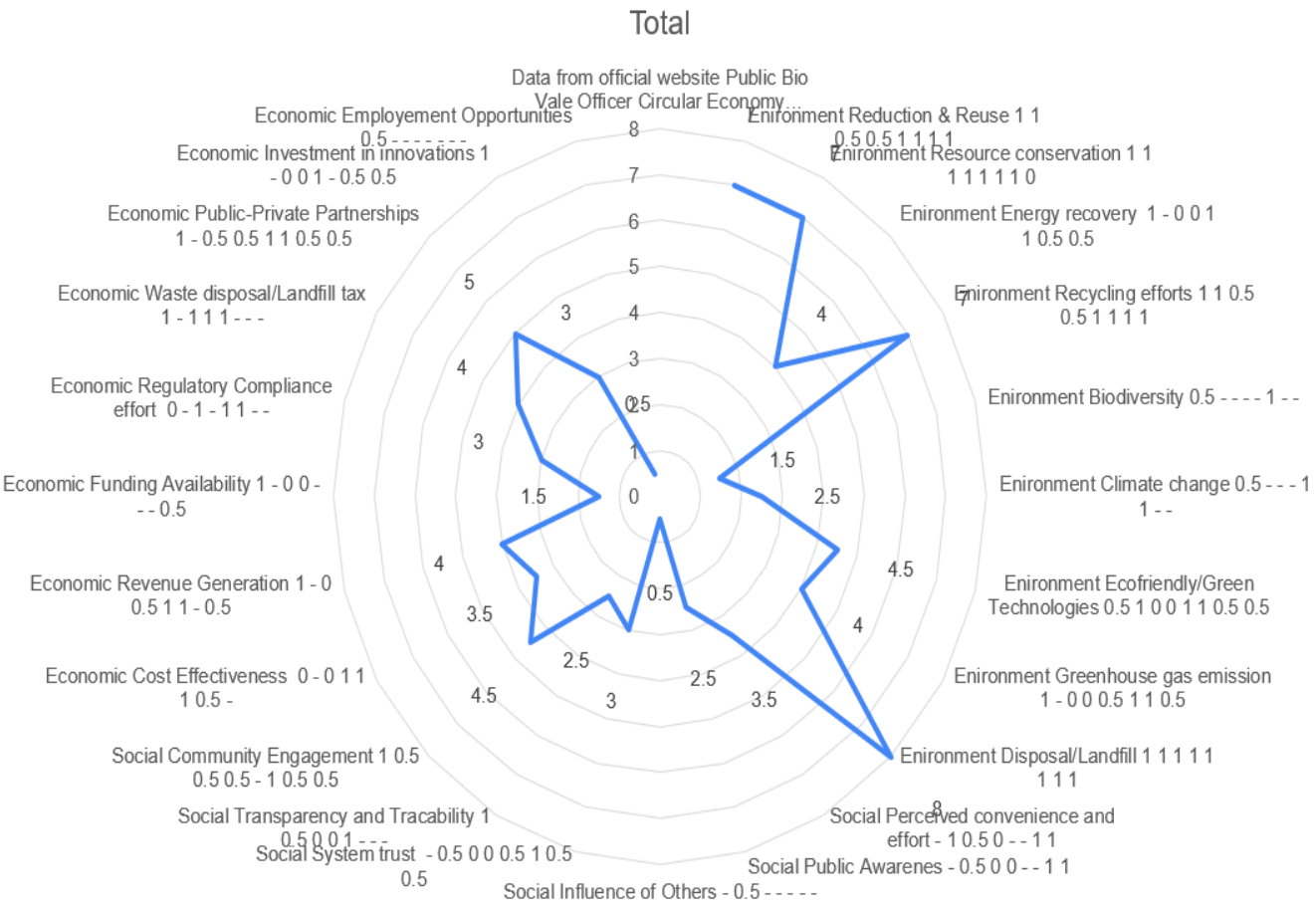

Figure 8:Scoring system statistical graph

Environmental Aspects:

The analysis shows that waste management has demonstrated commendable performance in various environmental sub-aspects, including reduction and reuse, resource conservation, energy recovery, recycling efforts, and disposal/landfill.

Even though the waste management companies pointed out the recycling and recovery efforts, the other interviewees showed some disagreement regarding this, especially the incineration of waste, resulting in a score of '0 and 0.5' for this sub-aspect from the other interviewees. The findings also highlight the need to improve biodiversity and greenhouse gas emissions. Additionally, two interviewees suggested potential enhancements for recycling efforts from the public and local government perspectives. Further research and data collection are essential to strengthen the evaluation of sub-aspects with limited data and ensure a comprehensive and informed analysis of waste management's sustainability.

Social Aspects:

Waste management's social aspects are primarily concerned with public perception. Waste management performs effectively in social sub-aspects, such as community engagement and perceived convenience. The survey's positive response reflects growing public awareness. However, there are areas with room for improvement, such as public awareness and trust.

To achieve sustainable waste management, efforts must be made to improve public education and increase transparency, traceability, and community involvement.

By addressing these issues, waste management can better align with sustainability goals and foster a more substantial commitment to responsible waste practices at the individual and community levels.

Economic Aspects:

The economic aspect of waste management demonstrates mixed results. While there are positive practices in revenue generation, waste disposal/landfill tax, public-private partnerships, and investment in innovations, there is room for improvement in funding availability, cost-effectiveness, regulatory compliance effort, and potentially in employment opportunities (data limited). Emphasising cost optimisation, adhering to regulations, and exploring innovative waste management approaches are essential for economic sustainability. Encouraging public-private partnerships can drive collaboration and resource sharing. Further research and data collection are necessary to strengthen the assessment of sub-aspects with limited data and facilitate evidence-based decision-making for sustainable economic waste management practices.

4.2 Literature Data Presentation & Analysis

The qualitative and quantitative data were gathered from various websites and reports that have the potential information to assess York's waste management practises concerning the SDGs. Specific waste management attributes were plotted on an Excel sheet using numerical data from the waste data flow and York open data websites. The Literature analysis will cover some of the identified sub-aspects of ***Environment, social and economic aspects.***

Data from 2018-19 to 2021-22 were used to refine the relationship between specific attributes, which also aids in understanding and analysing the trend over the last four years. Some attributes were compared to total England data to determine whether York aligns with the waste management trend. The Excel sheet for formulating the data is attached as a Google Drive link in Appendix V.

Waste Reduction & Resource Conservation:

Several existing practices in York aim to enhance waste reduction and resource conservation. The University of York and Yorkshire Water have established a new £1.2m UK Centre of Excellence for anaerobic digestion (AD) research. The Centre is based at the University and Yorkshire Water’s Naburn site and is part of a £1.2m project to advance the Centre’s research over the next four years. This will enable a greater understanding of the processes behind anaerobic digestion. AD facilities treat biodegradable waste and sewage sludge, reducing the emission of landfill gas into the atmosphere (York. ac, 2021). The new project aims to increase the potential of waste recycling and further boost renewable energy generation.

Composition of waste collected in York:

According to the data from Waste Dataflow. The composition of collected waste in York for each year has been identified (Waste dataflow, 2022a). The data indicates that organic waste (garden and other compost) is the most collected waste in all four years. Additionally, co-mingled waste, which consists of mixed wastes, is the second most collected type of waste in all four years, as shown in Figure 9.

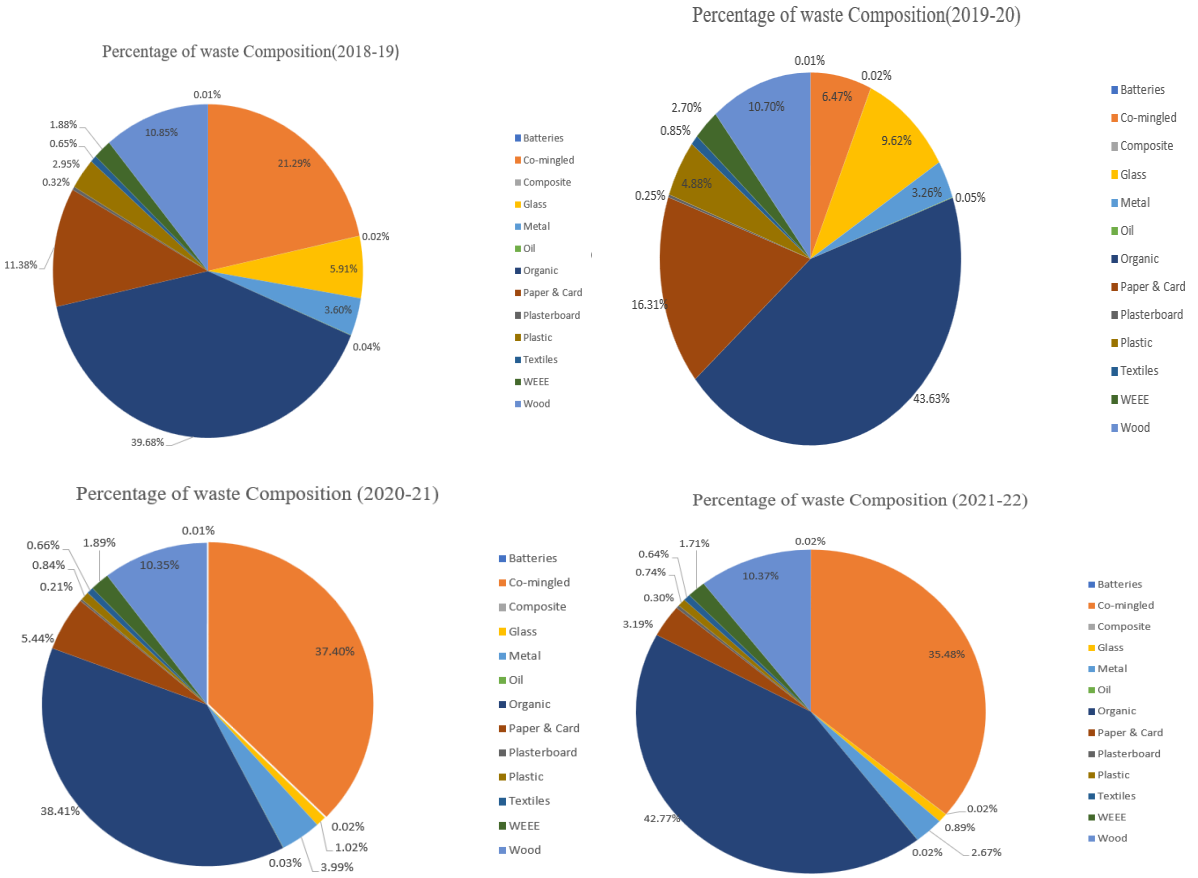

Figure 9:Composition of different waste collected (In percentage)

Total Municipal Waste Collected vs Sent to Landfill

According to waste data analysis from 2018-19 to 2021-22, York City has seen a significant reduction in municipal solid waste sent to landfills, indicating commendable progress in waste management initiatives, as shown in Figure 10 (Waste dataflow, 2022b). This positive trend aligns with the overall pattern observed in England, as in Figure 11.

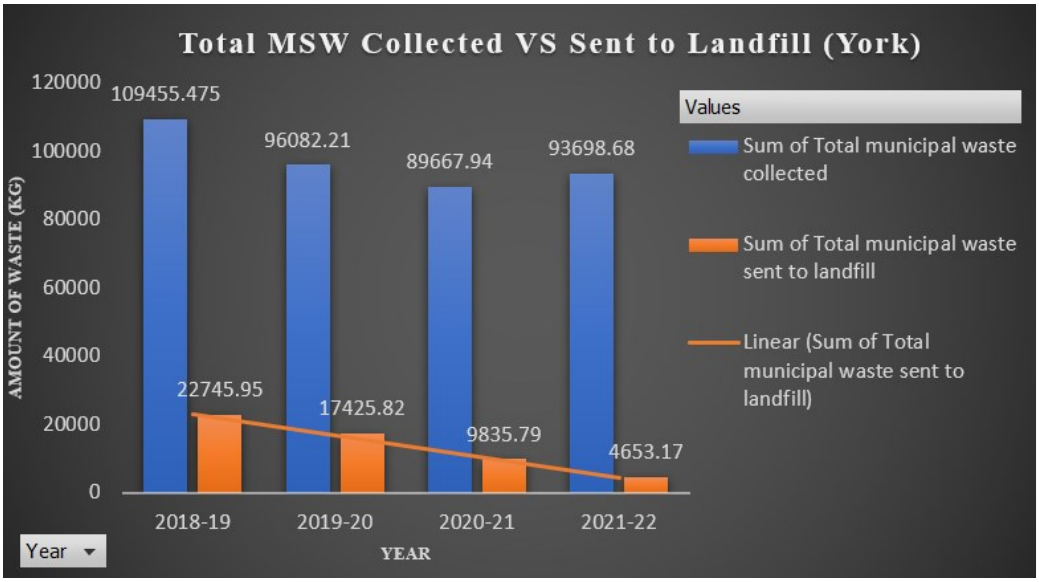

Figure 10:Total MSW collected Vs Sent to Landfill (in York).

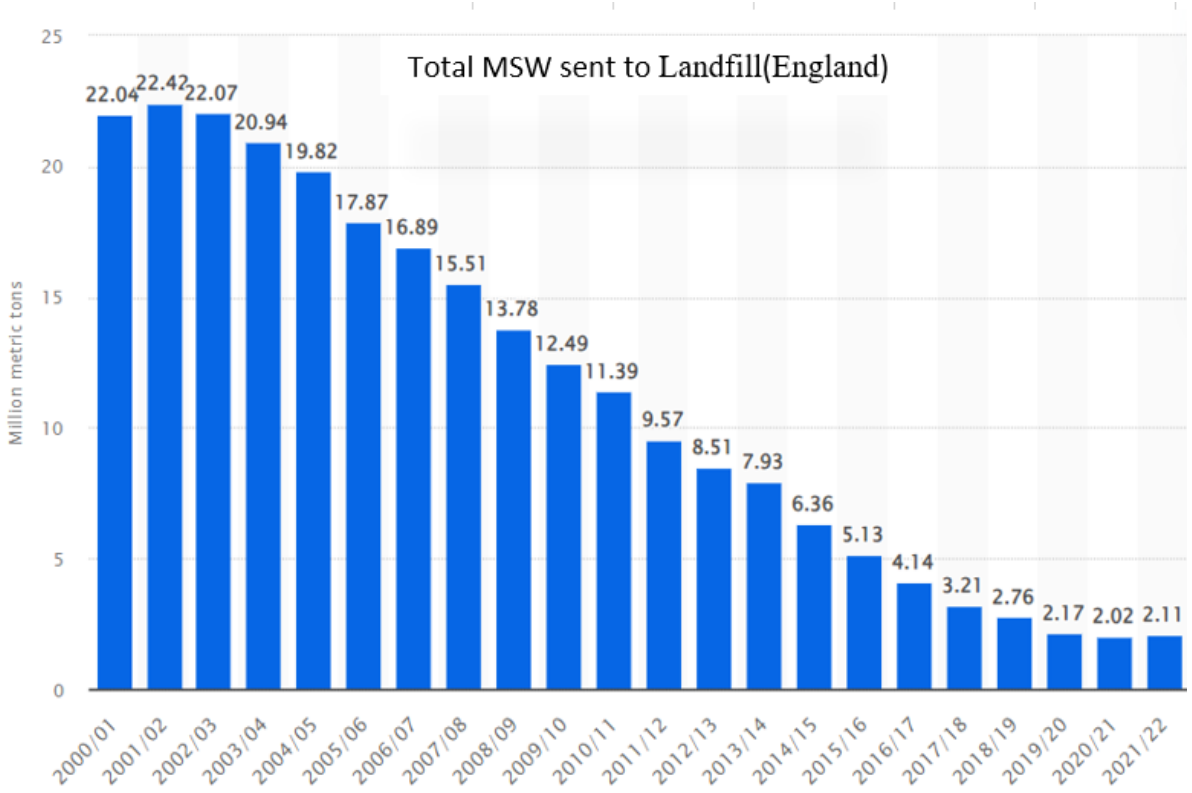

Figure 11:Total MSW sent to Landfill (overall in England) (Statista, 2022b)

Also, a notable reference from the news York Press found during that period is that the Harewood Whin landfill site in York is on the verge of transforming into a wildflower meadow (York Press, 2019a). This indicates the closure of the landfill site of the city. Additionally, the reporter says that the city's recycling rate during that time stands at 44 per cent, with aspirations to collaborate with retailers and the government to achieve even higher recycling levels (York Press, 2019b).

Household Waste vs Recycling Rate

A significant portion of the municipal solid waste in York is household waste, as shown in Table 4.

Year	Total household Waste collected (in %)	Other MSW collected (in %)
2018-19	80.61	19.39
2019-20	84.38	15.62
2020-21	90.55	9.45
2021-22	88.74	11.26

Table 4:Percentage of Household waste and other MSW collected

The recycling rates for York and the overall recycling rate for England are presented in Figure 12 and Figure 13. In 2021/22, the recycling rate for household waste in England was 44.1%, while York's recycling rate was slightly lower at 43.31%. However, in the year 2019-2020, something noteworthy happened. During that specific period, York's recycling rate aligned with England's overall recycling rate, achieving the highest rate among all the years considered in the last five years.

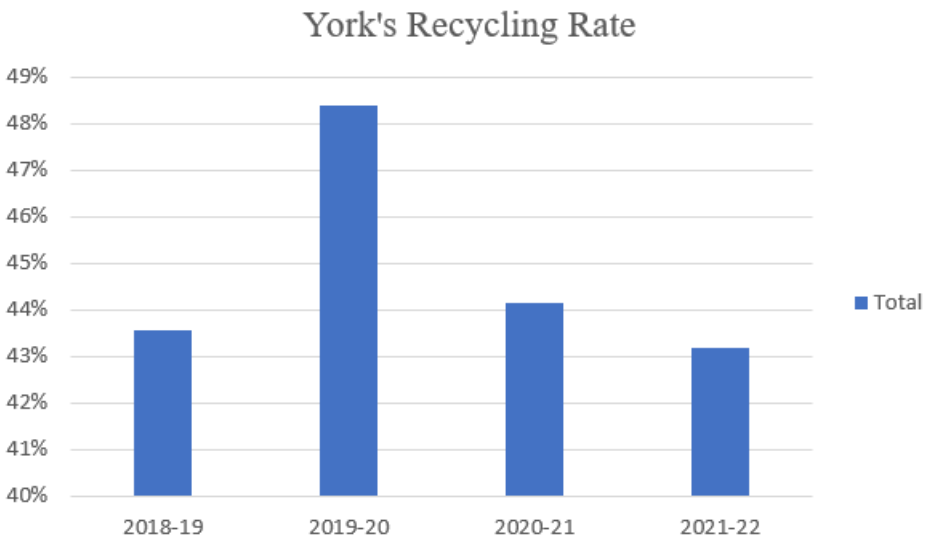

Figure 12:Household Recycling Rate of York during the period 2018-2022

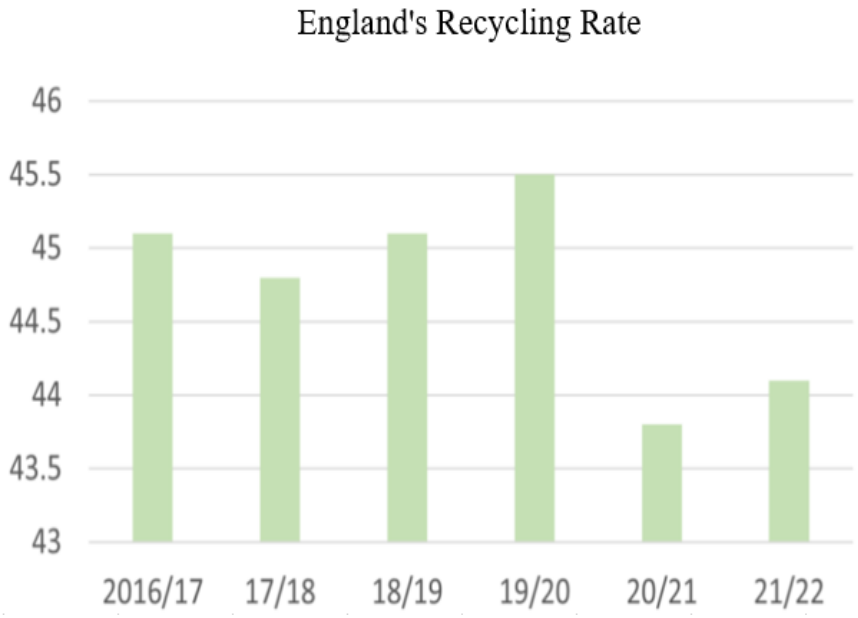

Figure 13:Household Recycling rate of England overall in past years (Joshua, 2023)

In 2019-20, household recycling saw a noticeable increase from 44% to 48%, suggesting improved recycling efforts. This rise coincided with the opening of a new waste recycling centre in Kirby Misperton, which was expected to boost recycling in York(Chloe, 2019). However, the recycling rate declined to 44% and 43% in 2021 and 2022, respectively. This may raise questions about the effectiveness of recycling initiatives during that period. One possible reason for the decrease could be the impact of the COVID-19 pandemic, which led to the closure of all household waste recycling centres during the first lockdown, as per a news report (Webster, 2020).

Conversely, the household waste not sent to recycling is concerning, which is more than 50% in the last four years, as shown in Figure 14.

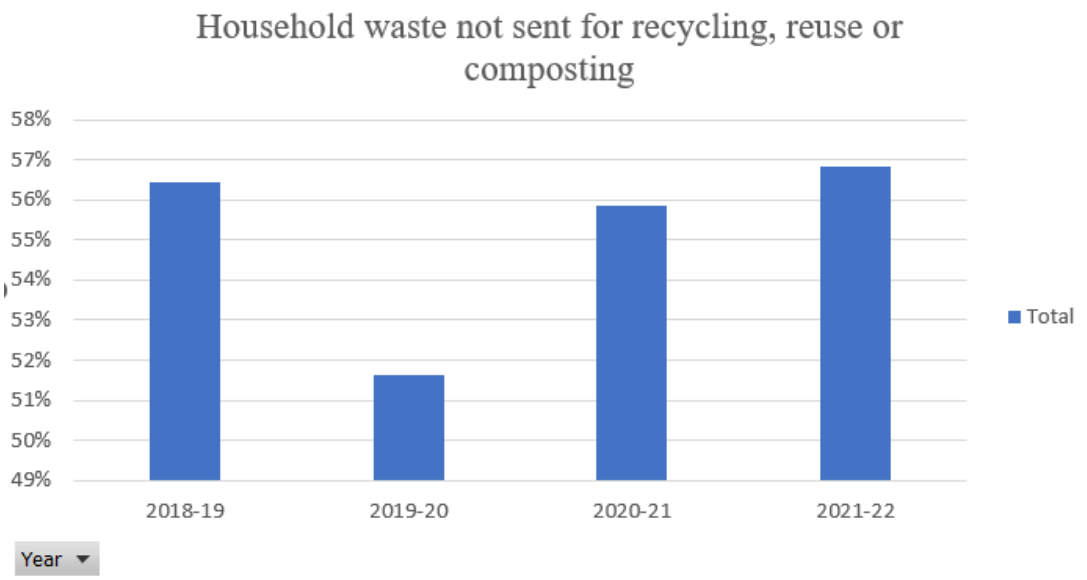

Figure 14:House hold waste not sent for recycling, reuse/composting.

Waste for Energy Generation:

According to the data, York has been making positive progress in their waste-to-energy efforts, as illustrated in Figure 15. Additionally, when compared to the overall trend in England, as shown in Figure 16, it is clear that a more significant amount of waste is being successfully converted into energy at the national level over time. This evidence suggests that waste-to-energy technologies are becoming more widely adopted as a sustainable and promising solution for waste management nationwide.

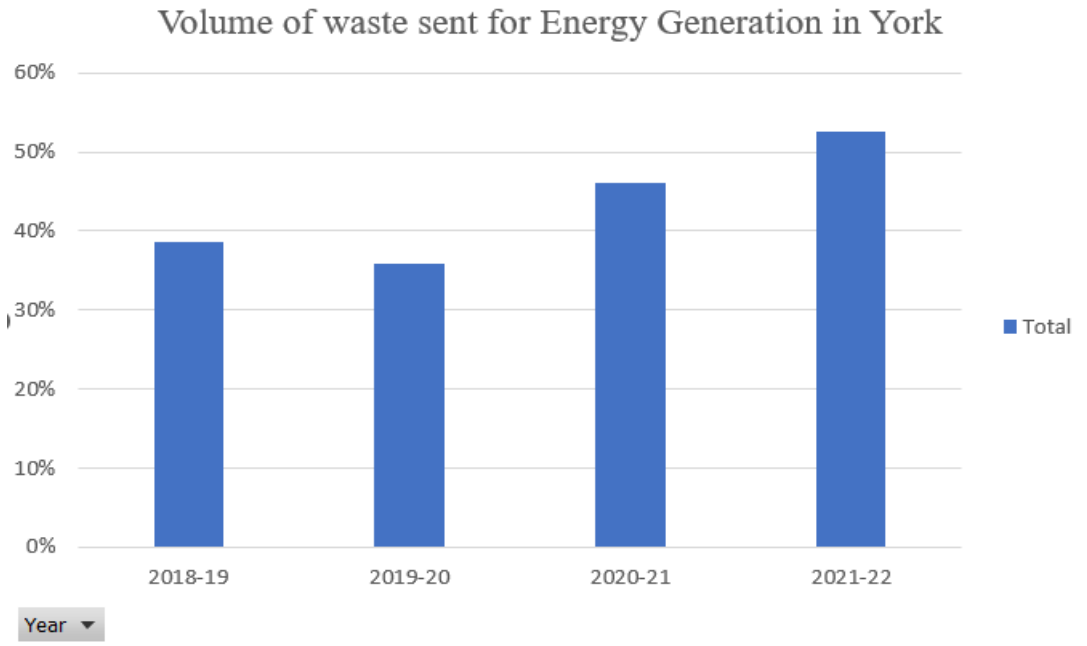

Figure 15:Volume of waste sent for Energy Generation (in York)

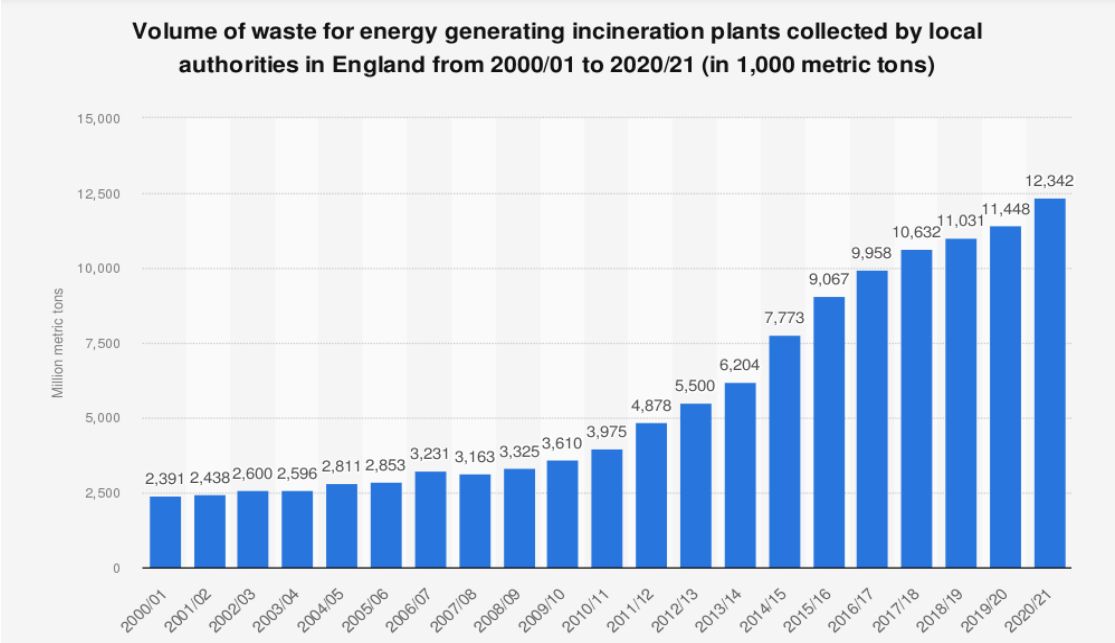

Figure 16:Volume of waste collected for WtE by local authorities in England from 2000/01 to 2020/21 (Statista, 2022)

Since 2020, York has made significant progress in waste-to-energy efforts, specifically in energy recovery. The City of York Council promotes waste recovery through different initiatives. One notable project is sending all household waste to the Allerton Waste Recovery Park (AWRP) instead of landfills. At AWRP, waste is recycled or converted into green energy through incineration. This eco-friendly approach is expected to save around £53 million over the next 25 years compared to landfill practices (York.gov, 2018). According to York Press, the facility opened in March 2018 and has already reduced carbon dioxide emissions by over 100,000 tonnes by recovering materials and energy from household waste (Megi, 2020).

4.3 Findings from Literature Analysis

The literature analysis reveals York's trend in recycling/recovering and commendable progress in waste management practices, particularly in reducing landfill waste and promoting waste-to-energy initiatives. However, there are still challenges to address, mainly household recycling rates and adopting sustainable waste management practices. This trend is illustrated in the provided Figure 17.

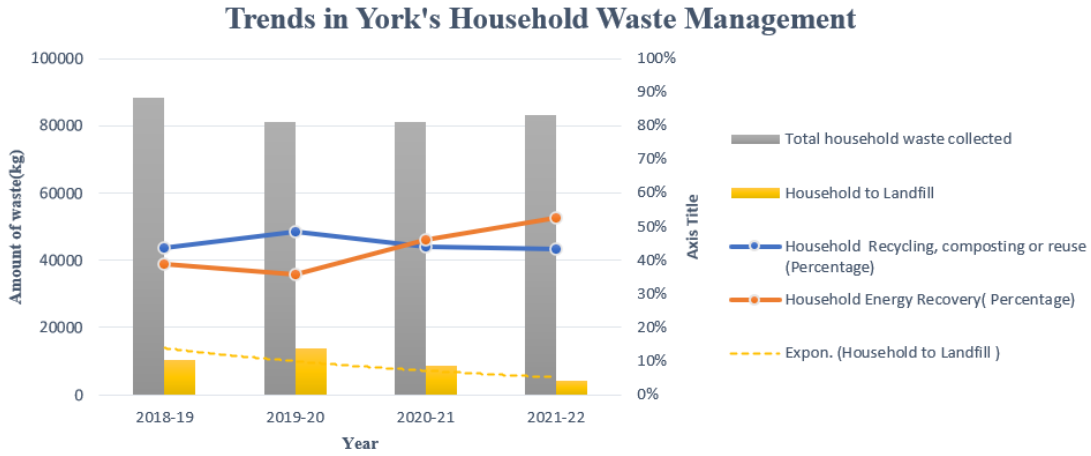

Figure 17:Trends in York's Waste Management Practices in the past four years