A DATA ANALYTICS DASHBOARD SYSTEM ON SCOTLAND WASTE MANAGEMENT SYSTEM USING POWER BI

by

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202468855

Word count: 9049

In partial fulfillment of requirements for the
degree of MSc Advanced Computer Science
with Data Science

University of Strathclyde Glasgow

Department of Computer and Information Sciences

SEPTEMBER 2024

ABSTRACT

The growing dependence on data-driven decision-making within waste management has highlighted the essential role of analytical tools in enhancing waste reduction and sustainability efforts. This project is focused on the development and deployment of the Scotland waste Management Dashboard, with Power BI serving as the primary platform. The dashboard was constructed using data sourced from the Scottish Environment Protection Agency (SEPA) for the years 2021 and 2022 and features key performance indicators (KPIs) such as recycling rates. It is divided into multiple interactive sections, which include analyses of waste generation, waste management strategies, regional household waste distribution, and comparison analysis of KPIs from 2021 to 2022. The main goals of this study were to create a user-friendly and interactive dashboard that aggregates, analyses, and visualizes waste management data in real-time; to allow users to filter and customize visualizations and key performance indicators (KPIs) according to their needs, and to evaluate the dashboard's effectiveness in promoting data-driven decision-making while aligning with Scotland's waste management policies. The results indicate that the dashboard successfully converts raw data into actionable insights, enabling stakeholders to observe trends, recognize areas of enhancement, and make informed decisions. This research highlights the importance of interactive and customizable dashboard solutions in enhancing waste management strategies and supporting sustainability efforts in Scotland

Keywords: Dashboard; Power BI; Key Performance Indicators (KPIs); Waste Management

DECLARATION

This dissertation is submitted in part fulfilment of the requirements for the degree of MSc of the University of Strathclyde.

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ACKNOWLEDGMENTS

I would like to thank everyone who has supported me throughout the entire course of this research.

Firstly, I would like to thanks Prof. Yashar Moshfeghi, whose guidance and experience was instrumental in the successful completion of the research project.

Finally, I would like to acknowledge the use of resources and tools from University of Strathclyde Library and Google Scholar which played a crucial role in completing this research project.

This project would not have been completed without support and encouragement of all the individuals and Strathclyde University.

Thank you.

Table of Contents

List of Figures

1 Introduction

The conservation and protection of the earth's natural resources is crucial. In order for Scotland to evolve into a resilient and resource-efficient economy, it is necessary to decrease waste production, maintain the circulation of materials for as long as feasible, prevent harm from waste management, and address the issue of waste-related criminal activities (Sepa, 2024). Scotland has made significant strides in waste management, significantly lowering the quantity of waste sent to landfills while simultaneously experiencing a surge in recycling efforts. The "zero-waste Scotland" plan aims for a 70% recycling rate and a maximum of 5% waste to be sent to landfills by 2025 across Scotland. The objective of a zero-waste Scotland is to optimize resource utilization by reducing by minimizing the demand for primary resources and enhancing the reuse, recycling, and recovery of materials rather than treating them as waste (Scottish Government, 2010). New tools are being designed to gather and report data regarding waste management. Among these is a comprehensive Digital Waste Tracking system that will operate across the United Kingdom to record waste transfers (Scottish Government, 2010). Moreover, data visualization will play a crucial role in tracking and managing waste data.

Data visualization plays a crucial role in the process of data analysis, as it enhances comprehension by transforming complex data into visually appealing and easily interpretable formats that are accessible to everyone. It can also represent a vast amount of data within a limited visual area (Singh, et al., 2023). Dashboards will be helpful in displaying the visualizations, enabling users to view and interact with the data more effectively. The usage of dashboards in organizations, alongside the advancement of dashboard applications, has seen significant growth nowadays. This phenomenon is largely a consequence of the rapid advancement in information and communication technology (ICT) facilitated by the rise of Big Data. There is an increasing necessity for individuals, and both governmental and non-governmental organizations to visualize their performance and activities on a consolidated computer screen (Rahman, et al., 2017). Dashboards are extensively used for various sectors, including education, healthcare, and logistics industries (Charleer, et al., 2016). Moreover, the objectives of a dashboard differ based on the managerial level of the user, which is influenced by their specific responsibilities within the organization. The purpose of a dashboard is thus defined by the specific tasks that the user engages in (Eckerson, 2010).

Power BI is an on online service platform that facilitates data exploration, transformation, visualization, and dissemination of reports and dashboards to users within the same or different organization, as well as with the general public (Krishnan, et al., 2017). Power BI was incorporated into Office 365 in September 2013 and subsequently made available to the general public in July 2015 (Becker and Gould, 2019). By February 2017, more than 200,000 organizations across 205 countries were utilizing Power BI. Additionally, Power Bi possesses the capability to integrate various databases, files and web services, enabling swift adjustments and automated problem solutions (Krishnan, et al., 2017). The components of Power BI may appear complex in a theoretical context; however, the graphical interfaces based on commonly utilised tools, enable users to easily visualise data and understand the processes necessary in connecting various data sources. The available measures for visualization are standard descriptive statistics which includes sums, counts, measures of central tendency and minimum and maximum values. These measures can be applied to an entire column of data or to specific segments based on the user's visual configurations and filtering options (Becker and Gould, 2019).

1.1 Research objectives

- **To organize data into different waste types, geographic areas, and time periods for optimized analysis.**

  The aim is to classify data into specific waste categories, including recycled waste, recovered waste, disposed waste, household waste, landfill, and incinerated waste), as well as geographic classifications that cover different regions and cities and temporal classifications that reflect different time frames. This structured approach enhances the analytical process, thereby allowing for a more accurate evaluation of waste management strategies in Scotland.

- **To compare the key performance indicators related to Scotland waste management between 2021 and 2022.**

  The focus is on identifying any significant changes, trends, or patterns in waste management practices. Additionally, it seeks to evaluate the progress made towards fulfilling Scotland's environmental targets, particularly in reducing landfill, and incinerated waste and improving the recycling rate.

- **Examine the variations in recycling rates throughout the Scotland from 2021 to 2022.**

  The goal is to evaluate the efficacy of recycling initiatives and to pinpoint the factors that may have contributed to variations in recycling rates. This could encompass an analysis of the influence of public awareness campaigns, modifications in recycling policies, or the introduction of advanced recycling technologies.

- **Analyze the evolution of household waste management strategies from 2021 to 2022.**

  The aim would focus on analysis of how household engaged in waste management activities, such as recycling and waste reduction. It could assess the contributions of local authorities in facilitating household waste management and evaluate the success of various programs and incentives.

- **The comparison of landfill and incinerated practices for waste disposal between through 2021 and 2022.**

  This analysis would focus on analyzing the amounts of waste processed through landfills and incinerators, measuring advancements in minimizing landfills while promoting incineration usage, and evaluating the success of waste management strategies. Moreover, the research could explore the environmental impacts of both disposal techniques, particularly concerning greenhouse gas emissions and other harmful pollutants.

1.2 Research Questions

Question #1

In what ways can the Key Performance Indicators (KPIs) displayed on the dashboard be utilized to evaluate the success of waste management strategies and policies that were implemented in Scotland in 2021 and 2022?

Question #2

How well dashboard illustrate trends in landfill usage and incineration rates across Scotland for the years 2021 and 2022?

Question #3

How effectively does the dashboard represent and facilitate the comparison of household waste management data across different regions and kilograms per individual for the years 2021 and 2022?

Question #4

What improvements or modifications could be introduced to the dashboard to better align with user needs and improve the accuracy of waste management analysis?

This research aims to enhance the efficiency of waste management strategies by enabling policymakers and environmental agencies to utilize data-driven insights for more effective resource allocation. By analyzing elements such as waste classification, geographical variations, and sector-specific waste generation, authorities can formulate targeted interventions that tackle the most critical challenges in waste management. Overall, this research not only improves the efficacy of waste management practices throughout Scotland but also supports sustainability and innovation in environmental management.

1.3 Research Limitations

Data Access and Accuracy

One of the key challenges this dashboard faces is the quality and availability of the data it utilizes. This dashboard is largely dependent on waste management data from SEPA for the years 2021 and 2022. However, this data presents gaps or inconsistencies due to incomplete reporting from various regions or sectors. In certain instances, the data are not updated with sufficient frequency, leading to potential discrepancies when evaluating the recent trends. Additionally, the COVID-19 pandemic severely impacted data collection efforts for 2019 and 2020, which limits the ability to compare current findings with those before the pandemic.

Limited User Customization Options

Another drawback of this dashboard is its limited capacity for advanced customization options for diverse user types. While the dashboard delivers general insights into the performance of waste management, it does not permit users to adjust visualizations, metrics, or reports to align with their individual needs. For instance, policymakers may be particularly interested in key performance indicators that reflect recycling rates or landfill diversion, while environmental agencies may be more concerned with data on greenhouse gas emissions or energy recovery from incineration.

Access and Sharing Restrictions in Power BI

One significant drawback of employing Power BI for this waste management dashboard is the restriction on the sharing and publication of reports, which requires users to have a Microsoft account, whether it is personal, business, or educational. While the plat form excels in providing advanced visualization and analytical features, its sharing options are restricted to those with a registered Microsoft or educational account. This presents a challenge in reaching a wider audience, including local authorities, policymakers, and the general public who may not have access to the necessary accounts.

Section 1 of this report offers an overview of the waste management dashboard, highlighting its alignment with Scotland's waste management policies and initiatives designed to enhance environment sustainability. It discusses the vital role of data visualization tools and dashboards, with a particular focus on Power BI in developing interactive and user-friendly interfaces. This section also lays out the research objectives, which involve comparing waste management practices and assessing KPIs. Additionally, it outlines the research questions for analysis and highlights the limitations encountered, such as gaps in data and challenges related to user access.

Section 2 of this report provides a literature review on the advancements of dashboards as vital tools within business intelligence, highlighting their increasing demand in today's modern world. It details the feature of Power BI in generating complex data visualizations and underscores the importance of Key Performance Indicators (KPIs) in the evaluation of waste management practices. The literature also reviews existing studies on waste management dashboards, revealing how comparable tools have been developed to optimize waste management practices across the globe.

Section 3 of this report provides the implementation methodology for this dashboard. It details the entire procedure, which includes data collection and cleaning, as well as the design and integration of features that prioritize user-friendliness. The dashboard’s navigation and visual clarity were key considerations, with the inclusion of interactive buttons and slicers. This section also discusses the classification of data and utilization of DAX formulas within Power BI to assess KPIs.

Section 4 of this report analyses the dashboard success in representing waste management data and key performance indicators (KPIs). This section highlights the dashboard’s ability to showcase trends in landfill usage, incineration rates, and the efficiency of household waste management across Scotland. Additionally, this section considers potential upgrades to the dashboard. The findings indicate that the Scotland Waste Management Dashboard is a crucial resource for tracking and enhancing waste management approaches.

2 Literature Review

2.1 Introduction

This literature review offers a thorough analysis of the historical context, earlier studies, and research efforts associated with the application of data analytics dashboards in the field of waste management. It highlights the vital role of data visualization methodologies and Key Performance Indicators (KPIs) in improving waste management strategies. The aim of this section is to evaluate the effectiveness of data analytics tools, including Power BI, in transforming waste management methodologies, along with the importance of data visualizations and KPIs in monitoring and optimizing environmental performance. Additionally, it explores existing literature on waste management dashboards, focusing on their impact and relevance to the ongoing study.

2.2 Evolution of Dashboard

Dashboards are among the most frequently encountered applications of data visualizations, with their design and application context significantly differing from those of exploratory visualization tools (Sarikaya, et al., 2019). The advantages of dashboards become quickly apparent when navigating through complex spreadsheets or extensive reports to find and analyze relevant information. In the early 2000s, a confluence of decreasing software costs, the emergence of innovative business intelligence (BI) technologies, and the opening of various data sources facilitated the mainstream adoption of dashboards in organizations and government entities worldwide (Rasmussen, et al., 2009). Over time, the concept of dashboards has evolved from simple, single-view reporting screens to dynamic interactive interfaces that fulfill diverse functions, such as communication, education, and supporting decision-making processes (Sarikaya, et al., 2019).

For example, Mustafa and Schumann (2024) outlines the necessity for a structured approach to AI development, driven by regulatory requirements and the complexities associated with creating AI models. This dashboard is characterized as a comprehensive resource that facilitates the development, validation, and monitoring of models, ensuring conformity with industry standards. Through the integration of real-time data analysis and the tracking of essential performance metrics, the dashboards enhances both transparency and compliance with regulatory standards. This research illustrates how dashboards can optimize AI development and decision-making within heavily regulated sectors, providing a valuable framework for the integration of AI technologies within financial services.

Another example is the work by Naranjo, et al. (2019) who delivers a dashboard for real-time analytics and visual insights for both learners and educators, presenting a comprehensive overview of students engagement with cloud resource and their completion rates for assigned lab works. It compiles aggregate data to offer instructors macro view of class progress, while students can easily track their own advancement and pending assignments through a user-friendly interface. The tool has been successfully integrated into multiple cloud-focused courses, where it has effectively supported self-regulated learning and assisted students in managing their academic workloads. Additionally, the system features real-time progress tracking, timely feedback, and interactive learning tools, which play a crucial role in enhancing engagement within cloud-based educational platforms.

2.3 Power BI

Power BI is an advanced business intelligence (BI) platform that allows users to explore the essential metrics of an organization. This tool is utilized by businesses to create BI visualizations based on selected datasets, thereby obtaining vital insights into their business operations (O'Connor, 2018). This platform is composed of four integral components: Power Query, Power Pivot, Power View, and Power Map. This system is structured to include a desktop application, an online service, and a mobile application. Users generally appreciate the capability to adjust graphical outputs, to suit their needs. The Power BI mobile application, available for both Android and iOS devices, can be easily downloaded and set up, enabling users to access and interact with their data anytime and anywhere (Azuar, et al., 2021). Power BI features powerful visual representations of datasets, including a variety of graphs and charts. The capability to analyze these components in real-time via a live data feed significantly increases the interaction of users and allows for the quick emergence of relevant insights. Power BI dashboards are equipped with links, or tiles, that direct users to related reports, enhancing navigation between different reports (O' Connor, 2018). Additionally, Power BI ensures the security of internally generated reports and automatically updates data to reflect the most current information. This platform is capable of integrating all organizational data, whether stored in the cloud or on-premises, due to its gateway functionality, which enables connections to SQL Server databases, Analysis Services models, and numerous other data sources within the dashboard (Widjaja and Mauritsius, 2019).

2.4 Data Visualization and KPI

Data Visualization refers to the method of illustrating the importance of data through visual representations (Bhargava et al., 2018). One of the practical applications of this concept is the creation of dashboards, which are graphical interfaces that compile a variety of key metrics and performance indicators, enabling users to easily identify essential information on a single display (Kokina et al., 2017). The visualization process is divided into two key phases: encoding and decoding. The evolution of dashboards can be performed by determining how effectively they support these key phases. According to the authors, successful decoding leads to valuable and effective visualization, as it ensures that perceived data accurately reflects actual data quantities and relationships (Yigitbasioglu and Velcu, 2012). The goal of visualization is to enable access to information by focusing on certain tasks or features of the data, thus making it easier to understand and streamlining a more effective decision-making process (Dilla and Raschke, 2015).

A Key performance indicator (KPI) represents a numerical value that can be evaluated against either an internal target or an external benchmark, offering a reflection of performance. This value may originate from data that is either gathered or derived from different processes or activities (Ahmad and Dhafr, 2002). The choice of specific measures and indicators for ongoing assessment is vital for an organization’s success, which is why KPIs are subject to regular and comprehensive analysis. These indicators represent a series of measurable factors that provide insights into how effectively an organization is meeting its strategic goals, assisting in the definition of performance targets for departments or individuals, allowing for benchmarking against competitors, and influencing the distribution of rewards and consequences among employees (Setiawan and Purba, 2020). Bernard Marr(2024), who simplifies the definition of Key Performance Indicators (KPIs) by stating that they serve as a means of communicating an organization's performance to stakeholders, assisting them in determining whether the organization is aligned with its strategic goals and objectives. The application of KPIs allows organizations to achieve three key objectives. First, they facilitate learning and improvement among team members, as the data provided can lead to more informed decision-making and subsequent enhancements. Second, KPIs can be utilized for external communication with stakeholders, demonstrating compliance with external reporting standards and requirements. Finally, KPIs enable the oversight and management of individual behaviors and actions, as they objectively assess the achievement of goals and offer feedback on any deviations from expected outcomes, thereby aiming to minimize variance and enhance alignment.

2.5 Existing Works on Waste Management Dashboard

This research underscores the necessity of data-driven decision–making in waste management, particularly in urban settings. It identifies an absence of integrated dashboards that effectively display waste data alongside socio-economic indicators. To bridge this gap, the research develops a GIS-based dashboard that visualizes six years of household waste data from New South Wales (NSW), Australia, classified into recyclable, residual, and organic waste, through the use of thematic mapping, spatial relationship maps, and correlation matrices. This methodology involved the systematic collection and preprocessing of extensive datasets, followed by the implementation of advanced GIS tools for conducting spatial analyses. The results highlight a significant relationship between waste generation and socioeconomic factors, illustrating how changes in the population can affect waste tonnage and the potential impact of land values on waste production. The findings of this research are important for advancing waste management dashboards, as it illustrates how the benefits of merging multiple data sources with advanced visualization techniques can enhance the effectiveness and informative depth of tools designed for urban waste management (Xu et al., 2023).

This research introduces the Environmental Waste Utilization (EWU) score as a more inclusive metric for assessing the performance of waste management systems, offering a superior alternative to traditional indicators such as recycling and diversion rates. The EWU score takes into account both the environmental benefits of recovered materials and energy, as well as the ecological burdens imposed by waste treatment processes. A significant advancement of this study is the introduction of the EWU Dashboard, a spreadsheet-based tool that allows for the calculation and monitoring of EWU scores across multiple waste streams and treatment options. This dashboard enables users to easily compare the environmental impacts of various waste management strategies, including recycling, incineration, and landfilling. It is designed for policymakers, providing them with the capability to stimulate different scenarios and understand the trade-offs associated with different waste treatment options. It also provides an interactive platform that enables users to modify parameters related to various waste types, treatment methodologies, and recovery processes, with immediate updates to scores that reflect environmental consequences. This research contributes significantly to understanding how performance metrics, represented through dashboards, in improving decision-making within waste management, particularly in the context of developing waste management dashboards that concentrate on Scotland's waste data (Schmidt and Laner, 2023).

This research presents an innovative dashboard that integrates a variety of environmental metrics, providing a thorough assessment of a data center's green compliance. This dashboard employs a three-color coding framework (red, green, yellow), to represent the performance of essential sustainability indicators, allowing data center managers to identify the areas in need of improvement. It monitors several environmental factors, such as energy consumption, material recycling, and cooling system efficiency, consolidating these metrics into a singular environmental score. This research is closely aligned with waste management dashboards, highlighting the role of visual tools in tracking environmental performance and ensuring compliance. This methodology underscores the importance of user accessibility, with a dashboard that is easy to navigate and intuitive, while also offering essential insights into environmental sustainability. For waste management purposes, similar dashboards metrics such as Recycle efficiency, Landfill and Incineration rates can be integrated, which would assist cities and policymakers in enhancing their waste management strategies. This study provides important insights into the utilization of dashboards to clarify complex environmental data and support decision—making processes, thereby underscoring its relevance for future advancements in waste management (Muthaiyah et al., 2013).

This research unveils a specialized dashboard to provide an analysis of waste management in production processes, specifically for the leather tanning industry. By incorporating ERP systems, the dashboard supports automated data collection and monitoring of various environmental performance metrics, including energy use, water consumption, and waste generation. This strategy aims to reduce environmental impacts and ensure that production processes meet sustainability targets. The dashboard consolidates these metrics and displays them in an accessible, real-time interface. Key Perform Indicators (KPIs) are color-coded to facilitate users to easily evaluate performance and compliance with environmental standards. This enables managers to identify the areas for improvement by allowing them to make data-driven decisions that help decrease environmental pollution. This paper illustrates the benefits of visual tools in promoting sustainable production practices and maintaining compliance with environmental regulations, positioning it as an essential reference for the creation of waste management dashboards that focus on advancing environmental performance (Nuraini et al., 2021).

3 Methodology

3.1 Introduction

The methodology for developing the Scotland Waste Management Data Analytics Dashboard is a crucial aspect of the project, guaranteeing that the data collected, processed, and analyzed is useful for the users. The dashboard's primary aim is to offer a comprehensive and user-friendly platform that facilitates the exploration and analysis of Scotland's waste management practices during the years 2021 and 2022. This methodology outlines a systematic approach to data collection from the Scottish Environment Protection Agency (SEPA), cleaning and preprocessing it to maintain its integrity, categorizing it for in-depth analysis, and ultimately presenting it in an interactive and accessible format via the dashboard. Key Perform Indicators(KPIs) are essential in this process, as they provide users with measurable metrics that enable comparisons and analyses of data from 2021 and 2022.

The objective of this chapter is to present the methodological strategies that underpin the research objectives of this study. It will provide a comprehensive overview of the diverse methods and techniques implemented for the collection, processing, and visualization of waste management data. The intention is to equip users with valuable insights regarding waste generation, recycling, recovery, and disposal practices, as well as waste management methods, including landfills and incineration, alongside household waste across different regions and sectors.

3.2 Research Approach

In this research, a quantitative approach was adopted to examine the waste management data of Scotland for the years 2021 and 2022. The data obtained from the SEPA, was analyzed and represented through Power BI, highlighting essential indicators such as recycling rates. Focusing on measurable data allows for an objective assessment of waste management effectiveness and the impact of strategies implemented over the analyzed period.

3.2.1 Quantitative Research Method

In this research, a quantitative methodology was employed to analyze and evaluate waste management data in Scotland for the years 2021 and 2022. The primary data was sourced from the Scottish Environment Protection Agency (SEPA), which provided extensive waste statistics classified by waste type recyclable, recoverable, disposed, region, and kilograms per capita. The dataset was preprocessed with Python to remove any duplicate entries and to highlight the cities generating the most household waste. The cleaned data was then visualized in Power BI, creating a dynamic dashboard that included interactive features such as slicers, maps, and charts.

The performance of the dashboard was assessed using key performance indicators through the implementation of Data Analytics Expressions (DAX). These KPIs were subjected to quantitative analysis to identify trends over time and to compare the performance of waste management across different regions. This quantitative methodology supports an objective evaluation of the success of waste management strategies, thereby enabling policymakers to make data-driven decisions. Statistical techniques, including correlation analysis and percentage change calculations, were applied to compare the data from the years 2021 and 2022.

3.3 Research Tools and Applications

3.3.1 Hardware Requirements

Processor: multi-core CPU (e.g. Intel i5 or AMD Ryzen 5) for optimal data processing and model training.

Memory: It is recommended to have no less than 8 GB of RAM to support the handling of extensive datasets and for uninterrupted functioning of dashboard.

3.3.2 Software Requirements

Python: The main programming language utilized for the development of algorithms and the handling of data.

Excel: It is used for a role in the processes of data cleaning, organization, and initial analysis, making it essential for the preparation of data prior to its integration into more complex dashboards.

Power BI: It serves as an accessible platform that connects with various data sources, allowing users to create interactive and dynamic visualizations alongside detailed reports, which ultimately support enhanced decision-making based on data analysis.

Kaggle: A popular platform for data science and machine learning, providing a vast repository of datasets, code, notebooks, and competitions. This platform enables users to advance, share, and enhance their skills in data science.

3.4 Research Planning

3.4.1 Data Collection

The dataset used for the Scotland Waste Management Data Analytics Dashboard was primarily acquired from the Scottish Environment Protection Agency (SEPA), the principal authority for environmental data in Scotland. This data is specifically selected for its extensive coverage of waste management practices in Scotland during the years of 2021 and 2022. It includes various waste categories, such as recycle, recover, and disposed waste, along with the quantities managed through different management methods, including landfill and incineration waste. Additionally, the dataset encompasses waste generation information from key sectors, including construction and industrial, commercial, and household waste data that monitor waste production on a per capita basis across different regions.

3.4.2 Data cleaning and preprocessing

The process of data cleaning and preprocessing is a fundamental aspect of the methodology, as it ensures that the data is accurate, consistent, and relevant prior to its analysis and visualization in the Scotland Waste Management Data Analytics Dashboard. A primary step in this data-cleaning process was to identify and eliminate duplicate values. Duplicate entries within the dataset can significantly lead to misleading analytical results, particularly when calculating key performance indicators (KPIs) such as waste generation totals or recycling rates. To resolve this issue, the dataset was carefully assessed for duplicate records using Python's Pandas library to effectively identify and remove any repeated entries.

To achieve a focused analysis of Scotland's waste management practices, particularly regarding relation to household waste, it was essential to filter the dataset to underscore the regions that generate the highest level of waste. The filtering process included the aggregation of household waste data by region and subsequently ranking these regions according to the total tonnage of waste generated in 2021 and 2022. Such a ranking facilitated and identification of regions with the greatest waste output. Here are a few examples of coding.

```
//checking for duplicate values
manage1=management1.duplicated()
print(management1[manage1])
```

```
Empty DataFrame
Columns: [Waste type, Disposed, Recovered, Recycled]
Index: []
```

Figure 1 Checking duplicate values for waste management

```
//checking for duplicate values
land1=landfill1.duplicated()
print(landfill1[land1])
```

```
Empty DataFrame
Columns: [Waste type, 2021, Unnamed: 2]
Index: []
```

Figure 2 Checking duplicate values for waste landfill

```
//checking for duplicate values
gener1=generation1.duplicated()
print(generation1[gener1])
```

```
Empty DataFrame
Columns: [Waste type, Commercial and industrial, Construction and demolition, Household]
Index: []
```

Figure 3 Checking duplicate values for waste generation

```
//reading csv file
household2=pd.read_csv('/kaggle/input/scott-wastemanagement/Household waste generation 2022.csv
//filtering top waste producing cities
cities2=['Aberdeen City','Aberdeenshire','City of Edinburgh','Dundee City','Falkirk','Fife',
         'Glasgow City','Stirling','South Lanarkshire','North Lanarkshire','Highland']
filthouse2=household2[household2['Region'].isin(cities2)]
//displaying filtered region
print(filthouse2.head())
```

```
              Region    Tonnes  kg/person
0       Aberdeen City    88,802        396
1       Aberdeenshire  1,09,675        416
4   City of Edinburgh  1,87,628        366
7         Dundee City    60,499        409
12            Falkirk    64,308        406
```

Figure 4 Filtering top household waste producing cities

3.5 Design Principles and Features of the Dashboard

The Scotland Waste Management Dashboard system was created with a primary focus on delivering an intuitive and robust platform for the analysis and interpretation of waste management data. The system's design was driven by a set of essential principles aimed at ensuring the system meets the needs of its users. In order to improve user experience, the dashboard focuses on facilitating user-friendly navigation, ensuring that users can readily access important data points such as waste collection volumes, recycling rates, and landfill utilization. It features real-time data visualization tools that allow users to analyse trends over time and make good decisions. The dashboard allows for high-level of cutsomization, enabling various stakeholders, from local authorities to policymakers, to modify their views based on individual needs. Key performance indicators (KPI) are prominently featured, providing a clear overview of current waste management performance. Additionally, the platform allows users for the incorporation of external data sources, ensuring a thorough understanding of waste operations across various regions in Scotland.

3.5.1 User-friendly Design with Intuitive Navigation and Visual Clarity

The design of this dashboard prioritizes accessibility for users with a range of technical skills. This ensures that whether an individual is a data analyst or a policymaker with limited familiarity with data visualization, they can navigate the dashboard effectively and obtain valuable insights. Achieving this goal involved the use of uncomplicated language, explicit labeling, and well-structured data presentations. Effective navigation is also essential for the users to locate and engage with the data they require. This dashboard is arranged in a clean and logical manner, that facilitates smooth transitions between different sections. Important information is prioritized, and complex data sets are segmented into manageable portions to prevent users from feeling overwhelmed. Additionally, visual clarity was a fundamental aspect of the design. This dashboard features a consistent colour scheme and a clear visual hierarchy to underscore significant data and trends. The charts and graphs are crafted to be easily understandable, complete with labels and legends that clearly define the data's significance. This design strategy enables users to quickly understand the insights being conveyed, eliminating the need for users to decode complex visual representations.

3.5.2 Button features

This dashboard is organized into several sections that are designed to offer a thorough insight into waste management practices. The Summary button presents a high-level overview of critical data insights, encompassing evaluations of total waste generation and management activities throughout Scotland for 2021 and 2022. This feature allows users to quickly assess overall performance and the dashboard's capabilities. The Waste Generation button offers a detailed explanation of waste generation across various sectors, such as commercial, construction, industrial, and residential waste. Users can apply filters to get details of specific waste categories or sectors, facilitating the identification of trends and major contributors to total waste. The Waste Management button is designed to oversee the administration of various waste types, particularly recycling, recovery, and disposal techniques. This feature enables users to evaluate the efficiency of different strategies across multiple regions and time frames, thereby highlighting opportunities for enhancement or successful initiatives that could be expanded. The household waste button provides a comprehensive analysis of household waste statistics, presenting regional distributions and per capita data through visual representations such as graphs and maps. This aids the local authorities and policymakers in targeting interventions in regions characterized by higher waste generation rates. The Waste Management methods provide an in-depth analysis of various disposal techniques, including landfill and incineration, while incorporating filters that enable users to concentrate on specific waste categories or geographical locations. Furthermore, the KPI (Key Performance Indicators) feature enables users to compare waste management performance between 2021 and 2022, incorporating metrics like recycling rates, recovery rates, disposal rates, total waste generation and landfill/incineration rates. This analysis offers insights into Scotland's progress and highlights areas for potential improvement or decline in waste management strategies over time.

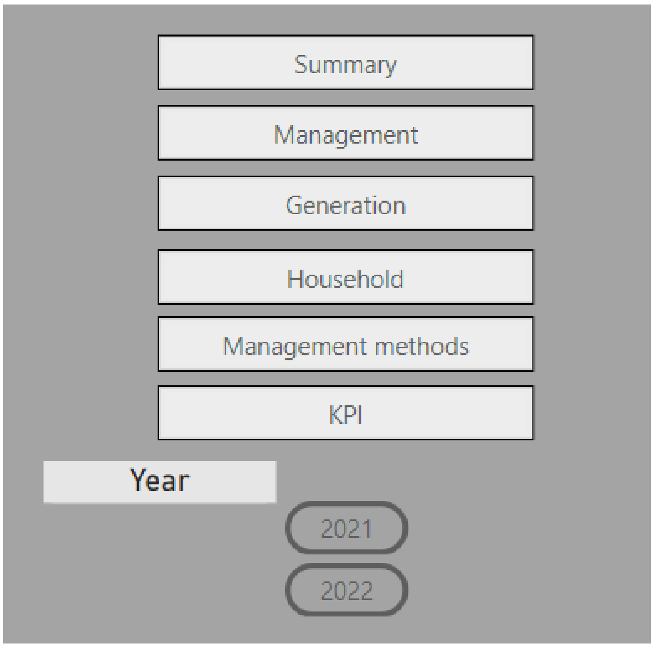


Figure 5 Button features to navigate through multiple pages

3.6 Data classifications

Data classification serves as an essential component in the structuring and examination of the substantial waste management data collected for the Scotland Waste Management Dashboard. The process involves the grouping of data into meaningful categories, which enhances targeted analysis and provides significant insights into waste management practices.

A fundamental classification applied to the dataset is based on the type of waste management, dividing waste into recyclable, recoverable, and disposed categories. This classification enables the dashboard to conduct a detailed analyze to the management of each waste type specifically across Scotland from 2021 and 2022.

3.6.1 Sector-based classification

In this dashboard waste generation data was categorized according to economic sectors, including commercial and industrial, construction and demolition, and household. This sector-specific classification is crucial for evaluating waste management practises across various economic activities, thereby assisting policymakers and industry leaders in identifying specific challenges and opportunities for the improvement of waste management practices.

Figure 6 Generation of waste from various sectors

3.6.2 Geographic Classification

The classification of household waste data geographically involved organizing the data by region and per capita waste output, expressed in kilograms per person. This approach is essential for grasping the regional variations in waste generation and management practices. It not only enhances the understanding of waste trends across Scotland but also supports the development of targeted strategies and the effective allocation of resources to improve waste management practices at the regional level.

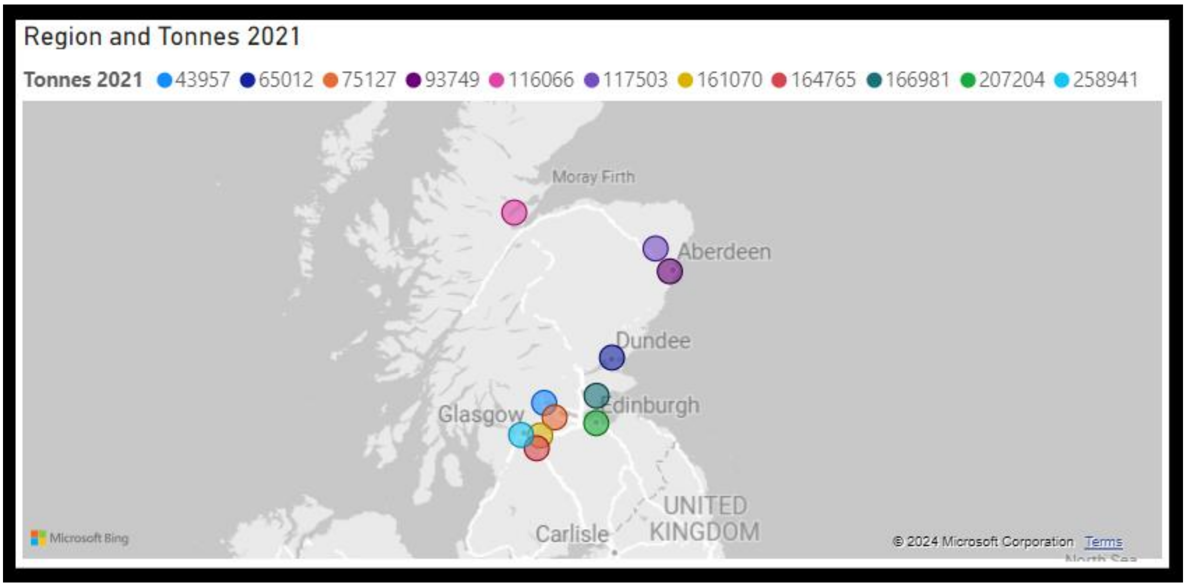


Figure 7 Household waste by regions (2021)

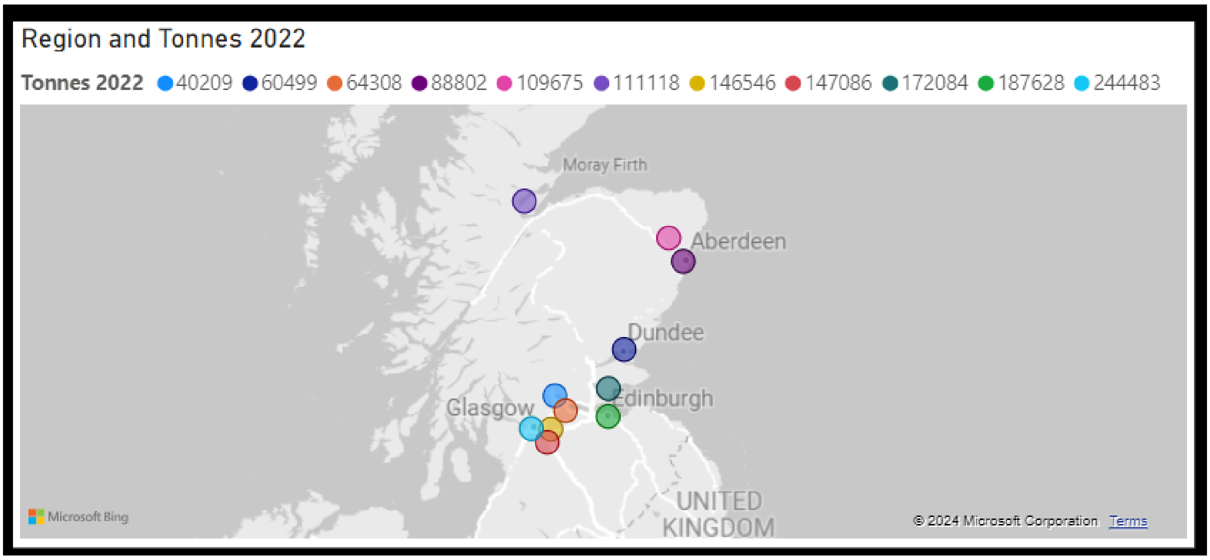


Figure 8 Household waste by regions (2022)

3.6.3 Disposal method

The waste data was categorized according to disposal methods, with a focus on landfills and incineration. This classification is crucial for understanding the final disposal of waste and the environmental impacts, including land and air pollution, that arise from these methods. It plays a significant role in assessing the effectiveness of waste management policies and driving progress in sustainable waste management solutions.

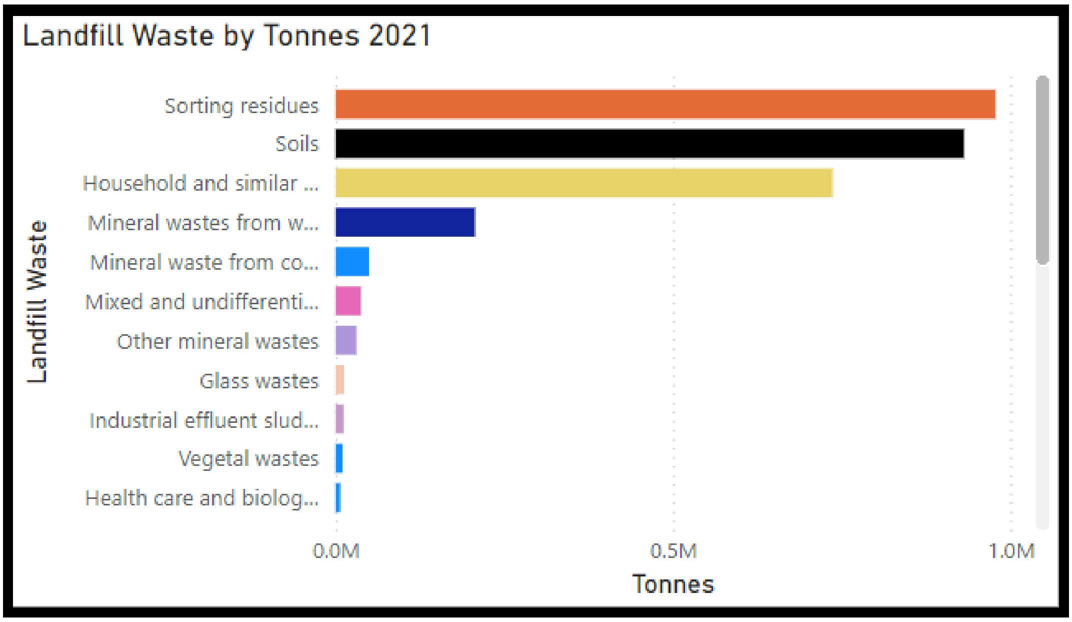


Figure 9 Landfill waste by tonnes (2021)

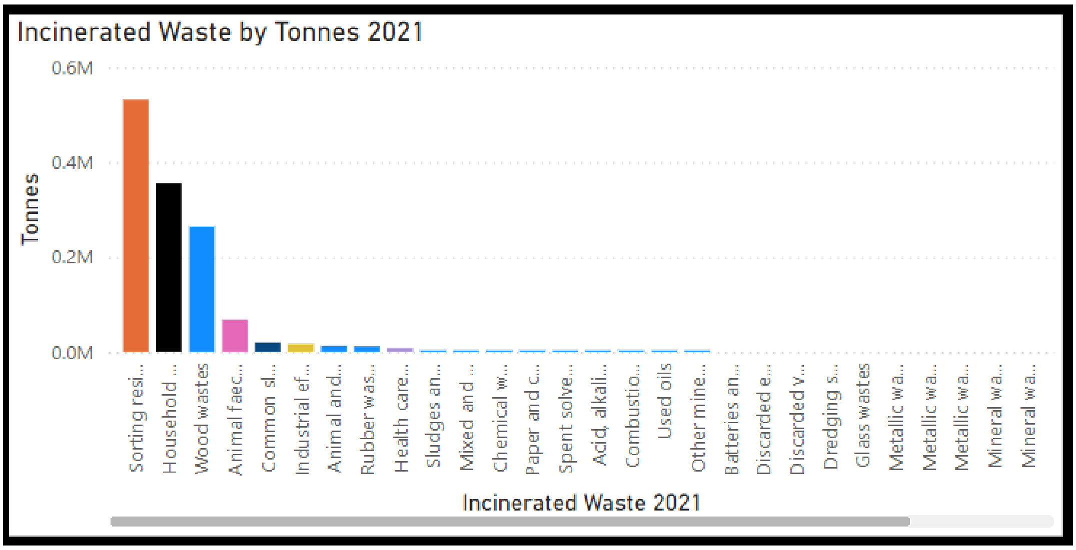


Figure 10 Incinerated waste by tonnes (2022)

3.7 KPI Calculations and Comparative Analysis

This dashboard integrates various Key Performance Indicators (KPIs) to measure the performance of waste management practices across Scotland for the years 2021 and 2022. These KPIs deliver both percentages and totals of waste to the users, allowing for an in-depth analysis of the results. Key indicators featured in the dashboard include the recycling rate, recovery rate, disposal rate, total waste generation, and the rates of landfill and incinerated waste. Additionally, it provides insights into household waste per kilogram per individual and the efficiency rate of waste management. The analysis and comparisons of these metrics were conducted using DAX (Data Analysis Expressions) within the dashboard, ensuring that the evaluations of the KPIs are both accurate and dynamic.

- **Total Waste Generation:** It signifies the aggregate amount of waste produced across all sectors and regions. This total is calculated by summing the waste data reported from different sectors and geographical areas.

```
Total Waste generation 2021 = SUM('Waste generation 2021'[Commercial and industrial])+SUM('Waste generation 2021'[Construction and demolition])+SUM('Waste generation 2021'[Household])
```

```
Total Waste generation 2022 = SUM('Waste generation 2022'[Commercial and industrial])+SUM('Waste generation 2022'[Construction and demolition])+SUM('Waste generation 2022'[Household])
```

Figure 11 DAX formula for total waste generation (2021 and 2022)

- **Waste Management Efficiency:** It evaluates the effectiveness of waste management practices and assesses the ratio of waste that is successfully recycled or recovered to the total waste generated. This indicator serves to evaluate how effectively Scotland is minimizing waste disposal through landfills and incineration. The calculation involves summing the total quantities of waste recycled and recovered, dividing this total by the overall waste generated, and presenting the outcome as a percentage.

```
Waste Management efficiency 2021 = DIVIDE(CALCULATE(SUM('Waste management 2021'[Recycled]))+CALCULATE(SUM('Waste management 2021'[Recovered])),CALCULATE(SUM('Waste generation 2021'[Commercial and industrial]))+CALCULATE(SUM('Waste generation 2021'[Construction and demolition]))+CALCULATE(SUM('Waste generation 2021'[Household])))*100
```

```
Waste Management efficiency 2022 = DIVIDE(CALCULATE(SUM('Waste management 2022'[Recycled]))+CALCULATE(SUM('Waste management 2022'[Recovered])),CALCULATE(SUM('Waste generation 2022'[Commercial and industrial]))+CALCULATE(SUM('Waste generation 2021'[Construction and demolition]))+CALCULATE(SUM('Waste generation 2021'[Household])))*100
```

Figure 12 DAX formula for total management efficiency (2021 and 2022)

- **Recycling Rate:** This indicator assesses the proportion of total waste that is recycled. It is computed by dividing the total amount of waste that has been recycled by the total waste generated, and then multiplying the result by 100 to yield a percentage representation.

```
Recycling rate 2021 = DIVIDE(CALCULATE(SUM('Waste management 2021'[Recycled])),CALCULATE(SUM('Waste generation 2021'[Commercial and industrial]))+CALCULATE(SUM('Waste generation 2021'[Construction and demolition]))+CALCULATE(SUM('Waste generation 2021'[Household])))*100
```

```
Recycling rate 2022 = DIVIDE(CALCULATE(SUM('Waste management 2022'[Recycled])),CALCULATE(SUM('Waste generation 2022'[Commercial and industrial]))+CALCULATE(SUM('Waste generation 2022'[Construction and demolition]))+CALCULATE(SUM('Waste generation 2022'[Household])))*100
```

Figure 13 DAX formula for recycling rate (2021 and 2022)

- **Recovery Rate:** This indicator includes various methods of waste recovery, such as recycling, composting and energy recovery. The calculation for the recovery rate is analogous to that of the recycling rate, but it includes all forms of recovered waste rather than focusing solely on recycling.

```
Recovery rate 2021 = DIVIDE(CALCULATE(SUM('Waste management 2021'[Recovered])),CALCULATE(SUM('Waste generation 2021'[Commercial and industrial]))+CALCULATE(SUM('Waste generation 2021'[Construction and demolition]))+CALCULATE(SUM('Waste generation 2021'[Household])))*100
```

```
Recovery rate 2022 = DIVIDE(CALCULATE(SUM('Waste management 2022'[Recovered])),CALCULATE(SUM('Waste generation 2022'[Commercial and industrial]))+CALCULATE(SUM('Waste generation 2022'[Construction and demolition]))+CALCULATE(SUM('Waste generation 2022'[Household])))*100
```

Figure 14 DAX formula for recovery rate (2021 and 2022)

- **Disposed Rate**: This indicator measures the percentage of total waste that is not recovered and is instead disposed of in landfills and incinerated without recovering energy. The calculation is performed by subtracting the recovered waste from the total waste from the waste produced, followed by dividing the figure by the total waste generated and presenting the result as a percentage.

```
Disposed rate 2021 = DIVIDE(CALCULATE(SUM('Waste management 2021'[Disposed])),CALCULATE(SUM('Waste generation 2021'[Commercial and industrial]))+CALCULATE(SUM('Waste generation 2021'[Construction and demolition]))+CALCULATE(SUM('Waste generation 2021'[Household])))*100
```

```
Disposed rate 2022 = DIVIDE(CALCULATE(SUM('Waste management 2022'[Disposed])),CALCULATE(SUM('Waste generation 2022'[Commercial and industrial]))+CALCULATE(SUM('Waste generation 2022'[Construction and demolition]))+CALCULATE(SUM('Waste generation 2022'[Household])))*100
```

Figure 15 DAX formula for disposed rate (2021 and 2022)

- **Landfill and Incinerated Waste:** The rates of waste sent to landfills and incineration were determined by calculating the percentage of total waste that was allocated to each of these disposal methods. This process specifically involved assessing the total waste directed towards landfilling or incineration.

```
Incinerated waste 2021 = SUM('Incinerated Waste 2021'[Year (2021)])
```

```
Incinerated waste 2022 = SUM('Incinerated Waste 2022'[Year (2022)])
```

```
Landfill waste 2021 = SUM('Waste landfill 2021'[(Year) 2021])
```

```
Landfill waste 2022 = SUM('Waste landfill 2022'[Year (2022)])
```

Figure 16 DAX formula for landfill and incinerated waste (2021 and 2022)

- **Household Waste:** The indicator of household waste assesses the quantity of waste generated by households in relation to the various regions. This total is calculated by summing the waste data reported from household waste from different regions.

```
Household waste 2021 = SUM('Waste generation 2021'[Household])
```

```
Household waste 2022 = SUM('Waste generation 2022'[Household])
```

Figure 17 DAX formula for household waste (2021 and 2022)

4 Analysis

4.1 Measuring Waste Management Dashboard Success with KPIs

4.1.1 Waste Management KPIs

The Recycling Rate is a significant KPI that measures the effectiveness of recycling efforts in Scotland. This KPI illustrates how well various strategies, such as public awareness initiatives, enhancements in waste sorting infrastructure, and the introduction of improved recycling programs. By analyzing the recycling rate for Scotland during the years 2021 and 2022, stakeholders can determine the success of these initiatives in encouraging sustainable waste management practices among residents and enterprises. An increase in the environmental impact of waste by diverting it from landfills and converting it into valuable materials.

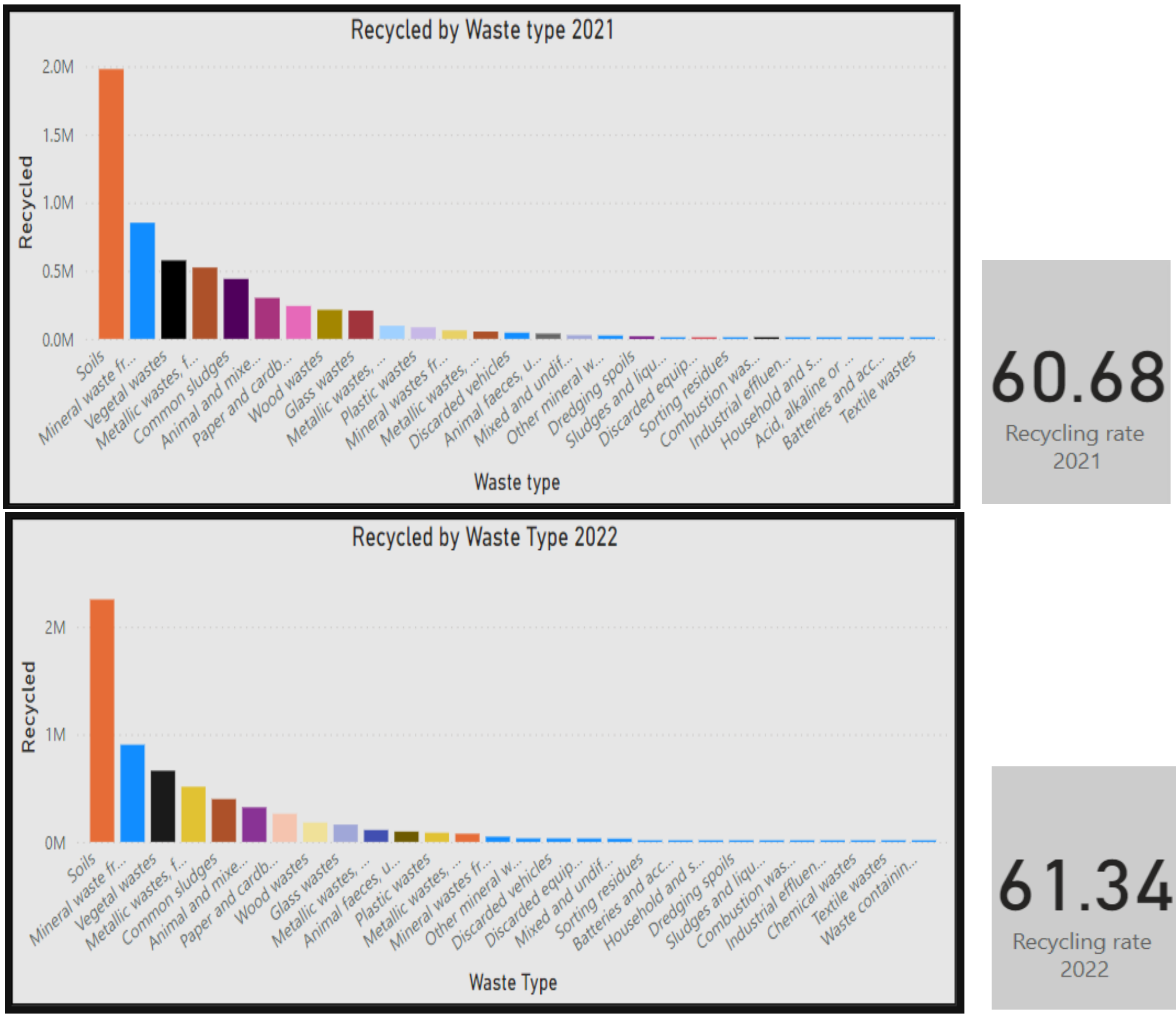


Figure 18 Recycling rate (2021 and 2022)

The Recovery Rate KPI provides a comprehensive view of waste management by including all categories of waste recovery. This indicator is significant for understanding Scotland's success in diversion waste from landfills and transforming it in a manner that supports a circular economy. A higher recovery rate reflects the efficacy of strategies designed to enhance resource recovery and minimize waste generation. By tracking this KPI, policymakers can assess the overall effects of waste recovery strategies and recognize areas that may benefit from enhanced sustainability efforts.

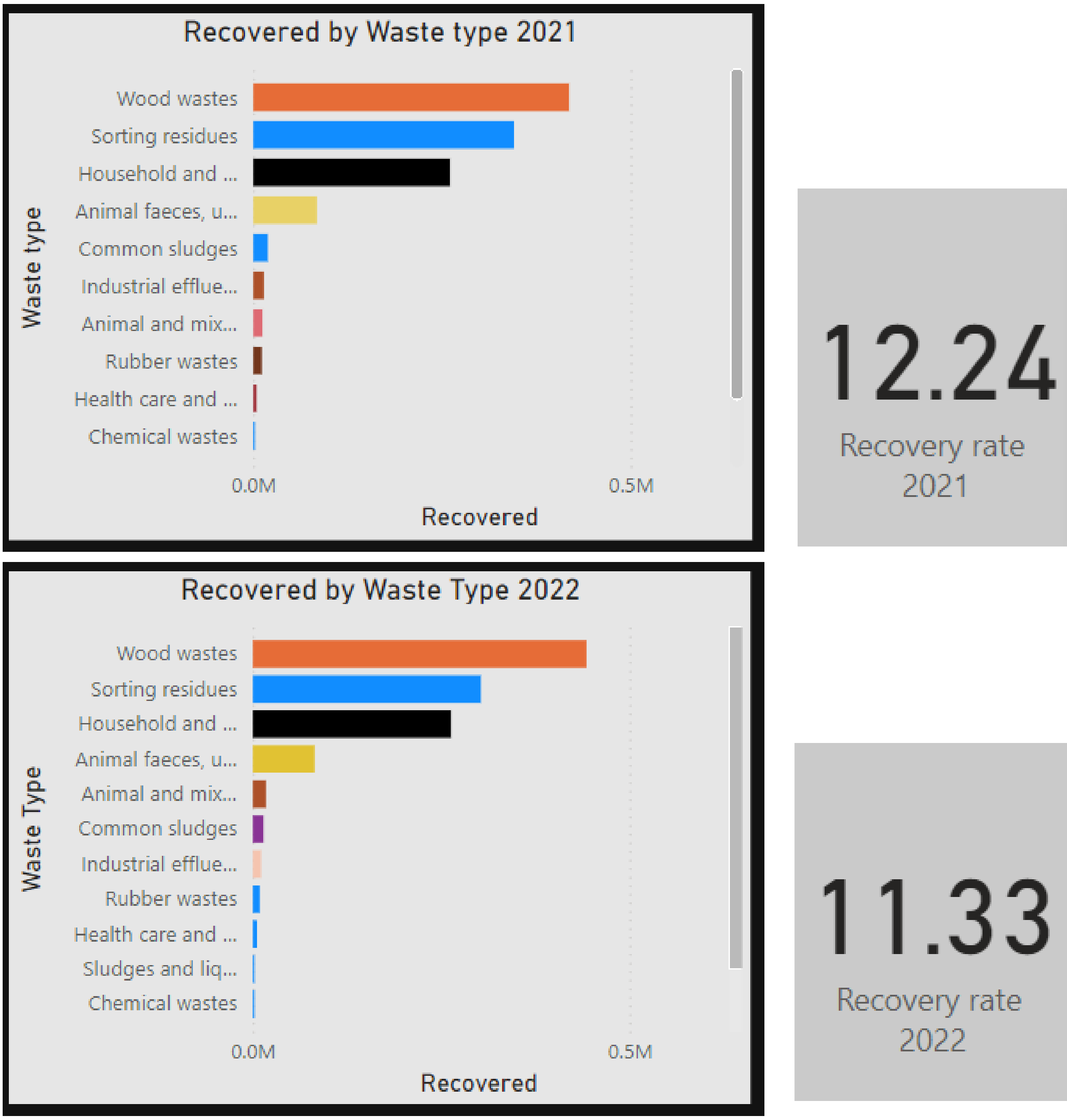


Figure 19 Recovery rate (2021 and 2022)

The Disposal Rate indicator lies in its ability to measure the effectiveness of waste diversion strategies designed to minimize the dependence on disposal methods. A reduced disposal rate serves as a clear indicator of waste reduction and diversion efforts, indicating that less waste is being allocated to landfills or incineration. By concentrating on this KPI, stakeholders can evaluate the performance of current waste management policies and identify any existing gaps in the system, which will aid in directing future improvements.

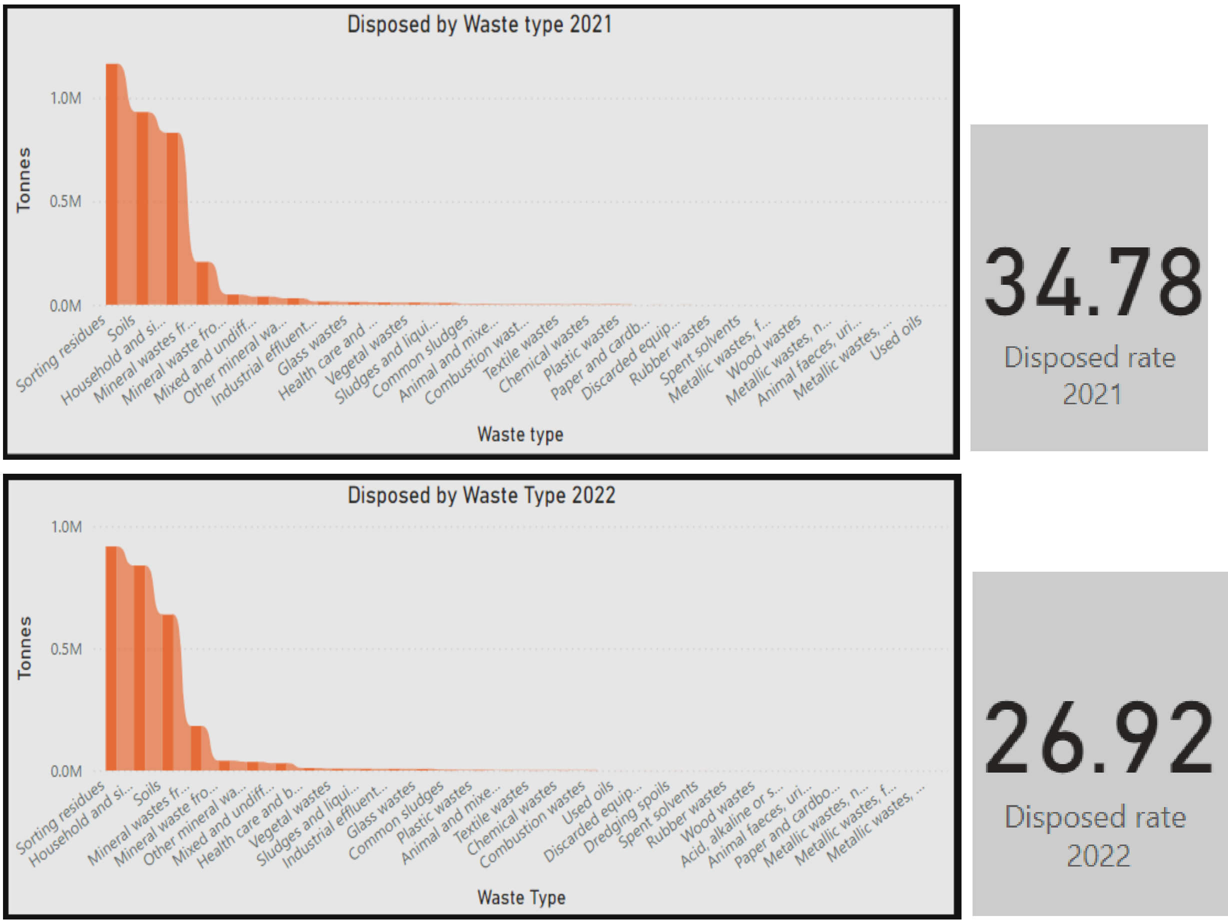


Figure 20 Disposed rate (2021 and 2022)

The Landfill and Incineration Rates as Key Performance Indicators are essential for evaluating waste management at the end of its lifecycle. These indicators are fundamental in evaluating the success of policies designed to decrease landfill reliance and improve waste disposal methods. Continuous monitoring of these rates enables stakeholders to determine whether Scotland is advancing towards more sustainable waste management practices and mitigating its environmental impact.

Figure 21 Landfill and incinerated waste KPI (2021 and 2022)

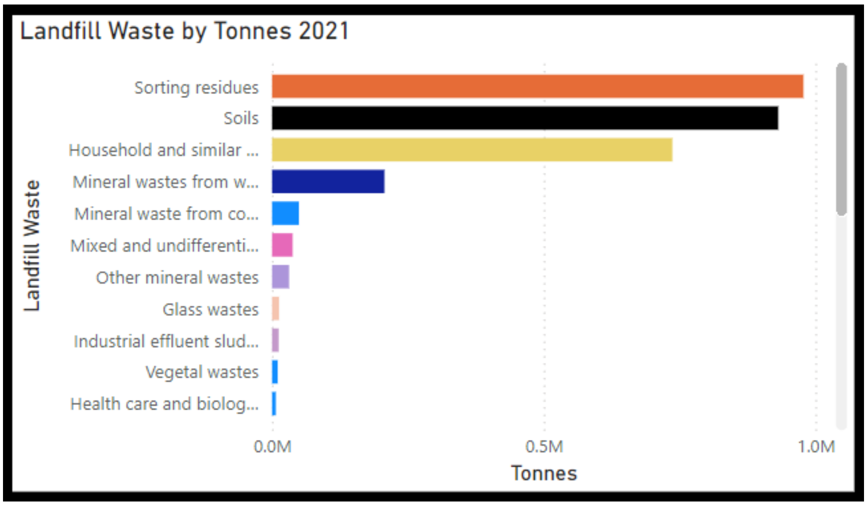
The Waste Management Efficiency KPI is an important measure of the overall success of Scotland's waste management policies. It provides a detailed evaluation of waste management policies by focusing the ratio of waste that is successfully recycled or recovered. A higher efficiency rate suggests Scotland's capability to minimize waste disposal through sustainable practices. This KPI is essential for evaluating the success of various waste management strategies and provides significant insights into the advancements made toward Scotland's environmental sustainability goals. By monitoring this efficiency, stakeholders can ensure that resources are being utilized effectively for responsible waste management.

Figure 22 Waste Management Efficiency KPI (2021 and 2022)

4.2 Highlighting Trends in Landfill Usage and Incineration Rates

4.2.1 Visualizing Trends in Landfill Utilization

This dashboard represents a clustered bar chart that represents landfill waste measured in tonnes for the years 2021 and 2022. This visualisation is particularly effective in showcasing the total amount of waste sent to landfills during these two years, allowing users to make quick comparisons between the data. The clustered bar chart simplifies the process of evaluating changes in landfill usage, indicating whether there has been an increase or decrease in waste disposal.



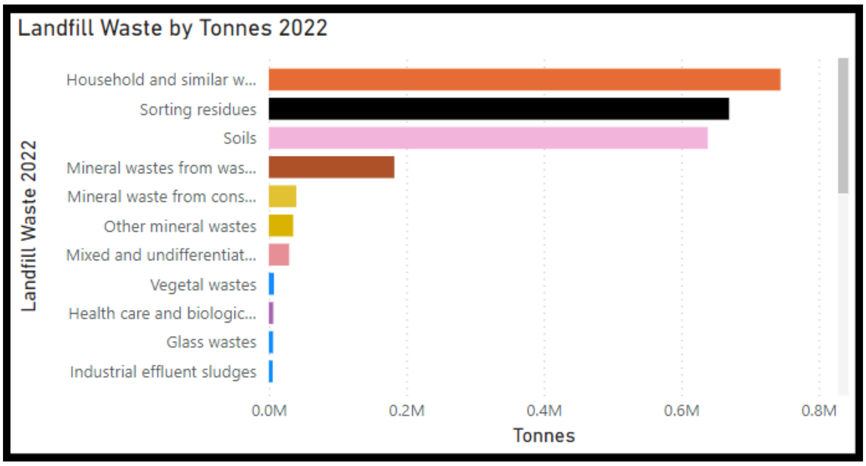


Figure 23 Clustered bar chart of Landfill waste by tonnes (2021 and 2022)

For a more detailed analysis, users can interact with the dashboard through a slicer that allows data filtering by specific waste types. This feature is important for understanding which waste categories contribute most to landfill totals and whether there have been improvements in

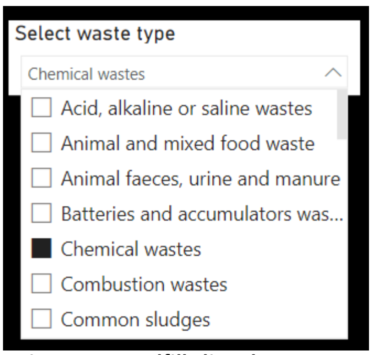


Figure 24 Landfill slicer by waste type

their management. For instance, users can select "household waste" or "industrial waste" to track how landfill usage for these specific types has evolved over time. These detailed insights are crucial for recognizing successful waste reduction initiatives or identifying areas that may require additional intervention.

Additionally, this dashboard includes a table that categorizes the top ten waste types by tonnes allocated to landfill in both 2021 and 2022. This table provides a clear and organized overview of the leading contributors to landfills, enabling users to identify the waste types that are most frequently disposed of in landfills. By analyzing the top ten waste types from both years, users can readily evaluate any significant changes in landfill waste composition, thereby aiding in the development of future waste management policies.

Top 10 Landfill waste 2021

Waste type
Glass wastes
Household and similar wastes
Industrial effluent sludges
Mineral waste from construction and demolition
Mineral wastes from waste treatment and stabilised wastes
Mixed and undifferentiated materials
Other mineral wastes
Soils
Sorting residues
Vegetal wastes

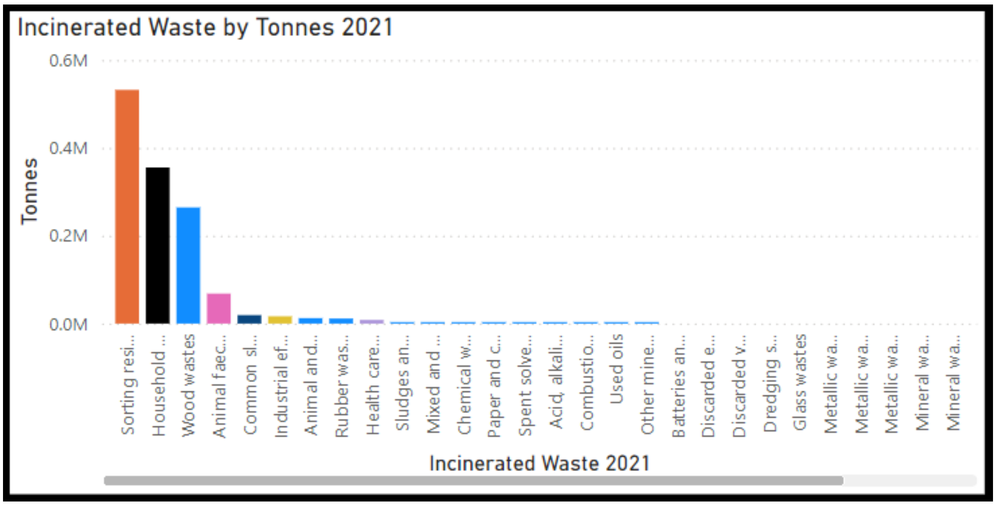
Top 10 Landfill waste 2022

Waste type
Vegetal wastes
Sorting residues
Soils
Other mineral wastes
Mixed and undifferentiated materials
Mineral wastes from waste treatment and stabilised wastes
Mineral waste from construction and demolition
Household and similar wastes
Health care and biological wastes
Glass wastes

Figure 25 Top ten landfill waste types (2021 and 2022)

4.2.2 Tracking Trends in Incineration Waste

This dashboard presents a clustered column chart depicting the amount of waste incinerated, measured in tonnes, for 2021 and 2022. This chart acts as an effective means of tracking the trends in incineration practices within Scotland, offering a visual description of the quantity of waste being incinerated and the changes in this practice over time.



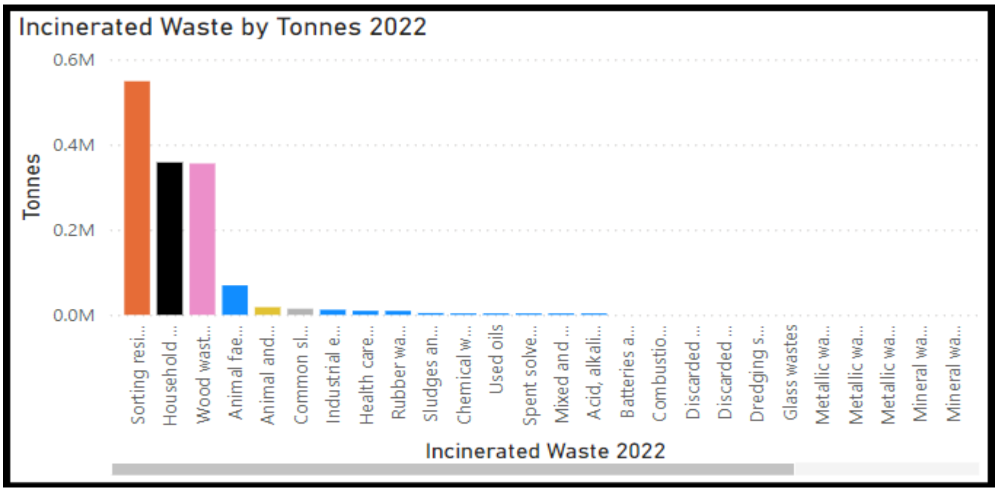


Figure 26 Clustered bar chart of Incinerated waste by tonnes (2021 and 2022)

Similar to landfill visualisation, the incineration chart is enhanced by a slicer that allows users to filter the data based on specific waste types. This feature is essential for understanding which categories of waste are more likely to be incinerated and whether the utilization of this method has increased or decreased over time. For example, users may choose “organic waste” to analyze fluctuations in incineration rates for this specific category, thereby gaining insights into the evolving landscape of waste management practices.

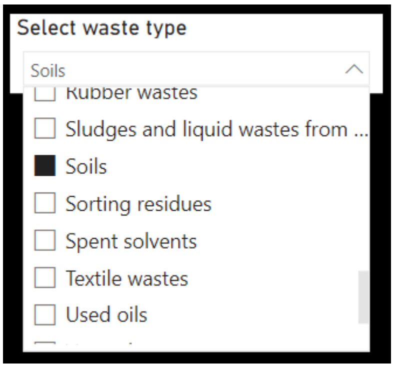


Figure 27 Incineration slicer by waste type

This dashboard comprises a table that lists the top ten waste types by tonnes for incineration during 2021 and 2022. This table, similar to the one employed for landfill waste, allows users to efficiently identify the waste types that have been incinerated the most and to compare their rankings over the two-year period. By offering a comprehensive overview of the largest contributors to incineration, this table enhances the understanding of any shifts in focus regarding specific waste types and how these align with the waste management goals of Scotland.

Top 10 Incinerated waste 2021

Waste Type
Wood wastes
Sorting residues
Sludges and liquid wastes from waste treatment
Rubber wastes
Industrial effluent sludges
Household and similar wastes
Health care and biological wastes
Common sludges
Animal faeces, urine and manure
Animal and mixed food waste

Top 10 Incinerated waste 2022

Waste Type
Animal and mixed food waste
Animal faeces, urine and manure
Common sludges
Health care and biological wastes
Household and similar wastes
Industrial effluent sludges
Rubber wastes
Sludges and liquid wastes from waste treatment
Sorting residues
Wood wastes

Figure 28 Top ten incineration waste types (2021 and 2022)

4.2.3 User Interface and Navigation

A key feature of the dashboard is its navigation buttons that correspond to specific years. By clicking on the buttons for 2021 or 2022, users are directed to a page that showcases the data from that year. This feature significantly enhances the user experience by providing a focused examination of the latest data, which is vital for users who are particularly focused on current trends and results.

The combination of these interactive features such as clustered charts, slicers, tables, and year-specific navigation enables users to easily navigate and interpret the trends in landfill usage and incineration rates. This dashboard is intentionally designed to be user-friendly, making it accessible to both seasoned data analysts and individuals with less technical skills.

4.3 Analyzing the Efficiency of Regional and Per Capita Household Waste Data Visualization for 2021 and 2022

4.3.1 Mapping Household Waste by Region

One of the key features of this dashboard is mapping capability, which visualizes household waste data by region. This feature enables users to quickly identify which regions are responsible for the highest waste generation, measured in tonnes. The map's visual format allows for the easy recognition of geographic trends in waste generation, such as the consistently higher waste output in urban areas compared to rural areas. Through the application of Python preprocessing to filter the cities with the most household waste, the dashboard presents only the most relevant data, thereby reducing unnecessary complexity and enhancing clarity. Additionally, the use of visual elements like colour gradients and markers on the map improves the user's capacity to recognize these trends, providing a clear and accessible means of comparing waste statistics throughout Scotland.

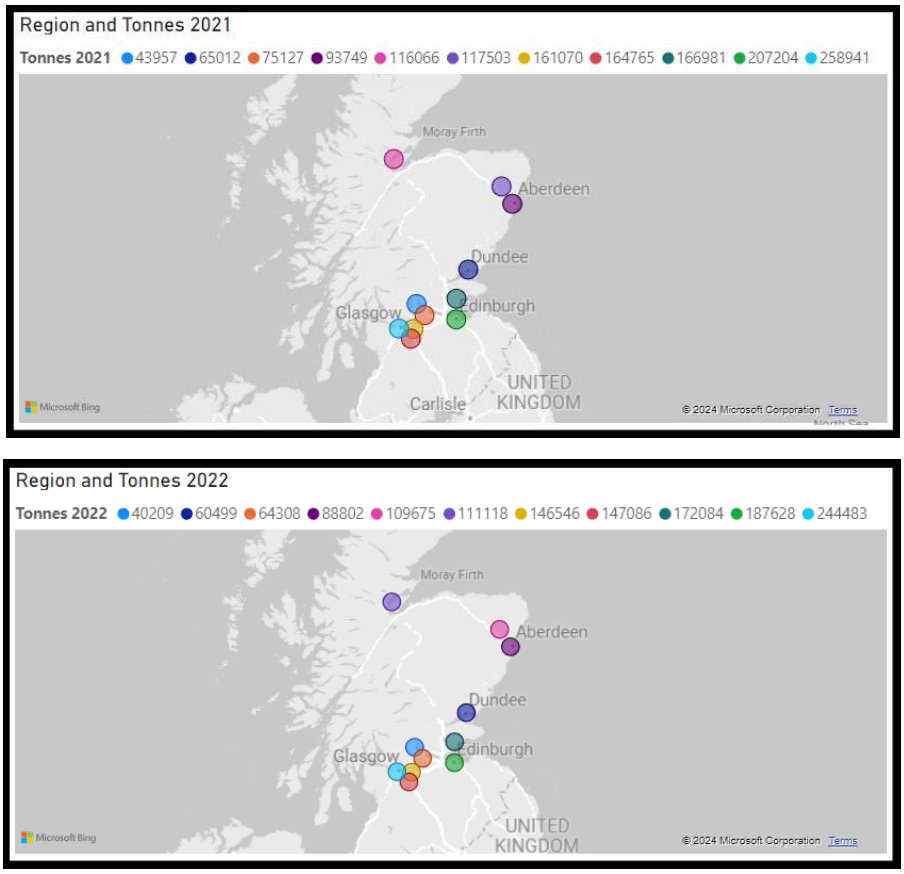
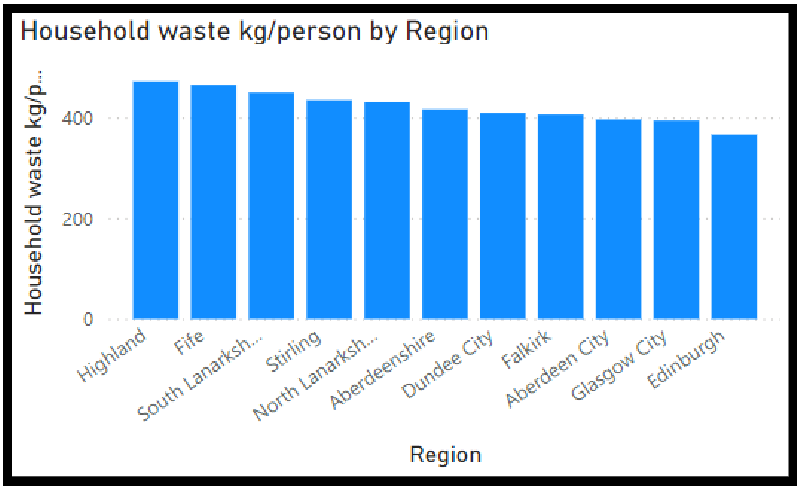


Figure 29 Household waste by region (2021 and 2022)

4.3.2 Evaluating Household Waste in Kilograms per Person



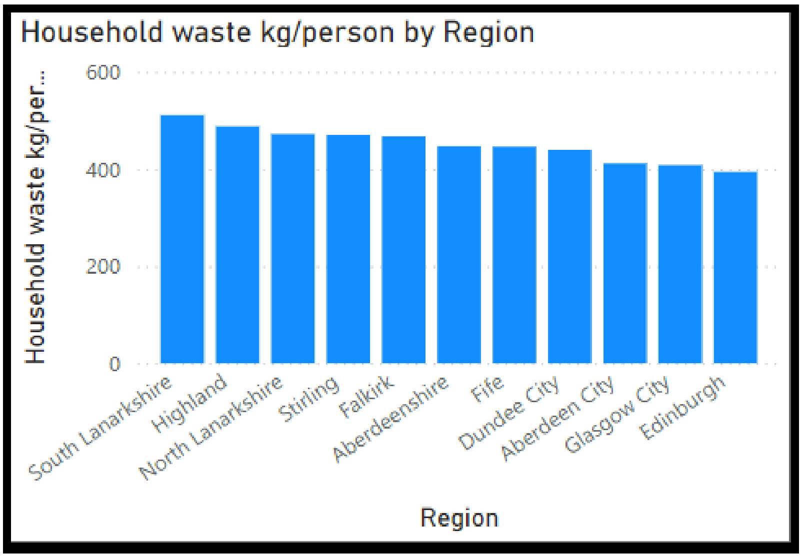


Figure 30 Household waste in kilograms per person (2021 and 2022)

The comparison of household waste generated in kilograms per person across various regions for the years 2021 and 2022. This chart is particularly useful for illustrating per capita waste generation, thereby offering a more standardized view of waste production that accounts for regional population differences. The clustered design, which displays the data for 2021 and 2022 in parallel, enables a clear comparison of how household waste per individual has evolved over time. This visualization is essential for assessing whether particular regions have succeeded in decreasing per capita waste, which serves as a significant indicator of the effectiveness of local waste management strategies.

4.3.3 Comprehensive Data Display Using Card Layout

The card method utilized in the dashboard represents a valuable feature which effectively summarizes the total household waste produced in both tonnes and kilograms per capita for the selected area. This summary is particularly useful for users who wish to examine a specific region, as it provides an immediate and clear overview of the waste statistics associated with that region. Moreover, the card's ability to dynamically reflect data changes based on user interactions with the slicer amplifies the dashboard's interactivity, allowing users to investigate the data further and gain targeted insights. For instance, when a user chooses a specific region using the slicer, the map, clustered column chart, and card concurrently refresh to present the corresponding data for that region. This integrated functionality among the dashboard components guarantees that users can access a complete set of information within a single view, thereby avoiding the need to navigate through multiple pages or visualizations. This card illustrates waste data in both total tonnes and total kg per person, providing a balanced insight that allows users to evaluate both the overall impact and the efficiency of waste management practices on an individual basis.

Figure 31 Household waste in tonnes and kilograms using card

4.3.4 User Interaction and Experience

This dashboard's interactive functionalities, including the slicer and the buttons for specific years, significantly improve the user experience. The slicer feature enables users to choose specific geographic areas, which promptly updates all related visualizations to reflect the chosen area. This level of interactivity is particularly important for users who need to concentrate on certain areas, whether for research, policy analysis, or operational strategies. Additionally, the year-specific buttons offer a convenient method for toggling between the datasets of 202 and 2022, enabling users to perform direct comparisons across years while maintaining contextual understanding.

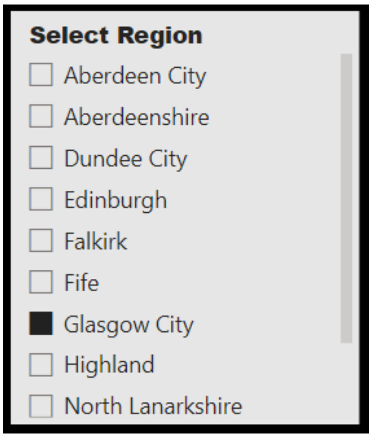


Figure 32 Household waste slicer by region

4.4 Possible Enhancements and Adjustments for the Scotland Waste Management Dashboard

4.4.1 Improved Data Precision and Advanced Filter Options

Enhancing the dashboard's functionality could be achieved by increasing the level of detail in the data it provides. Currently, this dashboard permits users to filter waste data into general categories like recoverable, recyclable, and disposed waste. However, a more effective classification into specific waste types such as plastics, organics, metals, and hazardous materials would offer users a deeper insight into waste generation and management. For instance, by analyzing recyclable waste into more specific subcategories, users could identify which materials are being recycled efficiently and which require enhanced recycling efforts.

The addition of more advanced filtering options would significantly improve the functionality of the dashboard. Specifically, allowing users to filter data by waste type, geographic area, and economic sector would allow for a more focused analysis. This capability could be particularly beneficial for policymakers focused on targeted waste management solutions or for researchers exploring the influence of socioeconomic conditions on waste production.

4.4.2 Optimized User Interface and Navigation

Although the current user interface is functional, there is significant potential for improving the user experience. By optimizing the navigation layout and decreasing the number of clicks required to access targeted data, the dashboard could become more accessible. For instance, instead of having individual pages for each year, a split-screen option could be introduced, allowing users to view and compare data from 2021 and 2022 side by side without the need to switch between pages. This adjustment would enhance the efficiency of the comparison process and assist users in gaining meaningful insights.

4.4.3 Real-Time Data Implementation

In order to maintain the dashboard's relevance and precision, the inclusion of real time data or more regular updates would be highly beneficial. At present, this dashboard focuses on historical data from 2021 and 2022. By adding functionality that supports ongoing data collection, users would be able to monitor waste management performance in real time. This enhancement would be particularly significant for local authorities and environmental agencies that require prompt decision-making based on the most current data. Additionally, consistent updates to the dashboard could introduce new key performance indicators (KPIs) or metrics that reflect the changing priorities in waste management.

4.5 Answering the Research Questions

Question #1

In what ways can the Key Performance Indicators (KPIs) displayed on the dashboard be utilized to evaluate the success of waste management strategies and policies that were implemented in Scotland in 2021 and 2022?

Answer: Analyzing the Key Performance Indicators (KPIs) featured on the dashboard allows policymakers to evaluate the growth of recycling efforts, the decline in landfill usage, and the improvements in waste management practices across various regions. The dashboard's ability to filter information by waste type and region provides a detailed assessment of localized policies, which enables targeted enhancements as needed. Additionally, the analysis of data from 2021 compared to 2022 reveals the effectiveness of Scotland's environmental policies in achieving sustainability goals.

Question #2

How well dashboard illustrate trends in landfill usage and incineration rates across Scotland for the years 2021 and 2022?

Answer: The dashboard illustrates trends in landfill usage and incineration rate across Scotland for the years 2021 and 2022 through the clustered column and bar chart. By aligning landfill and incineration data, users can easily compare the two years to identify significant trends. The interactive slicers provide the capability to focus on specific regions or waste types, offers a more detailed examination of waste management practices. Moreover, the year-specific buttons allow users to effortlessly switch between 2021 and 2022. This approach to visualization enhances the ability to evaluate the effectiveness of Scotland's waste management strategies in minimizing landfill use and promoting incineration with energy recovery.

Question #3

How effectively does the dashboard represent and facilitate the comparison of household waste management data across different regions and kilograms per individual for the years 2021 and 2022?

Answer: The Scotland Waste Management Dashboard provides an effective framework for comparing household waste data across regions, focusing on kilograms per individual for the years 2021 and 2022. Featuring clustered charts, interactive maps, and region-specific filters, this tool allows users to effectively analyze and compare per capita waste generation. Furthermore, the dashboard's card feature provides real-time summaries, allowing users to quickly evaluate waste trends and the success of management strategies.

Question #4

What improvements or modifications could be introduced to the dashboard to better align with user needs and improve the accuracy of waste management analysis?

Answer: To align more effectively with user expectations and increase accuracy, the dashboard might incorporate real-time data updates, which allow users to monitor waste management performance in a more dynamic manner. The integration of additional key performance indicators, such as carbon emissions from waste, would improve the depth of environmental analysis. Moreover, customizable user interfaces could enable various stakeholders to modify the dashboards to meet their unique requirements.

5 Conclusion and Future Work

The development of the Scotland Waste Management Dashboard, which compares waste management statistics 2021 and 2022, signifies an important milestone in advancing data-driven decision-making in waste management practices. This dashboard provides a detailed and intuitive interface that allows users to observe and assess various key performance indicators (KPIs), including recycling rates, landfill usage, recovery rates, and incineration rates. and household waste per capita. By utilizing data analytics platforms such as Power BI and employing advanced visualization techniques, the dashboard acts not only as a reporting tool but also as a critical resource for policymakers, local authorities, and environmental agencies dedicated to optimizing waste management strategies throughout Scotland.

This dashboard is remarkable for its effectiveness in visually representing large and complex datasets in a manner that is easily understandable. Through the use of interactive components such as slicers and buttons, users can investigate specific waste types or geographic areas, leading to enhanced insights into the data. A key advantage of this dashboard is ability to monitor key performance indicators (KPIs), providing an in-depth analysis of Scotland's waste management effectiveness. By clearly displaying these KPIs through clustered column charts, bar charts, and interactive maps, the dashboard enables users to easily interpret the data. This allows for quick assessments of whether recycling rates have improved, landfill usage has diminished, or if certain regions have excelled in managing household waste. This functionality is especially beneficial for policymakers, who can utilize the data to adapt waste management policies based on the observed performance metrics. The ability to complex datasets is vital for ensuring that decisions are based on accurate and current information. Additionally, the dashboard acts as an effective tool for comparative analysis. By allowing users to alternate between the data from 2021 and 2022, it allows for a comprehensive evaluation of waste management performance over these two successive years. This capability of comparison is particularly beneficial for identifying trends and patterns over time, including increases in recycling rates or decreases in landfill usage.

In conclusion, the Scotland Waste Management Dashboard is a detailed and effective mechanism for analyzing waste management data across the country. Its functionality in the visualization of key performance indicators such as household waste per capita, landfill usage, recycling rates, and recovery rates establishes it as a crucial tool for decision-makers. By allowing the users to compare year-over-year, the dashboard enhances informed decision-making and assists Scotland in achieving its environmental sustainability ambitions. As the landscape of waste management becomes more data-centric, instruments like this dashboard will be crucial in optimizing resource management, enhancing recycling practices, and reducing landfill reliance. This dashboard makes a significant evolution in waste management analytics, providing a strong platform for continuous analysis, decision-making, and future advancements.

5.1 Future Work

5.1.1 Integrating Predictive Models for Analytics

The integration of predictive analytics represents a highly promising direction for future development. Currently, this dashboard provides a detailed analysis of historical data from 2021 and 2022; however, it lacks the functionality to predict the future trends in waste generation and management. By integrating machine learning algorithms and predictive modeling, the dashboard could analyze past data to forecast future waste management trends, including expected increases in recycling rates or potential challenges associated with landfill usage. This advancement would allow policymakers and local authorities to engage in proactive planning for future waste management needs, rather than simply addressing issues as they emerge. For instance, predictive analytics could be utilized to project future waste generation based on factors like population growth, changes in recycling habits, and new policy initiatives.

5.1.2 Advanced Geographic Analysis

The current dashboard supplies regional waste management information, but future iterations could benefit from a more detailed geographic analysis. By enhancing the detail of regional data, a more accurate comprehension of local waste management practices could be achieved. For example, instead of utilizing broad regional categories, the dashboard could present data at the level of cities or neighborhoods. This would allow local authorities to pinpoint specific areas that require focused waste management actions or additional resources. By providing a more detailed examination, the dashboard could highlight areas where recycling efforts are insufficient or where excessive landfill use. Such detailed information would support the efficient allocation of resources and the formulation of policies, ensuring that waste management strategies are effectively implemented across Scotland.

5.1.3 Expanding KPI Metrics for Better Performance Tracking

Currently, the dashboards track various key performance indicators (KPIs), such as recycling rates, landfill usage, and household waste per capita. However, there is considerable potential to expand these metrics for deeper analytical insights. Future versions of the dashboard could feature additional KPIs, including the carbon emissions associated with waste management practices, the economic effects of recycling programs, and energy recovery rates from incineration. By expanding the range of KPIs, the dashboard would provide a more comprehensive overview of Scotland's waste management performance and its influence on environmental sustainability. Moreover, these additional KPIs could support he alignment of the dashboard with Scotland’s wider sustainability ambitions, particularly the goal of achieving net-zero carbon emissions by 2045.

5.1.4 Measuring Sustainability in a Circular Economy

In addition to establishing waste management key performance indicators (KPIs), the dashboard could expand its scope to include metrics associated with the circular economy. This would involve tracking not only the quantities of waste that are recycled or disposed of but also the extent to which resources are reused, repurposed, or maintained within the economy. The inclusion of metrics such as material recovery rates, product lifecycle assessments, and resource efficiency would enhance the dashboard’s ability to present a thorough overview of Scotland’s sustainability efforts. By concentrating on the circular economy’s principles, the dashboard would contribute to Scotland’s evolution towards more sustainable resource management practices.

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