Applying business intelligence concepts to create a simple user interface to aid in water loss identification and prevention

Gozwe' Debattista

Supervisor: Neil Aquilina

June - 2023

A dissertation submitted to the Institute of Information and Communication

Technology in partial fulfilment of the requirements for the degree of BSc (Hons) Software Development

Authorship Statement

This dissertation is based on the results of research carried out by myself, is my own composition, and has not been previously presented for any other certified or uncertified qualification.

The research was carried out under the supervision of Mr Neil Aquilina.

. . . .

Date   Signature

Copyright Statement

. . . .

Date Signature

Acknowledgements

The completion of this dissertation would not have been possible without the support and nurturing of my dissertation tutor Mr Neil Aquilina, whose guidance and invaluable advice have been appreciated throughout this whole study.

Abstract

Business analysis is a vital discipline that plays a crucial role in the success of organizations across various industries. It involves identifying business needs, analyzing processes, and proposing effective solutions to drive positive outcomes and achieve strategic objectives. Business analysts act as the bridge between stakeholders, technology teams, and management, ensuring alignment between business goals and IT capabilities.

This dissertation will investigate the development of user-friendly database visuals for the Water Services Corporation (WSC) in Malta. The research aims to address the challenge of providing non-database-oriented workers with efficient and accessible data visualization tools. The main research questions focus on identifying the key features that contribute to a user-friendly interface, exploring how such interfaces can facilitate faster and more efficient information identification, and understanding the factors that may hinder the development of a user-friendly visual interface.

The study consists of the development and testing of two prototypes, which serve as database dashboards or reports. These prototypes are then observed and evaluated by future users to gather insights and feedback. The research context revolves around WSC's local database, which tracks water consumption across different zones in Malta and Gozo. By visualizing patterns and trends in non-revenue water data, the aim is to prevent issues such as leakages and abuses.

Table of Contents

List of Abbreviations

WSC	Water Services Corporation
NRW	Non-Revenue Water
SITRA	Systematic Illegal Tapping/Theft of Reclaimed Water/Drinking Water

Chapter 1: Introduction

1.1 Research Questions

From this paper these research questions are to be answered: What are the main features that can make a user-friendly interface with all the raw data provided? How can this interface help in identifying information in a faster and a more efficient way? What will constrict the visual to having a lesser user-friendly interface?

1.2 Hypothesis

Using the raw data, a user-friendly visualization can be done to facilitate the navigation of the visual that is presented.

1.3 Choice and Motivation of Topic

I had the opportunity to work with Water Services Corporation for my apprenticeship and in there, there was a high demand of database visuals which that need to be used by workers that don't know how to code and navigate through data visualization tools so, the main problem was to find the best way to give the users the best user experience

1.4 Investigation

This research will consist of 2 prototypes that are going be database dashboards or reports and then are tested via observation to future users if the prototypes are going to be published in the future. Then the results are going to be evaluated so that a comparison can be made on the 2 prototypes.

1.5 Research Context

Malta's Water Services Corporation (WSC) has a local database that keeps track of all the water consumption of all Zones in Malta and Gozo. After a calculation regarding the water losses of these zones, the Non-Revenue Water is evaluated and added to the database for statistical purposes. Throughout number of weeks, a pattern can be seen within the data of non-revenue water and if the data can be visualized as a graph or alarms the user that the non-revenue water of that week is higher than the average, problems such as leakages and abuses can be prevented.

This can be done by using data visualization applications. These applications consist of a user interface where data can be manipulated in such a way that a non-database-oriented user can read the data and gather results and conclusions. To do this, these applications use: Bar Charts, that are used to compare values across categories, Line Charts, that are used to track changes over time, Pie Charts that are used to show proportions and distributions, Scatter Plots that are used to analyze the relationship between two variables, Maps that are used to visualize spatial data and patterns and Heat Maps, that are used to show patterns and trends in data by color-coding cells in a table. If there is one or more of these applications shown on the screen the whole user interface (UI) is called a Dashboard which is an interactive visual that displays that present information in real-time, allowing users to monitor and analyze key metrics and trends.

1.6 Structure of this Study

The dissertation structure comprises five interconnected chapters, starting with an introduction that outlines the research questions, hypothesis, and motivation behind the topic.

Literature review: This chapter explores existing research on user-friendly interfaces and data visualization.

Methodology and Testing: This chapter details the development process of the prototypes and describes the observation and data collection methods used.

Testing: This chapter presents the findings from the user observations, analyzing the performance and user experience of the prototypes.

Findings and Discussion of Results: This chapter synthesizes the findings, discusses their implications, and compares the prototypes together with the corresponding tasks.

Recommendations and Conclusion: This chapter offers recommendations for the development of user-friendly database visuals in the context of WSC. The study concludes with answering the research questions and the hypothesis stated in the introduction

Chapter 2: Literature Review

2.1 Literature Review Introduction

This section will focus on describing key topics that will aid in understanding how to reduce Non-Revenue Water (NRW) in water supply systems.

A brief overview of water supply systems will be conducted, followed by an explanation of NRW and its components, including Real Loss, Apparent Loss, and Systematic Illegal Tapping and/or Theft of Reclaimed Water and/or Drinking Water (SITRA) Loss. The relationship between these components and NRW will be explored. The solutions proposed to reduce NRW will then be described, with a particular focus on physical solutions and the use of technological solutions, such as Power BI and other visualization programs. The literature review will provide a comprehensive explanation of how Power BI works, its applications in water supply systems, and its effectiveness in reducing NRW. Finally, the section will conclude by summarizing the current state of research on reducing NRW and identifying gaps in the literature.

By the end of this literature review, the reader should gain knowledge regarding the various solutions proposed to reduce NRW, with a particular emphasis on the use of Power BI as a technological solution.

2.2 Water Supply System

Before considering working with Non-Revenue Water, it is important to have a definition of a Water Supply System.

Based on K. Chinnaraju, V. Chandrasekar, and K. Shanmugam [1], a water supply system can be defined as a network of pipes, tanks, pumps, valves, and other equipment that are used to transport water from a source (such as a lake, river, or underground aquifer) to the point of use (such as a home, business, or industrial facility). The components of a water supply system work together to ensure that water is delivered safely and reliably to consumers, and that it meets applicable quality standards.

According to G. Li, Y. Li, and Y. Xie [2], a water supply system can be defined as a comprehensive engineering system that encompasses the entire process of water supply, from the collection of water from a source to its transportation, storage, treatment, and distribution to the end-users.

Both above mentioned, consider that, “The design of a water supply system is critical to its effectiveness, and it must be optimized to ensure that it is efficient, reliable, and cost-effective.” [2]. This can be done by, “including the characteristics of the water source, the size and distribution of the population being served, and the needs of various types of users.” [1]

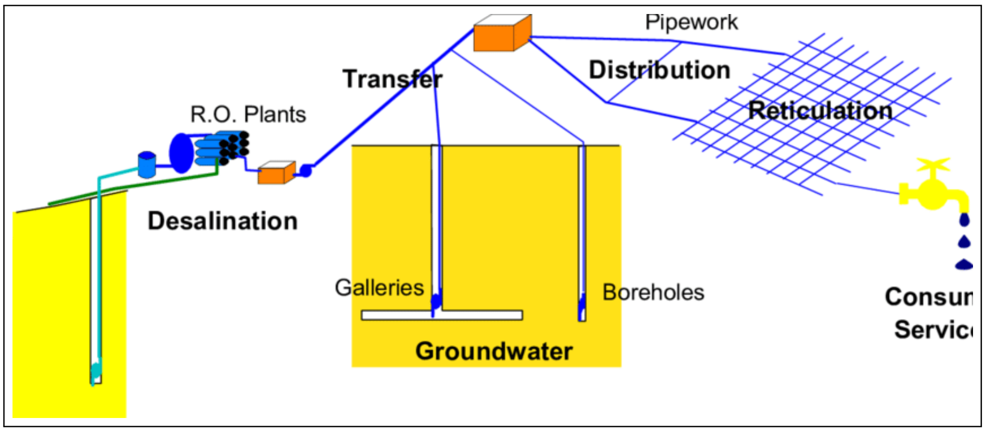


Figure 2.1: *Schematic presentation of Malta water supply system [3]*

2.2.1 Non-Revenue Water (NRW)

Non-revenue water can be defined as the difference between the total volume of water that is put into a water supply system and the volume of water that is billed to customers. (L. B. Gezahegn and A. Gebretsadik, 2019) [4]

C. Li et. al [5] define non-revenue water as, “water that has been produced and is lost before it reaches the customer, including physical losses such as leakage and commercial losses such as unauthorized consumption.”

Both authors mentioned above, go on to emphasize the importance of reducing non-revenue water, as it can lead to significant economic, social, and environmental impacts, such as revenue losses, water resource wastage, and negative effects on public health and the environment. They discuss various methods for measuring and managing non-revenue water.

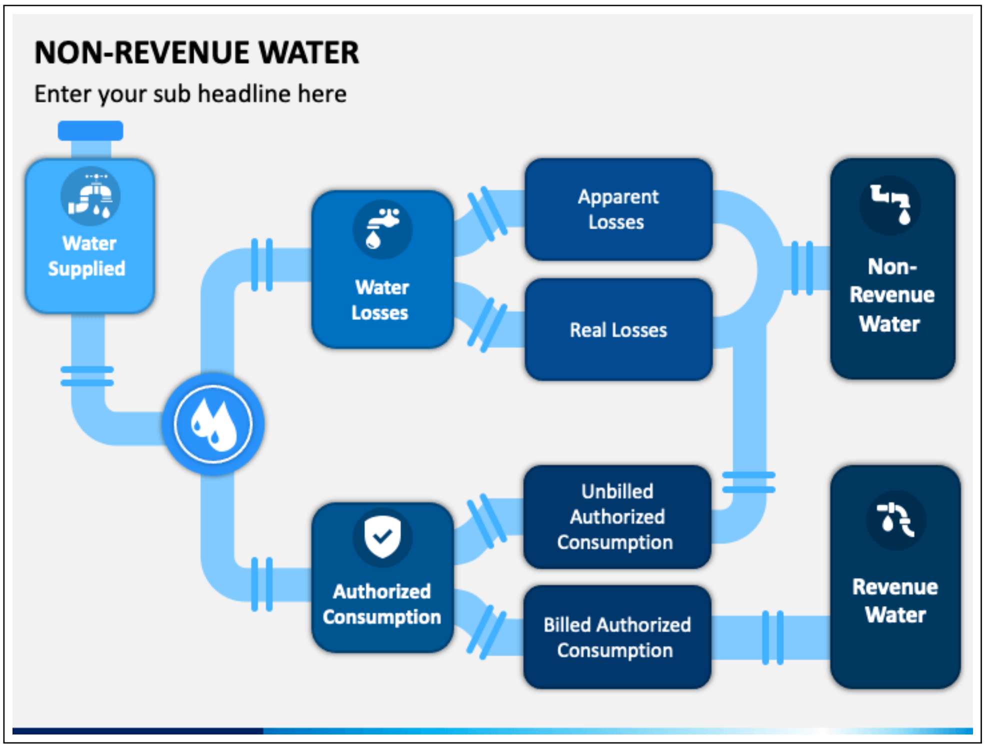


Figure 2.2: *Non-Revenue Water Image [6]*

2.2.2 Real Loss

According to P. D. D. Dominic, R. Arceivala, and D. P. T. Nguyen [7], real loss in water distribution systems can be defined as, “”water losses from a water distribution system that are physically lost due to leaks, breaks, and other defects in the system.”

It is also defined by A. Lambert, et al. [8] as, ”the volume of water that is lost from the distribution system as a result of leaks, breaks, and other forms of physical loss.”

Like authors who wrote about non-revenue water, the mentioned authors above emphasize that real losses are a critical issue for water utilities, as they can result in significant water resource wastage, energy consumption, and financial losses. They both go into detail of how real loss can be managed.

2.2.3 Apparent Loss

Apparent loss is water that is produced, but not accounted for due to reasons other than physical leakage or theft. Apparent loss includes metering inaccuracies, unauthorized consumption, data handling errors, and billing inaccuracies. (B. Bahadori and S. Sattari, 2020) [9]

According to ‘GUIDANCE NOTES ON APPARENT LOSSES AND WATER LOSS REDUCTION PLANNING’ written by Michel Vermersch et. al [10], apparent losses are classified according to the following categories: unauthorized consumption, customer metering errors, errors in estimates of unmetered consumption, and errors linked to the data acquisition process. They continue to write that, “some components of apparent losses can be either positive or negative” and, “unmetered authorized consumption may be over-estimated or under-estimated”

B. Bahadori and S. Sattari go into detail on the importance of accurately measuring and managing apparent loss in order to promote sustainable and efficient water management practices. The authors note that reducing apparent loss can lead to significant economic and environmental benefits, including increased revenue for water utilities, improved water availability for customers, and reduced energy consumption and greenhouse gas emissions associated with water treatment and distribution.

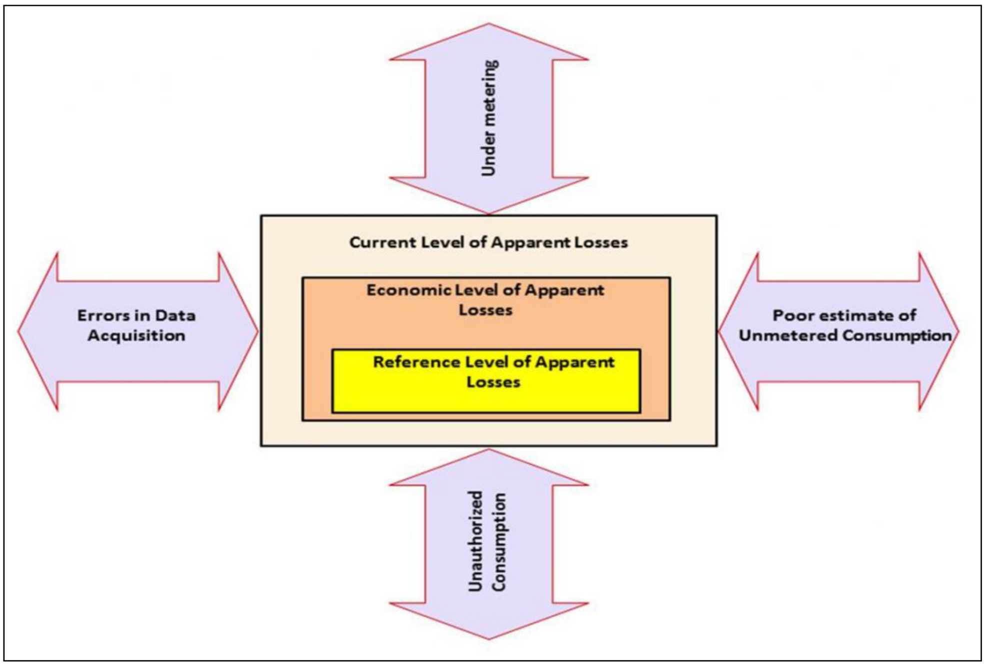


Figure 2.3: *Apparent Loss Diagram [11]*

2.2.4 SITRA Loss

SITRA can be defined as, "Systematic Illegal Tapping and/or Theft of Reclaimed Water and/or Drinking Water" (D. Musmarra, et al, 2019) [12]

D. Musmarra, et al, proceed to emphasize that SITRA loss is a significant issue for water utilities, as it can result in reduced revenue, increased water stress, and negative impacts on public health and the environment. They also highlight the importance of comprehensive SITRA loss management strategies and other ways of reducing this loss.

According to K. G. Villanueva-Rosales, et al. [13] SITRA loss can be defined as, "the volume of water that is illegally withdrawn from the distribution system for various purposes, including commercial use, domestic use, and agricultural activities." The authors look on developing countries where water management systems are often weak or lacking in enforcement and monitoring mechanisms and come emphasize that SITRA loss in those countries is a significant issue.

All these authors suggest that the use of technology can be helpful to monitor and detect SITRA losses.

2.2.5 Real Loss, Apparent Loss, SITRA Loss and NRW Relation

Real Loss and Apparent Loss are the two main components of Non-Revenue Water (NRW) in a water distribution system.

According to Lambert, A., Hirner, W., & Wyatt, A. [14], ”Real Loss is the volume of water lost due to physical causes, such as leaks and bursts, while Apparent Loss is the volume of water lost due to commercial causes, which includes SITRA Loss (unbilled authorized consumption).”

Sandoval-Solis, S., Porse, E., & McKinney, D. provide a similar definition [15], stating that ”Real losses occur due to physical causes such as leaks, bursts, and overflow, while apparent losses are caused by commercial activities such as metering errors and unauthorized consumption. SITRA loss is a sub-component of apparent losses, which includes unbilled authorized consumption.”

Farley, M.,& Trow, S. [16] add more detail to the definition of Apparent Loss, stating that it ”includes metering inaccuracies, theft, and other commercial causes.”

All three sources agree that NRW is the sum of Real Loss and Apparent Loss, and that SITRA Loss is a sub-component of Apparent Loss.

2.3 Solutions of Reducing NRW

2.3.1 Physical Solutions

According to Xu et al. [17], NRW can be reduced by using advanced metering infrastructure (AMI) coupled with a smart water network. This solution involves the use of real-time data from smart meters to detect and locate leaks and minimize water losses. The study found that the implementation of AMI and smart water network reduced NRW by 25.75% in a case study.

Another solution to reduce NRW is pressure management. As suggested by Kessouri et al. [18], pressure management involves controlling the pressure in the water network to minimize water losses due to leaks and bursts. The study found that pressure management reduced NRW by 36.4% in a case study of Algiers.

Optimization of the network layout, pipe size, and water storage capacity is also a viable solution to reduce NRW. Othman et al. [19]) proposed the use of an optimization model to minimize NRW by determining the optimal layout of pipes and storage facilities. The study found that the optimization model reduced NRW by 27.24% in a case study.

In conclusion, reducing NRW is crucial for sustainable water management, and the implementation of these solutions can significantly reduce NRW. AMI and smart water network, pressure management, and optimization of the network layout, pipe size, and water storage capacity are all effective solutions to minimize NRW in water supply systems.

2.3.2 Power Bi as a Solution

The use of data visualization tools, such as Power BI, has been shown to be effective in reducing Non-Revenue Water (NRW) in water supply systems. Gao et al. [20] proposed the use of Power BI to visualize water flow data, which can help identify anomalies and leaks in the system. By analyzing the data, water utilities can prioritize repair and maintenance efforts and minimize water losses due to leaks and other issues. The study found that the use of Power BI improved the detection rate of water anomalies by 28% and helped reduce NRW by 5% in a case study.

Babaei et al. [21] suggested using a data-driven approach with Power BI to analyze meter data and identify customers with high water consumption. This approach can help water utilities detect leaks in real-time and take corrective action before the situation worsens. The study found that the use of Power BI reduced the number of meter readings by 40% and helped reduce NRW by 23% in a case study.

Chong et al. [22] proposed a novel method for predicting NRW using machine learning and Power BI. The study used historical NRW data, water consumption data, and meteorological data to train a machine learning model. The model was then integrated with Power BI to visualize the predicted NRW, which can help water utilities proactively manage water losses. The study found that the proposed method achieved an accuracy of 86.67% in predicting NRW in a case study.

In conclusion, the use of data visualization tools, such as Power BI, can help water utilities reduce NRW and improve water management practices. The visualization of water flow data, the data-driven analysis of meter data, and the prediction of NRW using machine learning and Power BI are all effective ways to minimize water losses and improve water supply systems.

2.4 Literature Review Summary

This literature review provides a comprehensive overview of the key factors and potential solutions for reducing Non-Revenue Water (NRW) in the water supply system. The review highlights the significance of addressing NRW in the water supply system, given the increasing demand for water resources globally and the associated challenges of aging infrastructure, leakages, and limited funding.

The review focuses on NRW, which is defined as the difference between the amount of water produced and the amount of water that is billed to customers. The review distinguishes between Real Loss, Apparent Loss, and SITRA Loss, which are the three main categories of NRW. Real Loss refers to the loss of water from the water supply system through leaks in pipes and fittings, while Apparent Loss is attributed to data inaccuracies and illegal connections. SITRA Loss, on the other hand, refers to the loss of water from theft and illegal tapping. The review highlights the significance of each category of loss and the challenges associated with measuring them.

The review also examines the relation between Real Loss, Apparent Loss, SITRA Loss, and NRW, providing insights into how these factors contribute to water loss in the water supply system. The review underscores the importance of identifying the main contributors to water loss to design effective strategies for reducing NRW.

Furthermore, the review discusses the solutions for reducing NRW, which include physical solutions such as repairing leaks and replacing old infrastructure. Additionally, the review highlights the potential use of Power Bi and other visualization programs as a solution for reducing NRW. The use of Power Bi and other similar programs can aid water supply companies in visualizing and analyzing data to identify the main contributors to NRW, which can inform decision-making and the development of effective strategies to reduce water loss.

In conclusion, this literature review provides a comprehensive overview of the different factors affecting NRW and the potential solutions to reduce it. The information gathered through this review can aid water supply companies in reducing water loss and improving efficiency, which is critical in ensuring sustainable water management and meeting the increasing demand for water resources globally.

Chapter 3: Research Methodology

3.1 Methodology Introduction

This chapter will be split into three phases which will consist of the understanding of the scenario and the two different prototypes to be compared.

The first phase will guide the reader through the scenario of the problem being tackled, the thought process of how the two different prototypes are to be constructed and ideas how to make it more user friendly.

The second phase will explain how the first prototype was constructed and any technologies used within that prototype

Lastly, **the third phase** will explain how the second prototype was constructed and any technologies used within that prototype

This chapter will end with a brief conclusion on both prototypes and how they are going to be tested and compared.

3.2 Phase 1: Tackling the scenario

3.2.1 Scenario

The problem being tackled here is a database visual or a dashboard that displays changes into Non-Revenue Water (NRW) across different time lapses. It needs to be efficient so that it can run PCs that aren't the latest generation and need to be user friendly so that people who aren't experts in the field of databases can navigate through the visual. A schematic was given so that this can help with the visualization of the dashboard and maybe used for the dashboard itself.

3.2.2 Getting the data

In this scenario, data was snipped and extracted from Water Services Corporation (WSC), and it is not current so that the current data will remain in the hands of WSC, and the prototypes can work with data that was true in past times. The dashboards will get the data from an excel sheet and visualized through data visualization programs such as Power Bi.

3.2.3 Data Visualization Programs

After researching on what are one of the most common and easy to use and compare data visualization tools, the choice was between Power Bi and Google Data Studio.

3.2.4 Power Bi

Power BI is a business intelligence and data visualization tool developed by Microsoft. It allows users to connect to various data sources, transform and model the data, and create interactive visualizations and reports. Power BI offers a variety of data connectors, including Excel, SharePoint, Salesforce, and Google Analytics, among others.

3.2.5 Google Data Studio

Google Data Studio is a free, cloud-based business intelligence and data visualization tool developed by Google. It allows users to connect to a variety of data sources, including Google Analytics, Google Ads, and Google Sheets, as well as other non-Google sources like MySQL, PostgreSQL, and Salesforce, among others. It is a relatively new entrant in the data visualization space, but it has gained popularity in recent years due to its ease of use and integration with other Google products.

3.2.6 Schematics that were given

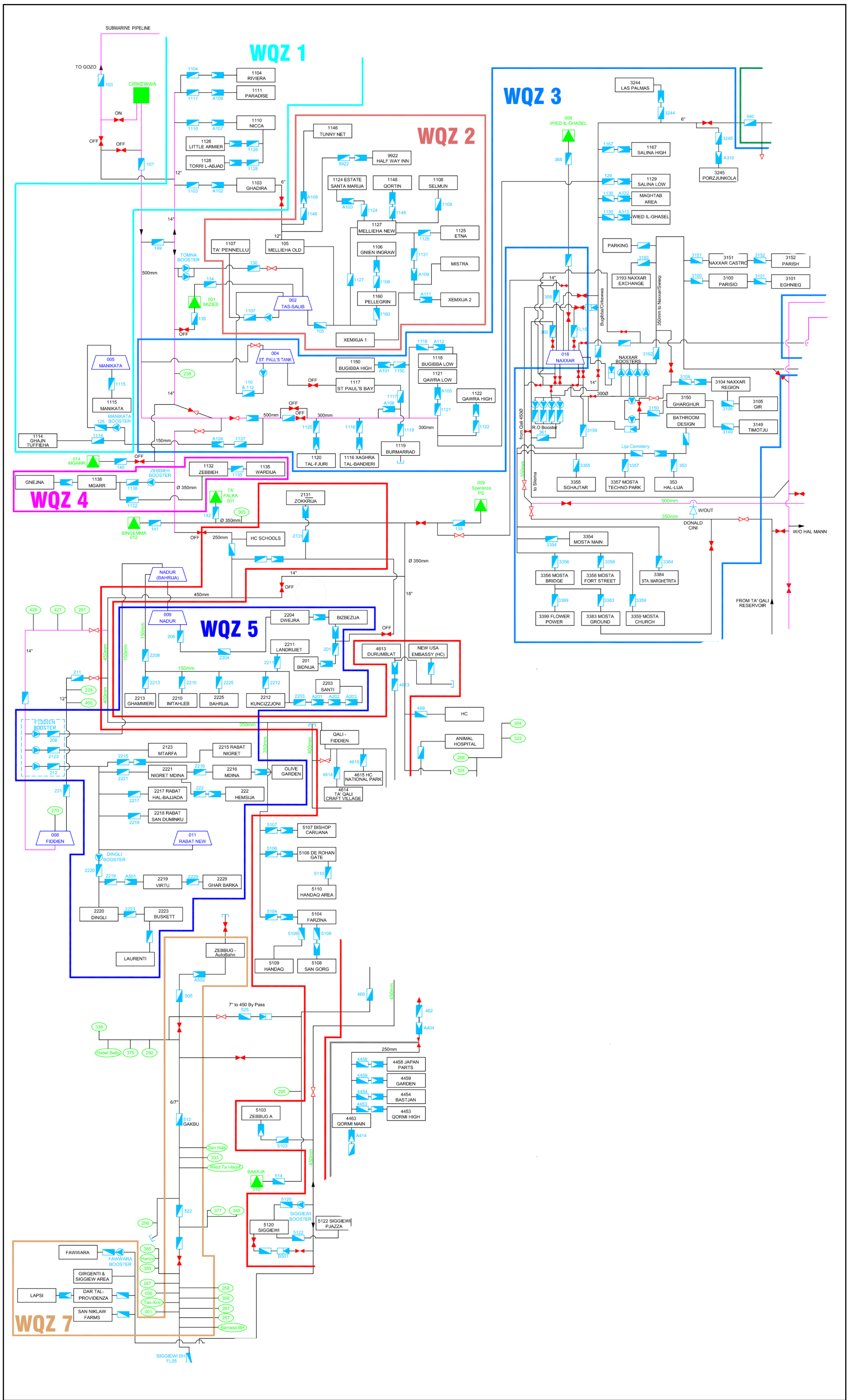


Figure 3.1: *Region 1: Schematic*

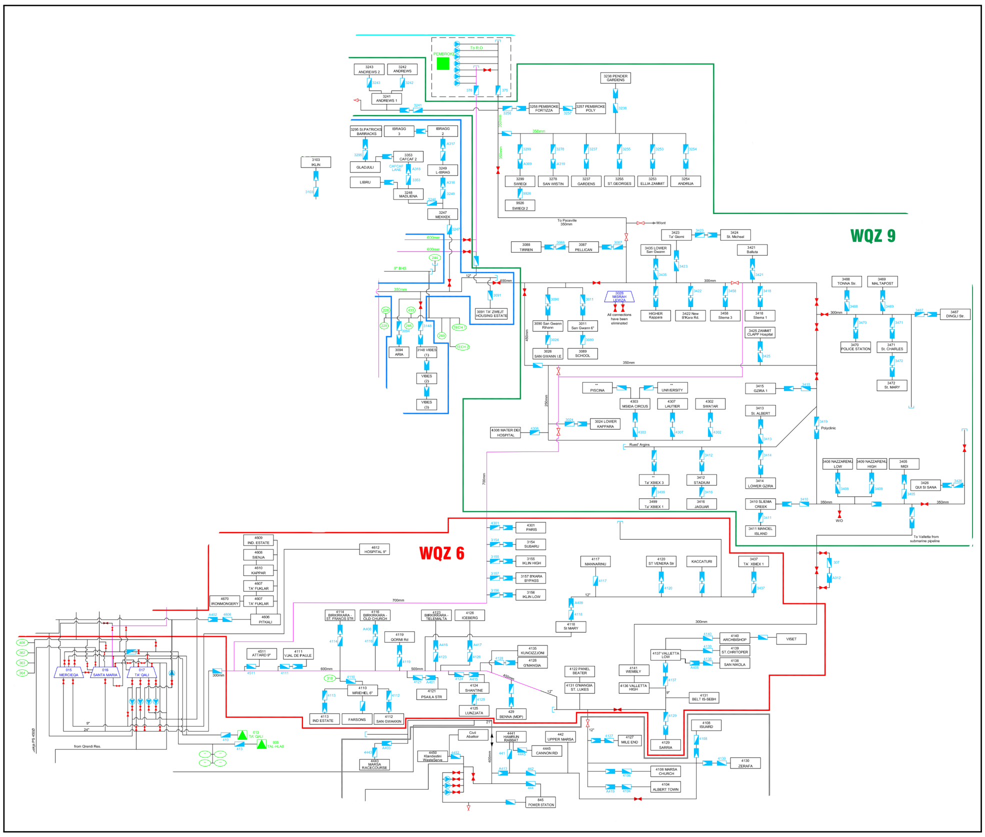


Figure 3.2: *Region 2: Schematic*

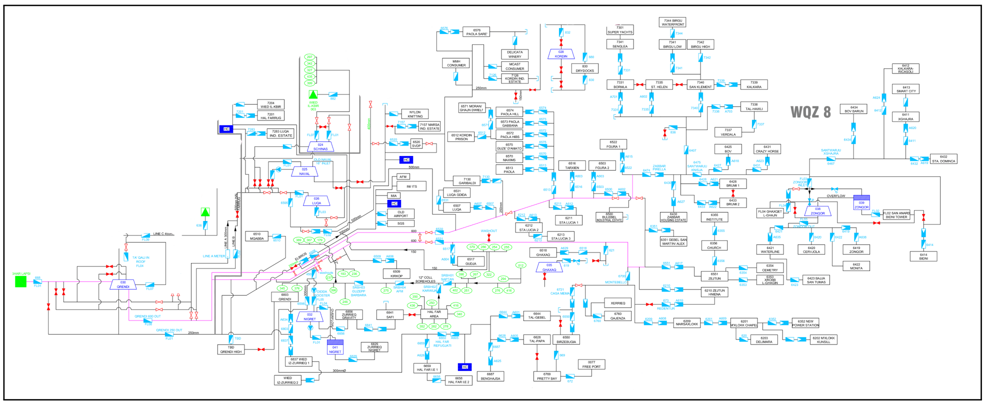


Figure 3.3: *Region 3: Schematic*

3.2.7 Snapshot of the data given

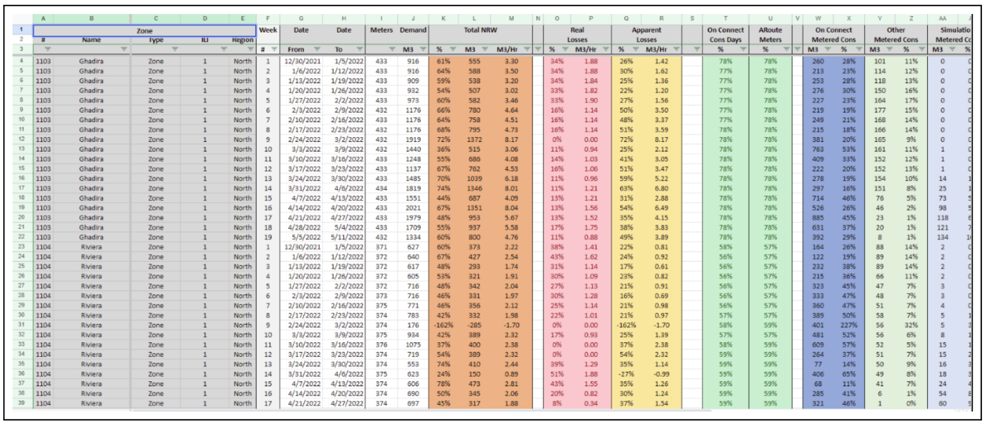


Figure 3.4: *Data Snapshot*

3.3 Phase 2: Constructing first Prototype with Power Bi

3.3.1 Menu Visualization

Since the map is going to be split, the Power Bi dashboard needs to have multiple tabs that the user can navigate through by clicking on the tabs or by making a menu bar with all the tabs inside. This can be done by inserting a shape from Power Bi and making them clickable by ticking the Action option.

3.3.2 Table Visualization

It is also required that the data can be seen in relation to the schematic given and the Zones named in the schematic. So, a table visual needs to be added to the dashboard in every tab so that the user can see the information with regards to every Zone number that the user chooses. The table visual will need all the information that the user will need. Since the Dashboard focus is going to be the Schematic, the table visualization was opted to be positioned at the bottom of the dashboard so that it will be legible, but it will not take too much of a space that will cover the focus of the dashboard. The data, as mentioned in phase 1, will be extracted from an excel sheet given. The table will always be sorted in weeks in descending order so that the user can always see the latest updated week on the current data.

3.3.3 Visualizing the Schematic

The Schematic, as mentioned, is the focus of the entire dashboard therefore, it needs to be important that the Visual will have all the options we need so that the database and other visuals can interact with this one so that the dashboard can be dynamic for the user to navigate through.

The Visual needs to edit the Schematic so that the Zones can be in a certain color to distinguish themselves from others. This sort of filtering is done so that the user can see changes from the schematic and warn them that there is an error or an emergency with that zone and it needs to be taken care of. The colors were controlled by the NRW% of that week and need to be changed every week or the visual needs to update for every week.

The colors need to be like in the figure 3.5

Violet	NRW%>50, NRW%<0
Red	40<NRW%<=50
Amber	30<NRW%<=40
Green	15<NRW%<=30
Blue	0<NRW%<=15

Figure 3.5: *Color table*

For this visualization, Power Bi has a visual called Synoptic Panel which is published by OKViz (a trademark of SQLBI) this visual has a feature which you can select areas of a picture and make them have an id that will permit the dashboard to read from it and interact with all the other visuals.

So, the schematic is then run through this website called https://synoptic.design/ and all the rectangles are filled with their responding zone number, which then will let the table connect to this visual and if the table has data on that zone, it will show on the table visual.

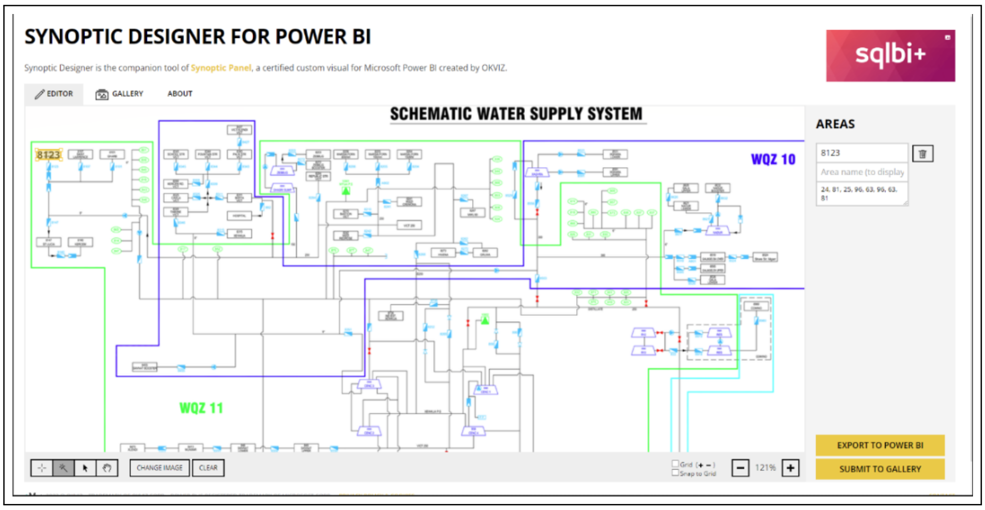


Figure 3.6: *Synoptic Designer*

After finishing with all the schematics and the zones, options need to be added to the synoptic panel visual so that colors and data will be linked to the visual. In Power Bi, colors and different colors on different occasions are called states. Therefore, different states need to be selected so that the map will display multiple changes in the NRW%

3.3.4 Weeks Visualization

The data needs to be updated per week and the weeks need to be updated according to the data. As well, the weeks need to be clickable and are dynamic with the table and the schematic which means that if the user clicks on a specific week, the user will be shown the colors of that specific week according to the parameters mentioned above in the schematic visualization.

For this scenario and options, a slicer will be chosen but not the default one since the default slicer of Power Bi has some restrictions that will not be compatible with the synoptic panel. Therefore, a ChicletSlicer is chosen instead. This will give us the necessary tools so that the weeks can be navigated and seen thoroughly by the user. It was opted to have the slicer and the right-hand side of the dashboard in a vertical position so that it will not hinder the user for the focus of the dashboard. With this slicer the schematic will change according to the clicked week

3.3.5 Other Options that Power Bi has and are good for the user experience of this dashboard

For the last touches of this dashboard, it was chosen to have an information tooltip, that will help the user navigate through the different colors of the schematic, a ‘clear filters’ button and 2 labels which will display the current zone clicked and the current week active

3.3.6 The Information tool-tip

The information tool-tip is a card visual with hover action and it will show an image of all the parameters of the colors of the NRW%. It is done by activating the tool-tip option in the general setting and having a custom tab in which the image will be displayed.

When the user hovers over the tool-tip icon, an image with the colors will be shown to the user.

3.3.7 Reset Filters button

Similarly, to the menu buttons, the reset filter button will be an image in this case, it will relocate itself to a bookmark of the page when it didn’t have any filters on it. This is done by activating the options in figure 17. The icon for the reset filter was chosen to be this: 

3.3.8 Current Zone clicked and Current Week clicked Labels

The Current Zone clicked label is a card visual which will take a measure in the field section. In this case the measure will be called Zone selected and it will have the current DAX code for it

ZoneSelected = if (ISBLANK(SELECTEDVALUE(Zone_Weekly_Extract[ZoneName])) ,”N/A”,SELECTEDVALUE(Zone_Weekly_Extract[ZoneName]))

With these options, if a zone is not clicked it will show a N/A and if it is clicked it will show the zone name.

The Current Week is almost identical as the Current Zone clicked but it will have a different measure and it is always clicked since the schematic is based on a current week. The measure used was called Filtered Week and with DAX annotation it will have the following code:

```
FilteredWeek = IF (
HASONEVALUE (Zone_Weekly_Extract[WeekNo]),
SELECTEDVALUE (Zone_Weekly_Extract[WeekNo]),
""
)
```

3.4 Phase 3: Constructing first Prototype with Google Data Studio

3.4.1 Menu Visualization

Since the map is going to be split, the Google Data Studio report needs to have multiple pages that the user can navigate through by clicking on the tabs or by making a menu bar with all the tabs inside. This can be done by inserting a button from Google Data Studio and using the navigation button type action. In this scenario, the tabs will be named, “North Page”, “Middle Page”, “South Page”.

3.4.2 Data Manipulation

Google Data Studio is a powerful tool for visualizing and analyzing data. However, to effectively utilize this tool, the data must be in a spreadsheet format that adheres to specific requirements. In certain cases, it becomes necessary to filter specific parts of the headers within the data, thereby facilitating its readability and enabling seamless visualization. To accomplish this, a visual alteration of the data is implemented while ensuring the preservation of data integrity.

The primary objective behind visually altering the data is to facilitate automatic detection of headers, which significantly streamlines the visualization process. By presenting the data in a format that Google Data Studio can readily interpret, users can leverage the full potential of the tool's features and functionalities. Moreover, this alteration provides users with the flexibility to rename headers according to their specific preferences, thereby enhancing the overall customization capabilities of the platform.

By adopting such an approach, users can effortlessly transform complex data sets into meaningful and visually appealing table visualizations. This not only promotes a better understanding of the underlying information but also facilitates insightful data analysis. The ability to rename headers according to individual requirements offers an additional layer of convenience, empowering users to align the data representation with their unique context and objectives.

3.4.3 Table Visualization

In addition to the requirements, it is crucial to incorporate a table visualization in the report, allowing users to analyze the data in relation to the provided schematic and the corresponding Zones. This table visual serves as a valuable resource for users to access relevant information based on their chosen Zone number.

The table visual is strategically positioned at the bottom of the dashboard to ensure readability without overshadowing the primary focus of the report, which is the schematic. By allocating this location, the table visualization does not occupy excessive space that may distract from the main content.

The table visual encompasses all the essential information necessary for users to gain comprehensive insights. To enhance usability, the table is consistently sorted in descending order based on weeks. This sorting method guarantees that users always have immediate access to the most up-to-date week's data, promoting real-time analysis and monitoring of the data set.

3.4.4 Visualizing the Schematic

Unlike Power BI, Google Data Studio does not provide an exact equivalent to the Synoptic Panel visualization. Consequently, in this report, the schematic will be presented as a static image that users can zoom into using the zoom functionality available in web browsers such as Google Chrome. This approach allows users to focus on specific areas of interest within the schematic and examine them in greater detail.

By utilizing the zoom mechanic, users can navigate the schematic image at their desired level of granularity. This flexibility empowers users to explore different regions of the schematic and analyze specific areas of importance to their analysis. The zoom functionality is a familiar feature in web browsers and ensures a seamless user experience when examining the schematic.

To further enhance usability, a filter will be incorporated into the report, enabling users to filter specific zones by their names. This filter functionality allows users to narrow down their analysis and focus on areas of relevance. By filtering the zones based on their names, users can conveniently isolate and analyze the data associated with their chosen zones, gaining insights tailored to their specific requirements.

3.4.5 Filter Visualization

Given the absence of the Synoptic Panel in Google Data Studio, it becomes essential to implement an alternative approach to provide users with more detailed results in the table visualization. To address this requirement, an advanced filter visual can be incorporated into the report. This advanced filter visual allows users to search for a specific zone name and dynamically modifies the table based on the search query.

The advanced filter visual enables users to enter a specific zone name into a search field, triggering a real-time search operation. The filter mechanism then scans the data set and retrieves data entries that match the searched zone name. This dynamic filtering process ensures that only relevant data related to the specified zone name is displayed in the table visual.

3.4.6 Weeks Visualization

In order to enhance the filtering capabilities and facilitate numeric filtering in Google Data Studio, an additional filter based on weeks will be implemented. To achieve this, a slicer will be utilized as the filter mechanism due to its suitability for numerical values.

However, before implementing the slicer, a data manipulation step is required for the ”Weeks No.” field. As Google Data Studio slicers only work with numeric values, it is necessary to create a new field that contains the numeric representation of the weeks. This can be accomplished using a formula integrated into Google Data Studio:

CAST(RIGHT_TEXT(WeekNo, 2) AS NUMBER)

This formula operates on the ”Weeks No.” field, extracting the last two characters (numbers) from the field and casting them as a numeric value. It is important to note that this formula assumes that the data in the ”Weeks No.” field is consistently in a numerical format, without any non-numeric characters. In this specific scenario, where the field contains only numeric data, this formula will successfully generate the desired numeric representation.

Once the new field with the numeric representation of weeks is created, it can be used in conjunction with the slicer to facilitate filtering based on week numbers. Users can interact with the slicer and select specific week numbers of interest, thereby dynamically updating the table visualization to display data corresponding to the selected weeks.

3.4.7 Reset Filters button

In line with the menu buttons, a reset filter button will be incorporated into the report, leveraging the built-in functionality provided by Google Data Studio. When clicked, this button will trigger a reset action that restores the filters to their default settings. The weeks visualization and the zone name filter will be reverted to their initial state, as if they had never been interacted with before.

Although it would have been desirable to visually represent the reset filter action with an image, the technical constraints of the page layout prevent the addition of an image to the button without significant modifications to the entire page. Therefore, the button will be simply labeled as ”Reset” to indicate its purpose of resetting filters.

3.5 Research Methods

During the development of the two prototypes, a systematic approach involving notetaking was employed to facilitate the gathering of valuable insights. This methodological strategy aligns with research methods commonly used in the field of data visualization. By recording observations and documenting key aspects, the process aimed to provide a comprehensive understanding of the prototypes' development, including comparisons, time consumption, constraints encountered, and any potential bugs or functional issues.

The utilization of note taking as a research method in this context serves multiple purposes. Firstly, it enables the accumulation of comparative data regarding the two prototypes, facilitating an objective evaluation of their strengths, weaknesses, and overall effectiveness. This comparative analysis helps identify which prototype is more aligned with the intended goals and requirements.

Secondly, note-taking throughout the development journey provides insights into the time consumption associated with different stages and tasks. By documenting the time required for various activities, such as data manipulation, visualization creation, and bug fixing, it becomes possible to assess the efficiency and effectiveness of the development process. This information aids in optimizing future development efforts and allocating resources appropriately.

Furthermore, the note-taking process captures the constraints encountered during prototype development. Constraints may arise from limitations within the chosen visualization tools or the available dataset. These notes shed light on the challenges faced and offer valuable information for decision-making in terms of tool selection, data preparation, or potential modifications to address constraints.

Lastly, documenting any bugs or malfunctioning properties of the visualizations contributes to the identification and resolution of issues. By systematically noting these problems, the development team can focus on troubleshooting and refining the prototypes, ensuring a smoother and more reliable user experience.

3.6 Methodology Summary

This chapter commences by presenting an overview of the data gathering process and the requisite tools necessary for the development of the prototypes. The importance of gathering relevant data and utilizing appropriate tools is highlighted to ensure the accuracy and effectiveness of the prototypes.

Furthermore, a brief description is provided to outline how the two programs are expected to function. This overview sets the stage for understanding the intended functionality and purpose of the prototypes.

Finally, the chapter presents a plan to compare the results of the two prototypes. This plan involves systematic evaluations that encompass various stages, such as data manipulation, visualization creation, and performance assessment. Throughout the development process, meticulous notes are taken to document and capture important elements, including comparisons, time consumption, constraints encountered, and any functional or technical issues observed.

Chapter 4: Testing

4.1 Testing Introduction

In this section, I will focus on implementing the diverse features of the two prototypes, as outlined in the methodology. The primary objective is to create dynamic and visually appealing dashboards/reports while ensuring readability and user-friendly interactions. To achieve this, careful considerations have been made regarding the selection of suitable tools, visualization techniques, and data manipulation strategies.

The implementation process will incorporate interactive elements such as filters, slicers, and table visuals to provide users with flexibility and control over the displayed data. These features allow users to refine their analysis by selecting specific zones, weeks, or other relevant parameters. By enabling dynamic filtering options, the prototypes empower users to customize their view and explore data from different perspectives. Additionally, the use of table visuals will present the data in a structured and organized manner, facilitating easy interpretation and comparison.

4.2 Prototype 1 (Power Bi) Functionalities

4.2.1 Menu Functionality

To enhance the navigational capabilities of the dashboard, additional tabs have been implemented as part of the menu buttons. These tabs are designed to provide users with easy access to specific regions, namely the ”North Region,” ”South Region,” and ”Central Region.”

Figure 4.1: *Tabs*

The functionality of these menu buttons has been implemented using the Shape format setting in Power BI. This allows for the creation of interactive buttons that can trigger actions when clicked.

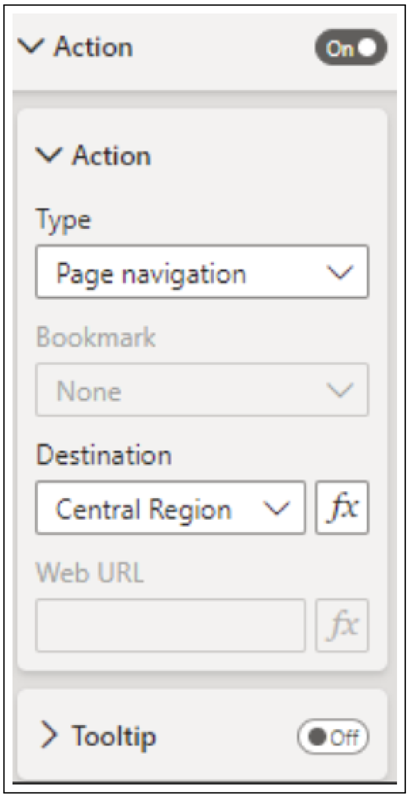


Figure 4.2: *Menu options*

To ensure a consistent user experience, this process has been repeated for each of the three tabs, resulting in a comprehensive set of navigation options. Furthermore, design considerations have been considered to make the overall dashboard more visually appealing and engaging. Attention has been given to aspects such as color schemes, layout, and font choices to create a visually cohesive and aesthetically pleasing presentation.

Figure 4.3: *Menu buttons*

4.2.2 Table Functionality

To make the table more visually appealing and familiar to the user, the headers of the table were the same as the headers of the data that was given. In addition, the same colors were used on the same fields that were colored by the same color in the sample data given. This was done by copying the hex code of the color from the spreadsheet to the option of the color in Power Bi

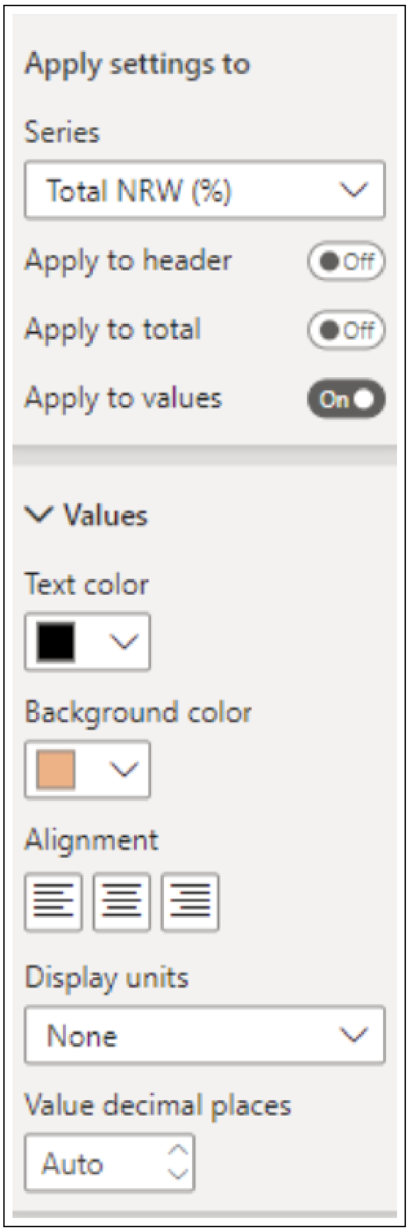
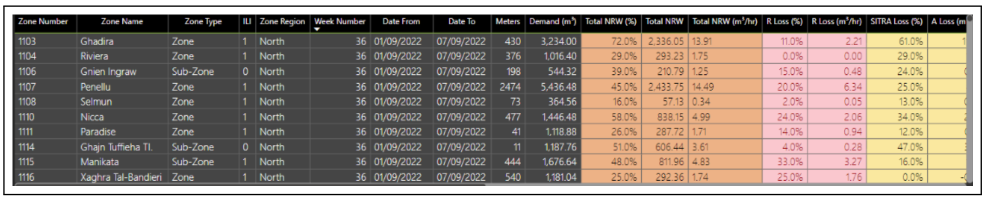


Figure 4.4: *Table options*

After some design considerations that have been considered to make the table more visually appealing and engaging, the table visual would look like this:



Zone Number	Zone Name	Zone Type	ILI	Zone Region	Week Number	Date From	Date To	Meters	Demand (m³)	Total NRW (%)	Total NRW	Total NRW (m³/hr)	R Loss (%)	R Loss (m³/hr)	SITRA Loss (%)	A Loss (m
1103	Ghadira	Zone	1	North	36	01/09/2022	07/09/2022	430	3,234.00	72.0%	2,336.05	13.91	11.0%	2.21	61.0%	[illegible]
1104	Riviera	Zone	1	North	36	01/09/2022	07/09/2022	376	1,016.40	29.0%	293.23	1.75	0.0%	0.00	29.0%	[illegible]
1106	Gnien Ingraw	Sub-Zone	0	North	36	01/09/2022	07/09/2022	198	544.32	39.0%	210.79	1.25	15.0%	0.48	24.0%	[illegible]
1107	Penellu	Zone	1	North	36	01/09/2022	07/09/2022	2474	5,436.48	45.0%	2,433.75	14.49	20.0%	6.34	25.0%	[illegible]
1108	Selmun	Zone	1	North	36	01/09/2022	07/09/2022	73	364.56	16.0%	57.13	0.34	2.0%	0.05	13.0%	[illegible]
1110	Nicca	Zone	1	North	36	01/09/2022	07/09/2022	477	1,446.48	58.0%	838.15	4.99	24.0%	2.06	34.0%	[illegible]
1111	Paradise	Zone	1	North	36	01/09/2022	07/09/2022	41	1,118.88	26.0%	287.72	1.71	14.0%	0.94	12.0%	[illegible]
1114	Ghajn Tuffieha Tl.	Sub-Zone	0	North	36	01/09/2022	07/09/2022	11	1,187.76	51.0%	606.44	3.61	4.0%	0.28	47.0%	[illegible]
1115	Manikata	Sub-Zone	1	North	36	01/09/2022	07/09/2022	444	1,676.64	48.0%	811.96	4.83	33.0%	3.27	16.0%	[illegible]
1116	Xaghra Tal-Bandieri	Zone	1	North	36	01/09/2022	07/09/2022	540	1,181.04	25.0%	292.36	1.74	25.0%	1.76	0.0%	[illegible]

Figure 4.5: *Table visual*

4.2.3 Synoptic Panel Functionality (Schematic)

After filling all the squares in the schematic to make a .svg (Scalable Vector Graphics) file that is going to be used in our dashboard, all the squares will result in a grey square meaning that the data would not be found.

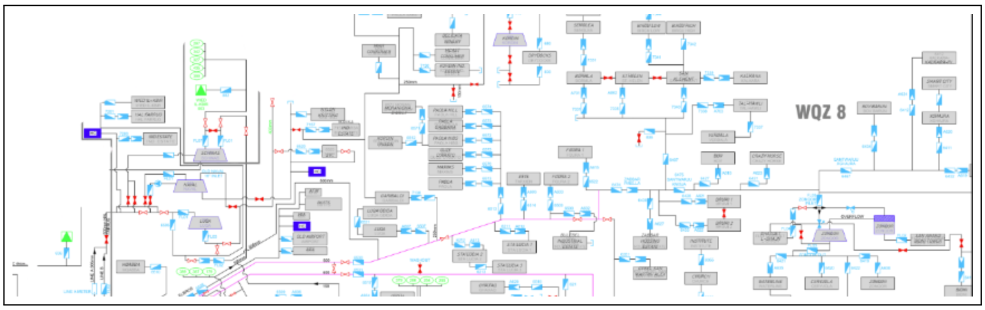


Figure 4.6: *Synoptic panel start*

But with a little bit of adjustments to the settings and entering the appropriate set of fields to display, the visual will run smoothly

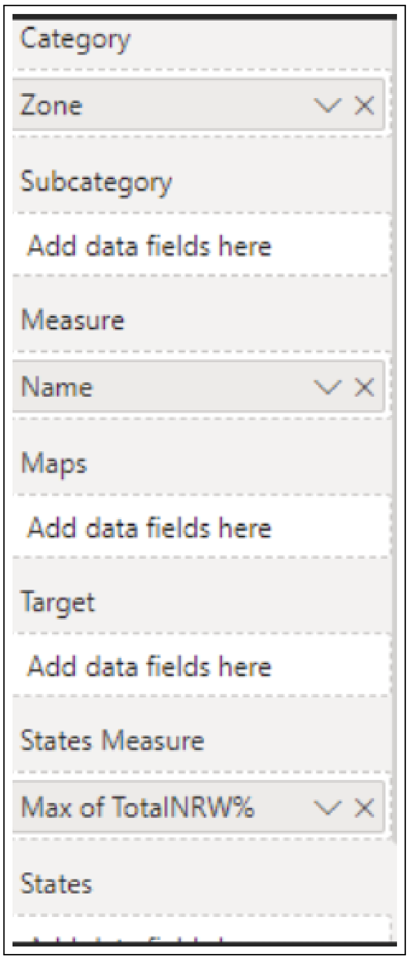


Figure 4.7: *Synoptic options*

Option Name	Definition
Category	What data are the Squares?
Measure	What can I measure when there is no data?
States Measure	What do I measure when there is Data?

Figure 4.8: *Option table*

The colors need to change to make them like it was requested

Violet	NRW%>50, NRW%<0
Red	40<NRW%<=50
Amber	30<NRW%<=40
Green	15<NRW%<=30
Blue	0<NRW%<=15

Figure 4.9: *Color table*

The states option was used in the synoptic panel and was done by logically inputting all the requirements needed.

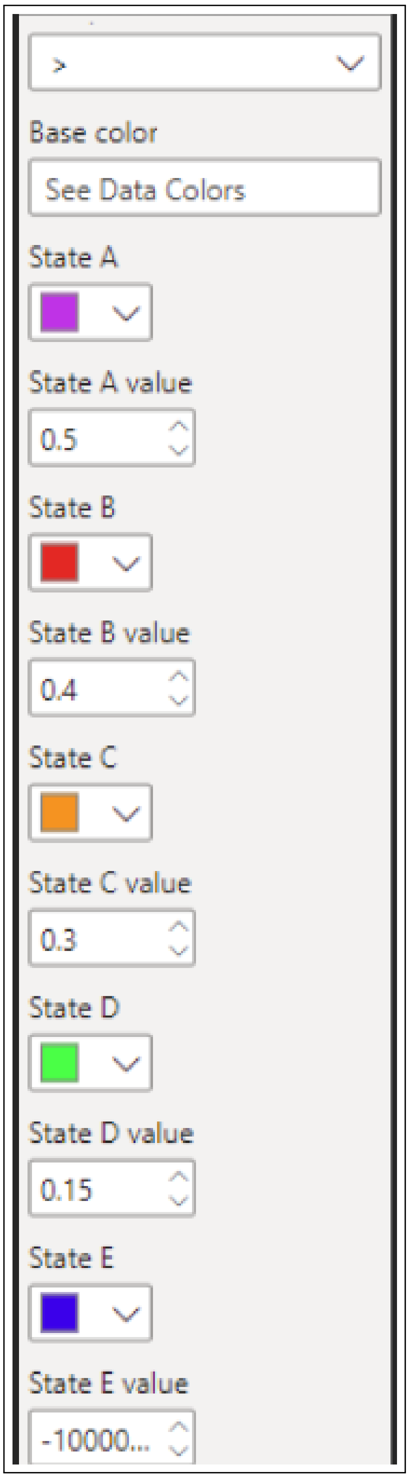


Figure 4.10: *Color States*

Note that the NRW% is not a percentage in the data, therefore the values are not percentages

With all these options done and centering the panel the synoptic panel would be like this would be like this

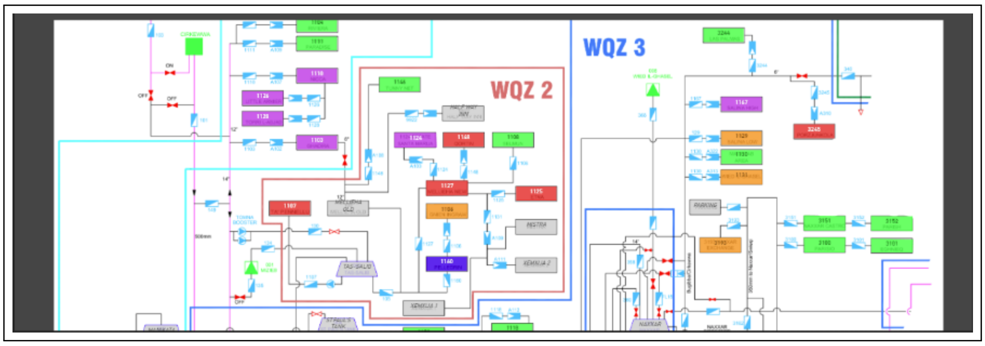


Figure 4.11: *Synoptic panel finish*

4.2.4 Weeks Functionality

For the ChicletSlicer, it needed to be mainly readable for the user so that they would know what they are clicking and what would happen to the synoptic panel if they clicked a circlet item. It was opted to make this slicer to the right of the dashboard so that it would not impede the schematic and the table visuals.

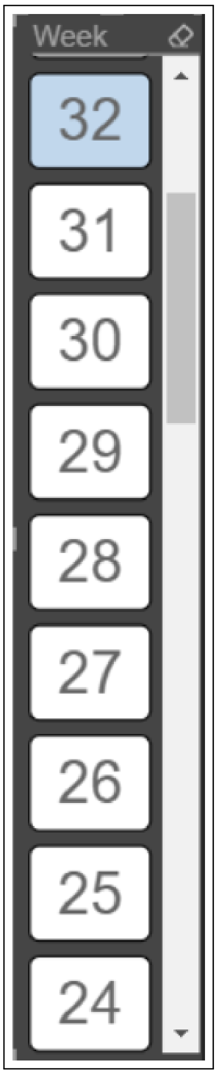


Figure 4.12: *Weeks visual*

Therefore, to make the circlet to the right alignment and going horizontally these options need to be assigned.

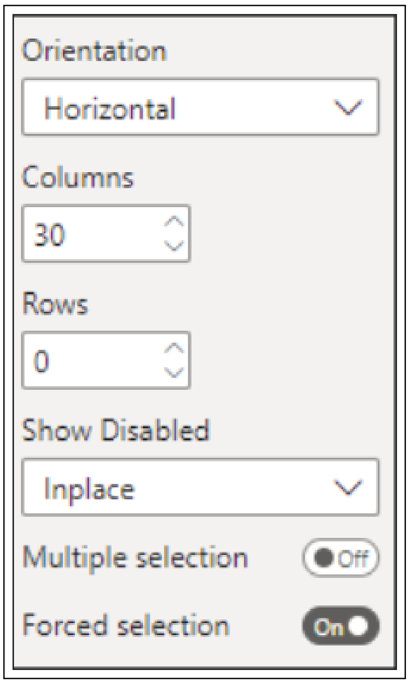


Figure 4.13: *Weeks Options*

4.3 Prototype 2 (Google Data Studio) Functionalities

4.3.1 Menu Functionality

To enhance the navigational capabilities of the report, additional pages have been implemented as part of the menu buttons. These pages are designed to provide users with easy access to specific areas, namely the "North Area," "South Area," and "Middle Area."

Figure 4.14: *Pages*

The functionality of these menu buttons has been implemented using the insert button and from the button action type setting set to page navigation. This allows for the creation of interactive buttons that can trigger actions when clicked.

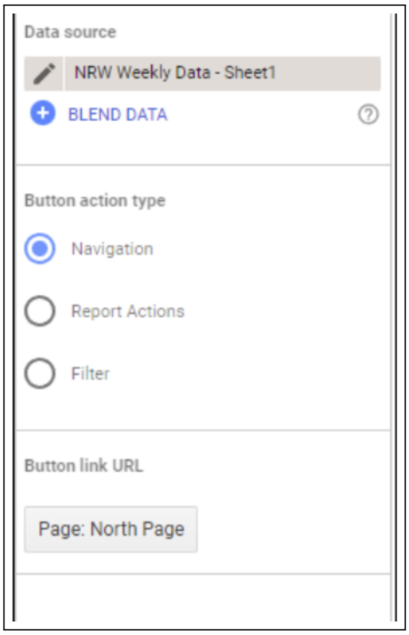


Figure 4.15: *Button options*

This process has been repeated for each of the three pages to ensure that navigation is functional. Attention has been given to aspects such as color schemes, layout, and font choices to create a visually cohesive and aesthetically pleasing presentation.

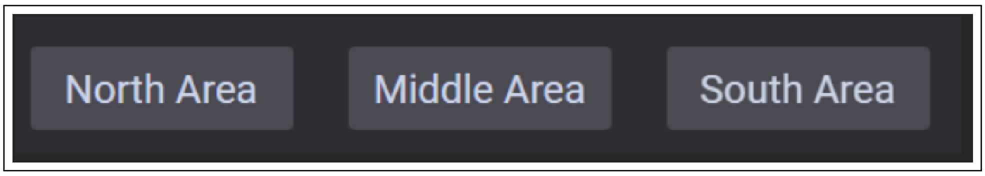


Figure 4.16: *Menu buttons 2*

4.3.2 Filter Functionality

To have the functionality of searching from the map and interacting with the table a filter needed to be done. It was done by inserting an advanced filter and entering the Zone Name field if the user wants to search with the zone name.

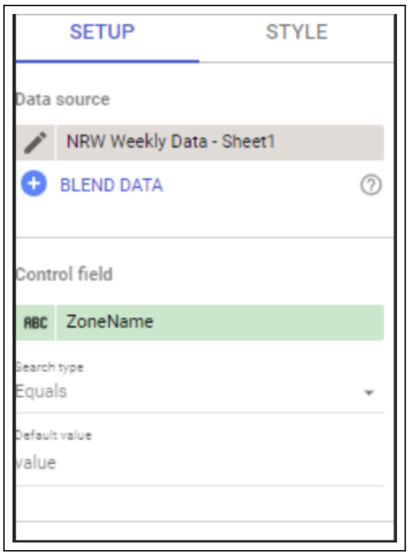


Figure 4.17: *Filter options*

With all the design and everything done, the advanced filter would be like this:

Figure 4.18: *Filter visual*

4.3.3 Weeks Functionality

Similar to prototype 1, the filter weeks functionality is going to be a slicer and with the alterations that it was done in the methodology, with the below options, the slicer would be like this:

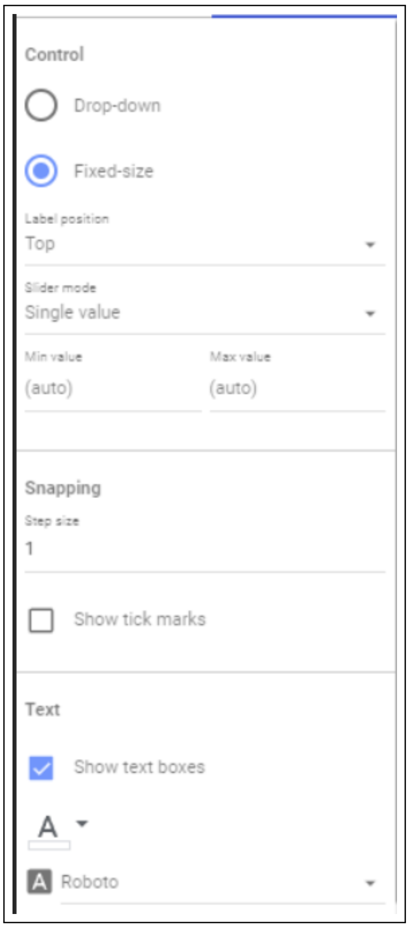


Figure 4.19: *Weeks options*

Figure 4.20: *Weeks slicer*

4.4 Observation Testing

The finished prototypes were given to the 5 people who use database visualizations to check things that are happening to their data, but they are not part of the data analysis team and were asked to do a simple task and then a more complex task with one prototype and then the other. Afterwards they were asked questions regarding those two prototypes. The person's identities were kept anonymous for the sake of their data protection.

4.5 Task Given

1. Give me the NRW% of Zone 6513 with the name "Paola" that was at week 7
2. Give me 2 Zone Names that have their NRW% lower than 30% in week 8

4.6 Questions asked

The questions asked were:

1. Can you briefly share your experience with database management and visualization tools? How often do you interact with databases in your work?
2. What are the main challenges you face when working with databases or database visual tools? Specifically, what aspects do you find difficult or time-consuming?
3. Can you describe any specific tasks or scenarios where you anticipate our database visual tool could significantly improve your workflow or efficiency?

4.7 Data Gather from observations

The Task given was documented with a steps recorder with time stamps

Their responses were written as an answer and summarized by the observer so that the response was documented accordingly.

4.8 Responses

Person 1:

”I don’t have extensive experience with database management and visualization tools, but I’ve had some exposure to them in my previous job. I interacted with databases occasionally, mainly for generating reports and extracting data for analysis. It wasn’t a core part of my role, but it was important for supporting decision-making processes.”

Person 2:

”As someone who doesn’t specialize in databases, working with database visualization tools can be challenging at times. Understanding the data schema and relationships can be tricky, especially when dealing with complex databases. Additionally, I find it time-consuming to create and customize visualizations that accurately represent the insights I want to convey.”

Person 3:

”While I don’t interact with databases frequently in my work, I can see the potential for a database visual tool to significantly improve my workflow. For instance, when I need to extract specific data for analysis or generate reports, having an intuitive and user-friendly visualization tool would make these tasks more efficient. It would save me time and allow me to focus more on interpreting the data and drawing meaningful insights.”

Person 4:

”In my role, I interact with databases sporadically, and one of the main challenges I face is working with database visualization tools. Understanding the data schema and how to navigate the tool can be difficult, especially if I'm dealing with complex databases. Additionally, creating visually appealing and informative visualizations can be time-consuming, as I don't have a strong background in database management."

Person 5:

"While I'm not a database expert, I can anticipate scenarios where our database visual tool could significantly improve efficiency. For example, when I need to collaborate with team members and share insights from the database, having a user-friendly visualization tool would make it easier to present data in an understandable format. It would streamline the process of communicating findings and facilitate more effective decision-making within the team."

4.9 Test Cases from Observation: Task 1

Task 1: Give me the NRW% of Zone 6513 with the name "Paola" that was at week 7.

4.9.1 Prototype 1: Power Bi

User	Testing outcome	Time to complete	Constraints Encountered	Potential Issues
User 1	Extracting the NRW % from the visual using all the tools in their disposal	31 seconds	No constraints encountered	None found
User 2	Extracting the NRW % from the visual using all the tools in their disposal	1 minute 20 seconds	The participant was looking to the whole map to see where the zone was	None Found
User 3	Extracting the NRW % from the visual using all the tools in their disposal	2 minutes 54 seconds	The participant did the task but the NRW% wasn't correct by 3%.	When the user clicks on the synoptic panel and clicks on the weeks, the synoptic panel is not refreshed. The user needs to click on outside the synoptic panel to fix the bug
User 4	Extracting the NRW % from the visual using all the tools in their disposal	57 seconds	The participant after done the task wanted to see what the whole data of that zone is.	When the table is clicked all the filters are refreshed. This is a bug in the table visual of Power Bi.
User 5	Extracting the NRW % from the visual using all the tools in their disposal	43 seconds	No constraints encountered	None found

Figure 4.21: *Prototype 1 Task 1*

4.9.2 Prototype 2: Google Data Studio

User	Testing outcome	Time to complete	Constraints Encountered	Potential Issues
User 1	Extracting the NRW % from the visual using all the tools in their disposal	42 seconds	The participant search with an equal on the filter and didn't do the capital 'p' for 'Paola'	None found
User 2	Extracting the NRW % from the visual using all the tools in their disposal	46 seconds	The participant was looking to the whole map to see where the zone was	None Found
User 3	Extracting the NRW % from the visual using all the tools in their disposal	55 seconds	No constraints encountered	None Found
User 4	Extracting the NRW % from the visual using all the tools in their disposal	27 seconds	The participant didn't switch page and searched the table without looking at the map for reference	Table doesn't split the data from one area to another
User 5	Extracting the NRW % from the visual using all the tools in their disposal	53 seconds	No constraints encountered	None found

Figure 4.22: *Prototype 2 Task 1*

4.10 Test Cases from Observation: Task 2

Task 2: Give me 2 Zone Names that have their NRW% lower than 30% in week 8

4.10.1 Prototype 1: Power Bi

User	Testing outcome	Time to complete	Constraints Encountered	Potential Issues
User 1	Extracting the Zone Names from the visual using all the tools in their disposal	17 seconds	No constraints encountered	None found
User 2	Extracting the Zone Names from the visual using all the tools in their disposal	19 seconds	No constraints encountered	None Found
User 3	Extracting the Zone Names from the visual using all the tools in their disposal	26 seconds	No constraints encountered	None found
User 4	Extracting the Zone Names from the visual using all the tools in their disposal	27 seconds	No constraints encountered	None found
User 5	Extracting the Zone Names from the visual using all the tools in their disposal	23 seconds	No constraints encountered	None found

Figure 4.23: *Prototype 1 Task 2*

4.10.2 Prototype 2: Google Data Studio

User	Testing outcome	Time to complete	Constraints Encountered	Potential Issues
User 1	Extracting the Zone Names from the visual using all the tools in their disposal	1 minute 3 seconds	The map was very difficult to comprehend	None found
User 2	Extracting the Zone Names from the visual using all the tools in their disposal	1 minute 14 seconds	The participant took a long time Zooming through the map to see the equivalent zone name.	None Found
User 3	Extracting the Zone Names from the visual using all the tools in their disposal	1 minute 27 seconds	The participant was looking to the whole map to see where the zone was	None Found
User 4	Extracting the Zone Names from the visual using all the tools in their disposal	58 seconds	The participant used the table only to check the NRW %. Image was not used	None Found
User 5	Extracting the Zone Names from the visual using all the tools in their disposal	1 minute 10 seconds	No constraints encountered	None found

Figure 4.24: *Prototype 2 Task 2*

Chapter 5: Findings and Discussion of Results

5.1 Findings and Discussion Introduction

This chapter will focus on providing detailed explanations regarding the observations that were held.

There were 5 people, who if these prototypes were to be published, would work on them on a regular basis to check the data visual. All these people are not on the data analysts' team, so they are not as qualified as the data analysts who do data visuals such as reports for Google Data Studio and dashboards for Power Bi, but they would be the target audience for this research.

5.2 Prototype 1 Results

For Task 1, most users were able to successfully extract the NRW% from the visual using the available tools without encountering any constraints or issues. Users 1, 2, 4, and 5 were able to complete the task efficiently within seconds. However, User 3 faced a bug where the synoptic panel did not refresh when clicking on the weeks, requiring an extra step of clicking outside the panel to fix the issue. Additionally, User 4 found a bug when clicking on the table visual refreshed all the filters, which affected their exploration of the whole data. Overall, the completion times varied from 31 seconds to 2 minutes 54 seconds resulting in an average of around 1 minute 17 seconds.

For Task 2, all users (User 1, User 2, User 3, User 4, and User 5) were able to extract the Zone Names with NRW% lower than 30% in week 8 using the available tools. No specific constraints or issues were reported during the task, and users completed it efficiently within 17 to 32 seconds resulting in an average of around 22 seconds.

5.3 Prototype 2 Results

For Task 1, all users (User 1, User 2, User 3, User 4, and User 5) successfully extracted the NRW% from the visual using the available tools. No specific constraints or issues were encountered during the task. The completion times ranged from 42 seconds to 55 seconds, indicating that users were able to accomplish the task without significant difficulties and resulting in an average of around 1 minute 3 seconds.

For Task 2, all users (User 1, User 2, User 3, User 4, and User 5) successfully extracted the Zone Names from the visual using the available tools. However, some users faced challenges in understanding or navigating the map visual, which resulted in slightly longer completion times. User 1 found the map difficult to comprehend, while User 2 took extra time zooming through the map to locate the equivalent zone names. User 3 also spent time looking at the whole map to identify the zones. Despite these challenges, all users were able to complete the task within reasonable time frames, ranging from 58 seconds to 1 minute 27 seconds resulting in an average of around 1 minute 10 seconds.

5.4 Prototypes Comparison and Discussion

5.4.1 Time to complete

When tasked to do a simple task which was task 1, prototype 1 took more time to complete on average than prototype 2. This can be explained with the case of user 3 who had an issue with the dashboard.

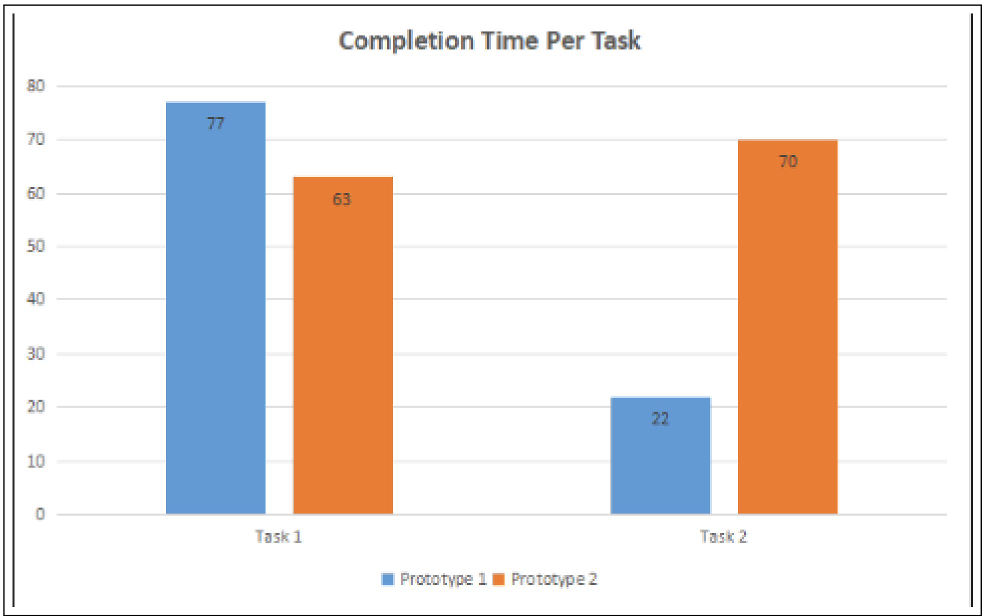


Figure 5.1: *Completion Time per Task*

In comparison to task 2, which was a more complex task, the completion time plummeted with prototype 1 and was relatively the same for prototype 2. This indicates that prototype 1 is better at handling complex tasks in less time and can have issues which would hinder your time.

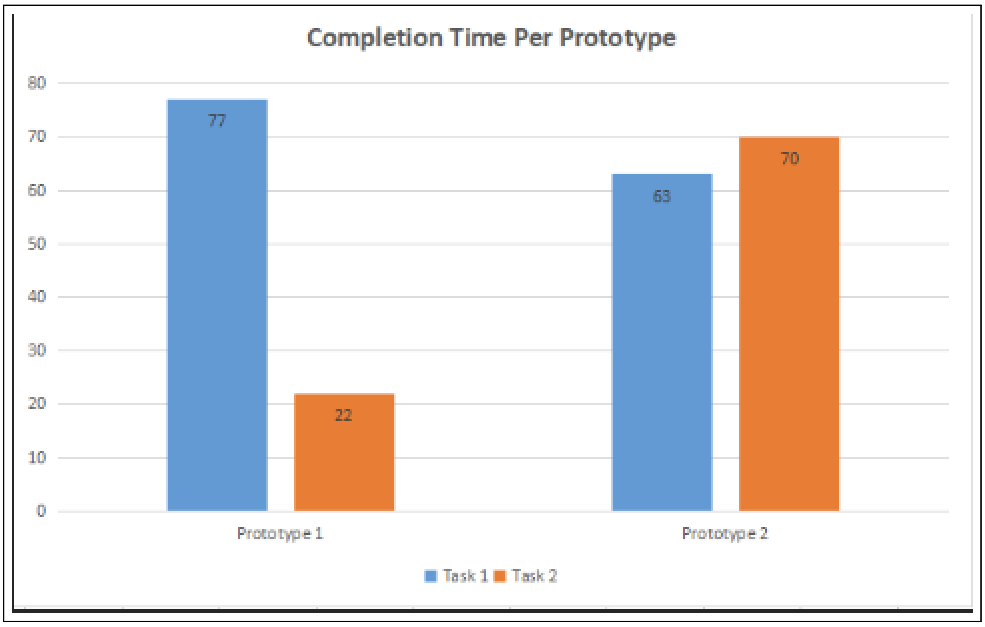


Figure 5.2: *Completion Time per Prototype*

5.4.2 Constraints encountered

For task 1, both the Prototypes had 3 constraints commented on by the user and observed. The 3 constraints on prototype 1 were, 2 on bugs that hindered the user from tackling the problem the most effective way and the other one was a little time wasted looking at the whole map colors. This latter one can be a positive thing since colors can indicate things which could help the user identify thresholds like in task 2. The 3 constraints on prototype 2 were all based on some human interaction that hindered or helped the user with their time.

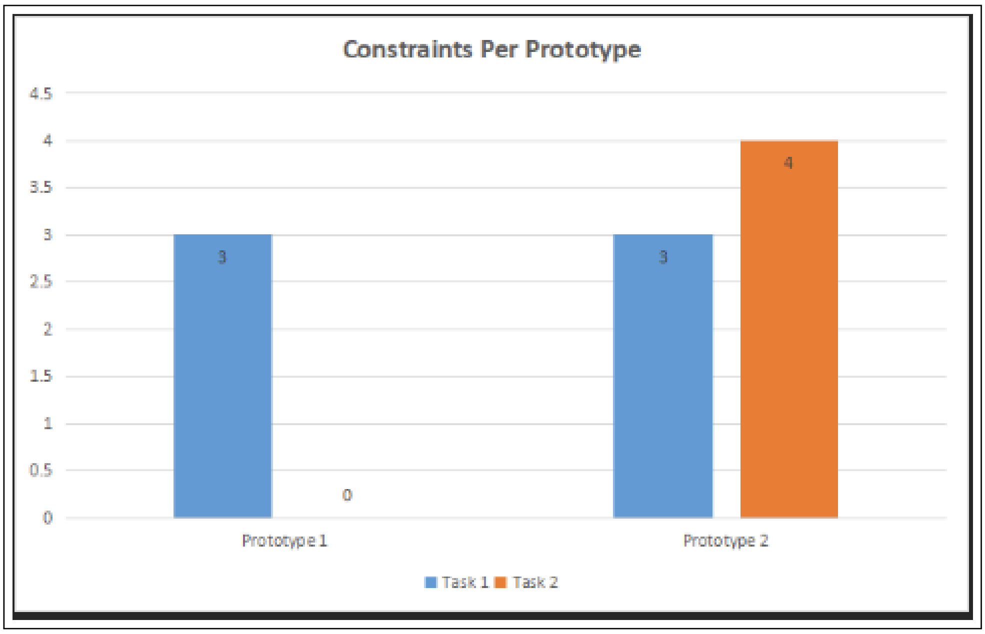


Figure 5.3: *Constraints Per Prototype*

In comparison, for task 2, with prototype 1, users did not comment on any constraint with the dashboard. However, in prototype 2, constraints were found mostly on the image of the map not being dynamic enough to check automatically with the map instead of using the table visual. This indicated that for complex tasks, prototype 1 would be the better option since it makes the dashboard more dynamic.

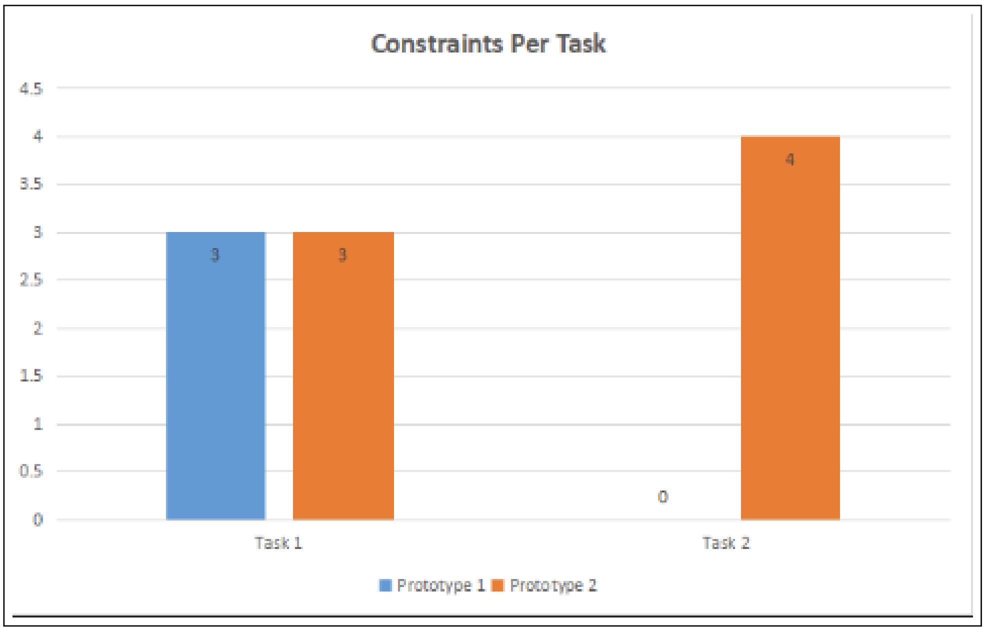


Figure 5.4: *Constraints Per Task*

5.4.3 Potential issues

Issues were found only in task 1. Prototype 1 had 2 potential bugs which occurred, one with user 3 and the other with user 4. Prototype 2 had 1 potential issue that could hinder security with the other areas.

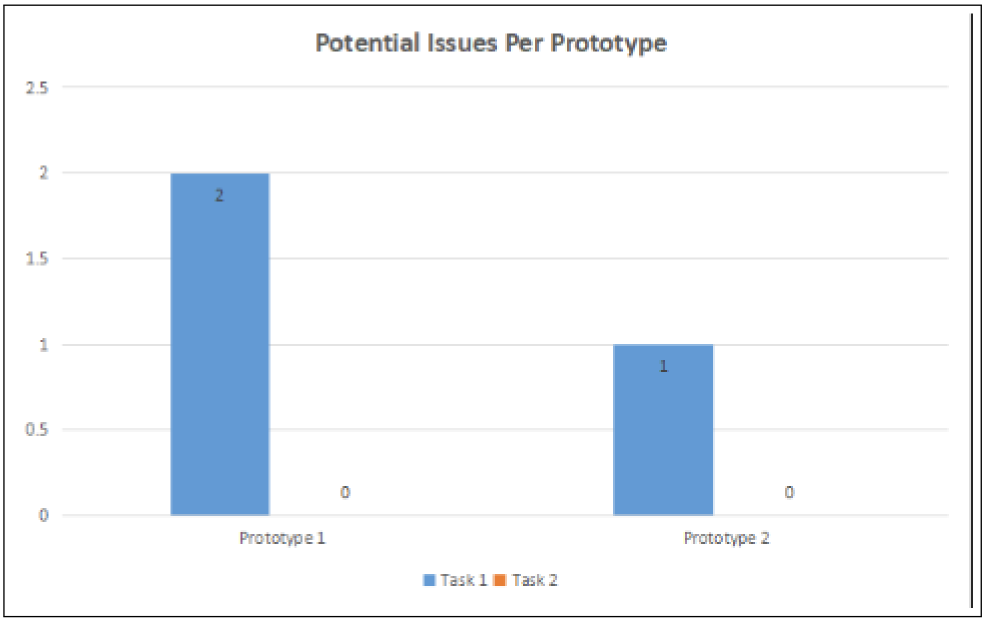


Figure 5.5: *Potential Issues Per Prototype*

With the potential issue results we can conclude that when the task was simpler, the user was more likely to have potential issues with both prototypes.

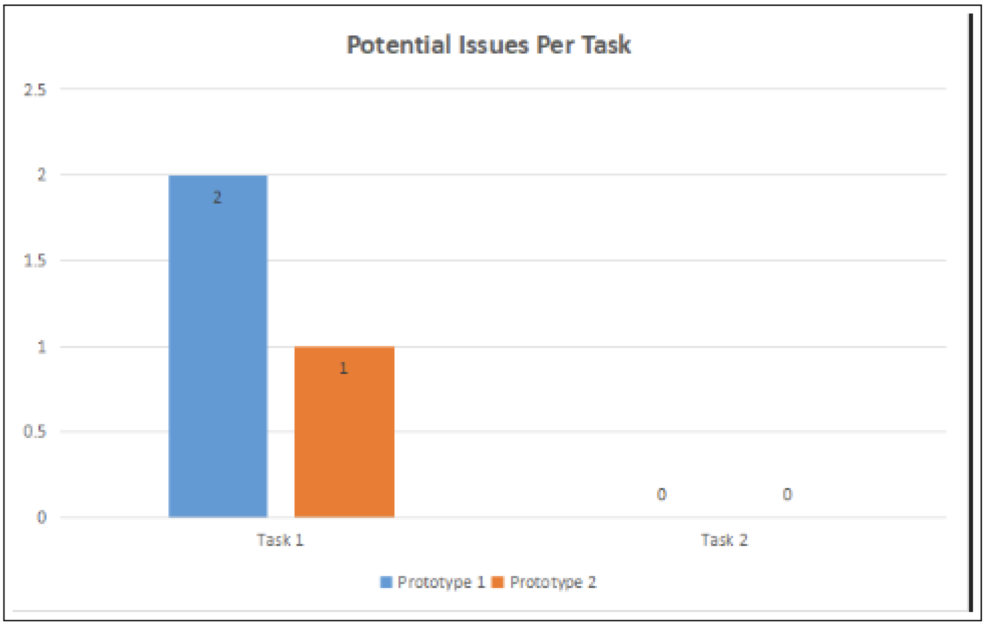


Figure 5.6: *Potential Issues Per Task*

5.5 Discussion

In summary, the results conclude that prototype 1 is more effective in complex tasks since the users had a substantial lesser time executing task 2 than task 1 and compared to prototype 2, the constraints don't exist. However, for simpler tasks such as task 1, prototype 2 was more effective with time and possible issues when compared to prototype 1.

To conclude, the 2 prototypes can handle both tasks in a relatively similar timing. The task determines which prototype is better to use. If the task is a simple search, then there is no need for the dynamic synoptic panel, therefore prototype 2 would have the advantage. If the task relies more on the user needing to see which zone on the map, then there is a need for a dynamic image that interacts with the table visual.

Chapter 6: Recommendations and Conclusion

6.1 Recommendations

If Prototype 1 is to be published in the future, several steps can be taken to enhance its functionality and usability. First, the data should be linked to an SQL database to ensure a reliable and efficient data source. This would enable seamless data retrieval and updates for the Power BI dashboard. Further development and testing should be conducted to address bugs or issues identified during the user observations, such as the data accuracy discrepancy encountered by Person 3. An instruction manual or documentation could be created to guide users on the proper usage and troubleshooting of the dashboard, reducing potential user errors and increasing overall satisfaction.

For Prototype 2, future publication can involve linking the report to an online database that refreshes the data periodically, ensuring that the displayed information remains up to date. This would enhance the usefulness and relevance of the report for users. Since Google Data Studio is a relatively new data visualization tool, ongoing development can focus on expanding the range of available visuals and interactive features. This would provide users with more options for visual representation and exploration of the data, improving the overall user experience and engagement.

To ensure the usability of both prototypes across various user skill levels, the target audience for observations can be broadened. By including individuals who may have limited knowledge of navigating dashboards or utilizing data visualization tools, the effectiveness and user-friendliness of the prototypes can be assessed comprehensively. This broader testing approach would help identify areas for improvement and ensure that the prototypes cater to a wider user base.

To further evaluate and compare the two prototypes, additional tasks can be incorporated into the observation process. These tasks could focus on different aspects of data analysis, exploration, or specific user scenarios. By expanding the scope of the observations, it would be possible to gather more insights into the strengths and weaknesses of each prototype and make more informed comparisons between them.

6.2 Conclusion

To conclude, with this research it was proven that multiple data visualization tools can result in similar outcomes if the task is simple enough. Although the prototypes presented were done having similar mindsets, the different platforms resulted into different prototypes which one focus more on visual aspects and dynamic approaches, and the other focused more on the simplicity and made the user more in control of the report. The first prototype would help the user see the data without searching it with a filter and the other gives the user the control of what they need to search without restricting them.

To answer the Research questions asked in the beginning of this dissertation:

"What are the main features that can make a user-friendly interface with all the raw data provided?" From the results provided within the different tasks, if the task is simple, different features such as slicers, advanced filters, buttons and images all help to make the interface user-friendly. If the task is more complex then, more advanced features are required to make the interface more user-friendly such as the synoptic panel, the circlet slicer and colors that help with the table visual.

How can these interfaces help in identifying information in a faster and a more efficient way? In prototype 1, with help of the synoptic panel and colors on the table visual, the data can be read very efficiently if the task requires a complex task. In prototype 2, with the help of advanced filters and the slicer, the table can be filtered and read very efficiently.

What will constrict the visual to having a lesser user-friendly interface? From the results, with prototype 1, that would be an abundance of visual distractions. For prototype 2, very minimal human errors punished the user for not being precise and the lack of visibility of the schematic were the things that constricted the visual more.

The outlined hypothesis, “Using the raw data, a user-friendly visualization can be done to facilitate the navigation of the visual that is presented” was found to be possible because in both tasks, the 2 prototypes delivered a positive answer in a relatively small amount of time averaging between around 20 seconds with no issues to around 2 minutes with issues.

List of References

[1] K Chinnaraju, V Chandrasekar, and K Shanmugam. Design of water supply system. *International Journal of Engineering Research and Applications*, 4(4):95–101, 2014.

[2] G Li, Y Li, and Y Xie. Design and optimization of water supply system in urban areas. *Applied Mechanics and Materials*, 399:26–29, 2013.

[3] Schematic presentation of malta water supply system. `https://www.researchgate.net/profile/Ernest-Azzopardi-2/publication/308212691/figure/fig1/AS:669479465938959@1536627751645/Schematic-presentation-of-Malta-water-supply-system_W640.jpg`.

[4] L B Gezahegn and A Gebretsadik. Non-revenue water management in urban water supply systems: A review. *Journal of Water Resource and Protection*, 11(7):836–852, 2019.

[5] Chengcheng Li, Xue Yang, and Chunhui Wang. Non-revenue water management in china: A review. *Sustainability*, 11(8):2319–2334, 2019.

[6] SketchBubble. Non-revenue water. `https://cdn.sketchbubble.com/pub/media/catalog/product/optimized1/4/4/`

`4443c7ccf570c8f1ab3c90cf92fd17b4d017f3cd82956a3641e77f56f7a60ef4/`
`non-revenue-water-slide4.png`, 2021.

[7] Prabu D D Dominic, Sharvari Arceivala, and Dang Pham Tung Nguyen. Real losses in water distribution systems. *Water*, 11(12):2466–2484, 2019.

[8] Adrian Lambert et al. Water loss management–a review of real loss component. *Journal of Water Supply: Research and Technology-AQUA*, 54(2):79–92, 2005.

[9] Mohammadreza Bahadori and Seyed Mohammad Reza Sattari. A systematic review of non-revenue water management. *Journal of Water Supply: Research and Technology-AQUA*, 69(7):686–700, 2020.

[10] M Vermersch, F Carteado, A Rizzo, E Johnson, F Arregui, and A Lambert. Guidance notes on apparent losses and water loss reduction planning. *Unpublished report*, 2016.

[11] Malta College of Arts, Science and Technology. Example of non-revenue water. `https://mcast.edu.mt/wp-content/uploads/2019/04/ap-loss-7-1-768x510.jpg`, 2019.

[12] Dino Musmarra et al. Non-revenue water reduction: Detection of illegal water withdrawal using satellite synthetic aperture radar interferometry. *Water*, 11(7):1496–1511, 2019.

[13] K G Villanueva-Rosales et al. Non-revenue water: An overview of strategies to address systematic illegal tapping and water losses in developing countries. *Sustainability*, 11(7):1–18, 2019.

[14] A. Lambert, W. Hirner, and A. Wyatt. Water losses in water distribution systems: standard terminology and performance measures. Technical Report 103, International Water Association, 1997.

[15] S. Sandoval-Solis, E. Porse, and D. McKinney. Comparison of methods for estimating real losses in water distribution systems. *Journal of Water Resources Planning and Management*, 142(5):04016006, 2016.

[16] M. Farley and S. Trow. Apparent loss methodology for water distribution systems. *Journal AWWA*, 102(3):46–55, 2010.

[17] Xiaoxia Xu, Wei Zeng, Ling Zhao, Zheng Liu, and Liang Chen. Non-revenue water reduction by using advanced metering infrastructure and smart water network. *Journal of Cleaner Production*, 242:118344, 2020.

[18] F. Kessouri, M. Djebabra, and J. Boudjerda. Pressure management for leakage reduction in water distribution networks: Case study of algiers. *Journal of Water Supply: Research and Technology-Aqua*, 67(6):562–573, 2018.

[19] Nor Hazurina Othman, Shuhana Shamsuddin, and Suhaimi Abdul-Talib. Optimization of water distribution system network layout and pipe size for non-revenue water reduction. *Journal of Cleaner Production*, 240:118216, 2019.

[20] Xiang Gao, Yan Zhang, and Yinhua Sun. Water flow analysis using power bi: A tool for reducing non-revenue water. *IOP Conference Series: Earth and Environmental Science*, 307:012009, 2019.

[21] Ahmad Babaei, Roshan N Waduge, and R M K B Rathnayaka. Data-driven approach to analyze non-revenue water: a case study. *Water Science and Technology: Water Supply*, 20(3):1121–1128, 2020.

[22] Kok Hua Chong, Mohd Khairul Amri Kamarudin, Muhammad Afiq Ramli, Nurul Aqilah Aziz, and Chee Seng Tan. Predicting non-revenue water losses using machine learning and power bi. *Journal of Cleaner Production*, 282:125104, 2021.