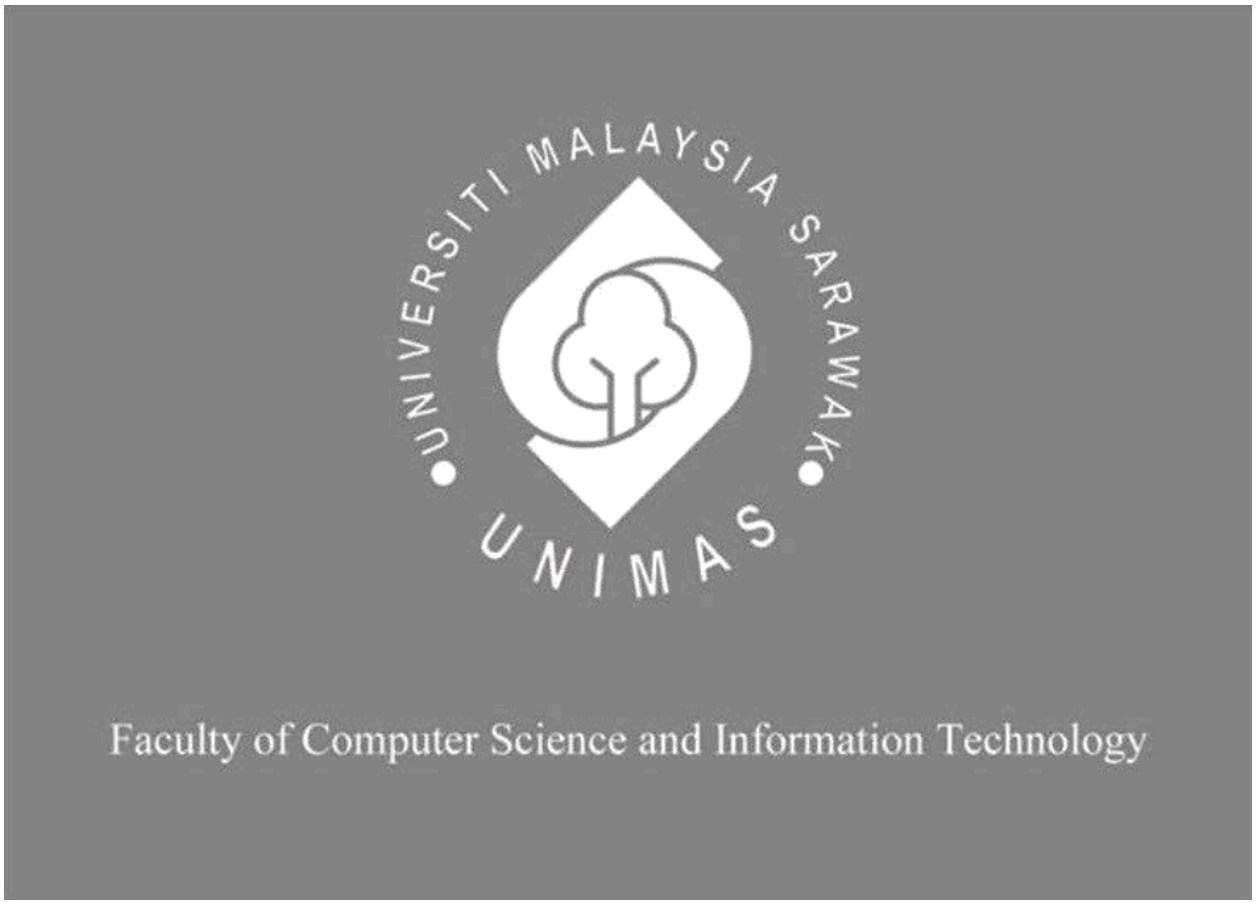

INTERACTIVE VISUALIZATION OF ENVIRONMENTAL DATA FOR PUBLIC AWARENESS AND INFORMED DECISION-MAKING

Jason Chan Fong

Bachelor of Computer Science with Honours (Multimedia Computing)

2025

INTERACTIVE VISUALIZATION OF ENVIRONMENTAL DATA FOR PUBLIC AWARENESS AND INFORMED DECISION-MAKING

JASON CHAN FONG

This project is submitted in partial fulfillment of the
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_____

Jason Chan Fong

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30 June 2025

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Abstract

This project focuses on developing "Enviz," an interactive web-based platform designed to enhance public awareness and facilitate informed decision-making regarding environmental issues in Malaysia. Recognizing the limitations of existing platforms that often present complex data in an inaccessible and unengaging manner, Enviz aims to bridge the gap between complex environmental data and actionable insights. Enviz will integrate diverse datasets, including climate trends, air and water quality, to provide a comprehensive and interactive overview of Malaysia's environmental landscape. The platform emphasizes clarity, interactivity, and accessibility through advanced data visualization techniques, such as interactive maps, time-series visualizations, and comparative charts. Key features include data filtering, downloadable content, and educational resources to enhance user engagement and understanding. Utilizing Agile methodology, the project follows a user-centered approach, iterating through design, development, and testing phases based on user feedback. By providing a user-friendly and accessible interface to users of all levels of technical expertise, Enviz aims to empower people with the knowledge and tools to make informed decisions and contribute to a more sustainable future.

Abstrak

Projek ini menumpukan pada pembangunan "Enviz," sebuah platform web interaktif yang direka untuk meningkatkan kesedaran awam dan memudahkan pembuatan keputusan yang termaklum mengenai isu-isu alam sekitar di Malaysia. Mengiktiraf keterbatasan platform sedia ada yang sering membentangkan data kompleks dengan cara yang tidak dapat diakses dan tidak menarik, Enviz bertujuan untuk menjembatani jurang antara data alam sekitar yang kompleks dengan tindakan yang boleh diambil. Enviz akan mengintegrasikan pelbagai set data, termasuklah trend iklim, kualiti udara, kualiti air, dan berpotensi data pembalakan, untuk memberikan gambaran keseluruhan yang komprehensif dan interaktif mengenai landskap alam sekitar Malaysia. Platform ini menekankan kejelasan, interaktiviti, dan aksesibiliti melalui teknik visualisasi data yang canggih, seperti peta interaktif, visualisasi siri masa, dan carta perbandingan. Ciri-ciri utama termasuk penapisan data, kandungan yang boleh dimuat turun, dan sumber pendidikan untuk meningkatkan penglibatan dan pemahaman pengguna. Mengguna pakai metodologi Agile, projek ini mengikuti pendekatan berpusatkan pengguna, mengulang melalui fasa reka bentuk, pembangunan, dan ujian berdasarkan maklum balas pengguna. Dengan menyediakan antara muka yang mesra pengguna dan boleh diakses oleh pengguna dengan semua tahap kepakaran teknikal, Enviz bertujuan untuk memperkasakan masyarakat dengan pengetahuan dan alat untuk membuat keputusan yang termaklum dan menyumbang kepada masa depan yang lebih mampan.

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Chapter 1: Introduction

1.1 Background

Climate change and environmental degradation are major issues facing the world today, with significant implications for ecosystems, economy, and human well-being (Tang, 2019). These issues are particularly critical in Malaysia, as seen in rising temperatures, decreasing air and water quality. The Intergovernmental Panel on Climate Change (Tang, 2019) stresses the urgent need for effective strategies to mitigate and adapt to these environmental challenges.

The availability of environmental data has grown substantially in recent years, offering valuable insights for decision-making and policy development. However, the sheer volume and complexity of such data often hinder effective interpretation and utilization. This highlights the importance of innovative approaches to presenting and communicating environmental information.

Interactive data visualizations have emerged as powerful tools for making complex environmental data more accessible and understandable (Heer & Shneiderman, 2004). These tools can simplify intricate datasets—such as climate, air quality, or water quality metrics—enabling users to identify patterns and trends that might otherwise remain hidden. For instance, visual representations of air quality data can reveal regions with high pollution levels, aiding targeted interventions (Kalaivani et al., 2023).

However, creating effective visualizations is not without its difficulties. Environmental data often vary in accuracy, detail, and quality, complicating integration and analysis (Mangal et

al., 2020). Additionally, the scale of modern environmental datasets necessitates advanced tools and methodologies to process and present the information effectively (Lazer et al., 2014).

This project aims to address these challenges by developing an interactive web-based platform that visualizes environmental data, focusing on climate, air quality, and water quality in Malaysia. By making these datasets more accessible and engaging, the platform seeks to empower users to better understand environmental issues.

1.2 Problem Statement

The challenges outlined in the problem statement highlight significant barriers to the effective use of environmental data. The complexity of data, often presented in diverse formats, creates difficulties in interpretation and analysis, particularly for non-experts. This issue is exacerbated by the lack of standardization in environmental data collection and reporting, which can lead to inconsistencies and gaps in understanding (Hampton et al., 2013). Addressing these challenges requires innovative approaches to data integration and visualization to make environmental information more accessible and actionable.

The limitations of existing tools further compound these issues, as many current platforms lack the interactivity needed for users to explore data and derive personalized insights. Interactive visualization tools have been shown to enhance user engagement and understanding, yet many environmental data platforms remain static and non-intuitive (Kalaivani et al., 2023). Developing more dynamic and user-centric tools could empower individuals and communities to engage more deeply with environmental data, fostering greater awareness and informed decision-making.

Finally, the lack of user-friendly interfaces presents a significant barrier to accessibility, particularly for users without specialized knowledge. Simplifying the presentation of complex environmental data through intuitive design and clear visualizations can bridge this gap. Research suggests that user-centered design principles can significantly improve the usability of environmental data platforms, making them more inclusive and effective (Roose et al., 2021). By addressing these challenges, we can enhance public understanding of environmental issues and support more informed decision-making at all levels.

Research Questions:

1. How can standardization and integration of environmental data improve its accessibility and usability for non-expert users?
2. What features of interactive visualization tools are most effective in enhancing user engagement and understanding of environmental data?
3. How can user-centered design principles be applied to create more intuitive and inclusive interfaces for environmental data platforms?

1.3 Scope

This project focuses on developing an interactive web-based platform that visualizes key environmental data, including:

- Climate Data: Trends in temperature and sea-level rise.
- Air Quality Data: Levels of pollutants such as PM2.5, CO2, and NO2.

- Water Quality Data: Nutrient levels, pH values, and contaminant concentrations.

The platform will show each urban area in Malaysia, such as Kuala Lumpur, Penang, and Johor Bahru. Departing from traditional dashboards, it will feature exploratory visualization tools, enabling users to interact with the data and uncover patterns and insights dynamically.

1.4 Aim and Objectives

Aim:

To develop an interactive web-based platform for visualizing and exploring environmental data in Malaysia.

Objectives:

1. **To analyse and visualize environmental data:**
    - Analyse climate, air quality, and water quality in Malaysia.
    - Develop effective visualizations, such as interactive maps, charts, and graphs, to communicate key findings and trends.
2. **To develop and implement a user-friendly platform:**
    - Design and develop a user-friendly and accessible web-based platform for data visualization.
    - Ensure seamless data integration and robust visualization functionalities within the platform.
3. **To evaluate platform effectiveness:**

- Conduct user testing to evaluate the platform's usability, effectiveness, and user satisfaction.
- Gather user feedback to identify areas for improvement and refine the platform accordingly.

1.5 Brief Methodology

This project will employ an Agile development methodology, prioritizing iterative development and continuous feedback. The project will be divided into three key phases:

Phase 1: Requirements Analysis and Data Collection (O1)

1. Data Collection
    - Collect relevant environmental data from various sources.
2. Data Cleaning and Preprocessing
    - Clean and preprocess the collected data to ensure accuracy, consistency, and reliability, addressing issues such as missing values, outliers, and data inconsistencies.
3. Exploratory Data Analysis (EDA)
    - Conduct EDA to identify patterns, trends, and anomalies within the datasets.

Milestones

- Completion of data collection and preprocessing.
- Completion of EDA and preparation for platform design.

Phase 2: Platform Design and Development (O2)

1. Design and Development
    - Design and develop the interactive web-based platform.

Milestones

- Completion of platform design and initial development of core functionalities.
- Completion of platform development and preparation for user testing.

Phase 3: Platform Evaluation and Refinement (O3)

1. User Testing
    - Conduct user testing with a diverse group of participants to evaluate the platform's usability, effectiveness, and user experience.
2. Platform Refinement
    - Refine the platform's functionality, improve user interface design and enhance data visualization capabilities based on user feedback.

Milestones

- Completion of user testing and analysis of user feedback.
- Completion of platform refinement and preparation for final report and presentation.

1.6 Significance of Project

This project aims to contribute to a better understanding of environmental issues in Malaysia. By developing an interactive web-based platform, the project will facilitate data analysis, allowing users to more effectively identify trends, patterns, and anomalies. Additionally, the project will contribute to the creation of an innovative visualization platform that communicates complex environmental data in an accessible and engaging manner. Lastly, the platform will serve as a

valuable educational tool, fostering a deeper understanding of environmental science and promoting environmental awareness among students, teachers, and the public.

1.7 Project Schedule

The project schedule is organized into key phases, including proposal initiation & planning, data collection & preparation, exploratory data analysis (EDA), visualization design & prototyping, platform development, user testing & evaluation, and final report & presentation, spanning a timeline of 9 months approximately. The project schedule is shown in **Appendix A**.

1.8 Expected Outcomes

1. **Development of a fully functional web-based platform**

   A platform designed to visualize key environmental data related to climate, air quality, and water quality in Malaysia.

2. **Effective and user-friendly visualisations**

   Development of interactive maps, charts, and graphs to enable users to identify trends, patterns, and anomalies in Malaysia's environmental data.

3. **Enhanced Understanding of Environmental Issues**

   Improved public understanding of environmental issues in Malaysia, fostering greater awareness and informed decision-making regarding climate and environmental challenges.

1.9 Summary

This chapter provides a comprehensive overview of the project, outlining the background, challenges, and proposed approach to developing an interactive web-based platform for visualizing key environmental data in Malaysia. The project aims to address the critical need for improved environmental data analysis and communication by creating a user-friendly platform that empowers users to explore and understand climate, air quality, and water quality data through interactive visualizations. The methodology emphasizes an Agile approach, ensuring iterative development and continuous feedback to effectively meet users' needs and achieve the project's objectives.

Chapter 2: Literature Review

2.1 Introduction

In recent years, environmental issues such as climate change, air pollution, and water pollution have gained significant global attention due to their profound impacts on ecosystems, public health, and economies (Abbass et al., 2022). These issues are exacerbated by rapid urbanization and industrialization, which contribute to environmental degradation on a global scale (Chasek & Downie, 2020). In Malaysia, these challenges are becoming increasingly critical as the nation contends with rising temperatures, deteriorating air and water quality, and other environmental concerns (Tang, 2019). Addressing these interconnected problems requires informed decision-making supported by accurate and accessible environmental data (Ncube & Ngulube, 2024).

While specialized platforms such as NASA Worldview, IQAir, Global Forest Watch, and Global Plastic Watch provide valuable insights, these systems often focus on specific environmental domains without offering a holistic perspective (Dong et al., 2018). This fragmented approach limits their ability to support comprehensive analyses and highlight interconnections among various environmental factors (Kosyakova et al., 2019). The lack of interoperability between these platforms further complicates efforts to create a unified understanding of environmental issues (Hazra et al., 2021). Furthermore, the complexity and technical nature of some platforms can deter non-expert users, reducing public engagement with these pressing issues (Nakić et al., 2022).

To bridge this gap, the proposed web application aims to integrate diverse environmental datasets into a unified, user-friendly platform tailored to Malaysia's unique environmental

challenges (Gessa & Sancha, 2019). By leveraging advanced visualization techniques, interactive tools, and dynamic filtering options, the platform seeks to enable users to analyze and visualize environmental data effectively (Balla et al., 2020).

This literature review explores existing systems to identify their strengths and limitations, providing a foundation for developing an integrated solution that addresses Malaysia's environmental sustainability challenges comprehensively.

2.2 Review on Existing Platforms

2.2.1 NASA Worldview

NASA Worldview is an interactive, web-based application developed by NASA's Earth Science Data and Information System (ESDIS) project, a part of the Earth Observing System Data and Information System (EOSDIS). The platform was launched in 2011 to provide the public, researchers, and policymakers with easy access to satellite imagery and Earth science data. Worldview acts as a gateway to visualize data collected by NASA's fleet of Earth-observing satellites, enabling the exploration of global environmental phenomena in near-real-time or over extended historical periods.

NASA Worldview was designed to enhance the accessibility of NASA's vast environmental datasets and make satellite imagery usable for diverse audiences, including non-experts. This aligns with NASA's mission to promote public understanding of environmental changes and supports decision-making in areas such as disaster response, agriculture, and climate research. The platform also allows users to search for specific locations or coordinates (Figure 2.3) and visualize data through an interactive map interface (Figure 2.4).

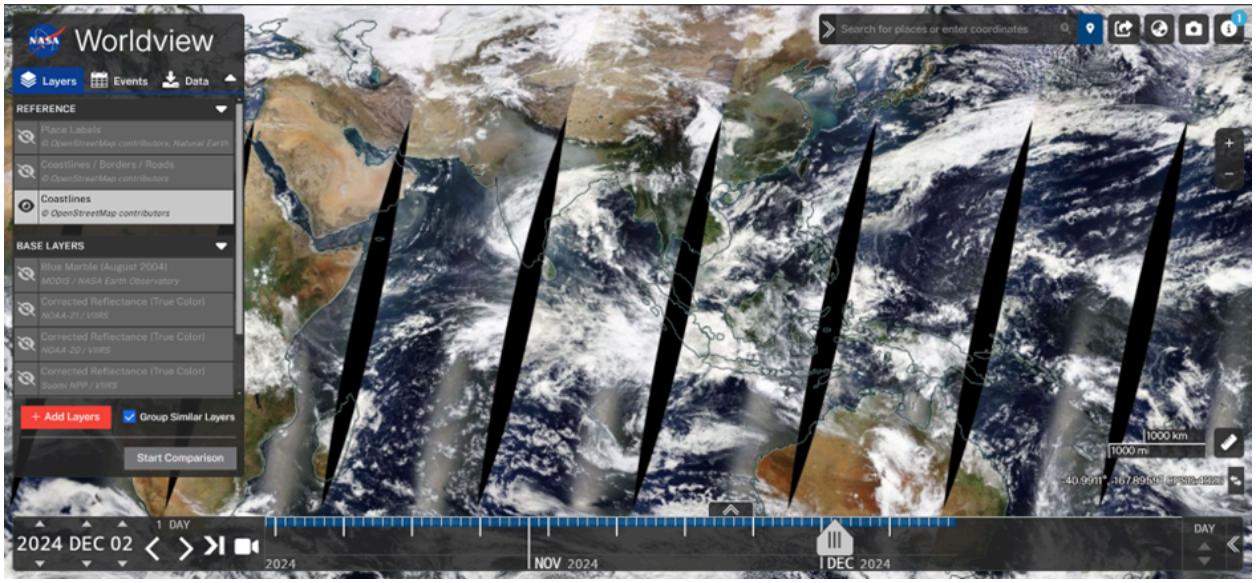


Figure 2.1. Homepage of NASA Worldview ("NASA Worldview", 2011)

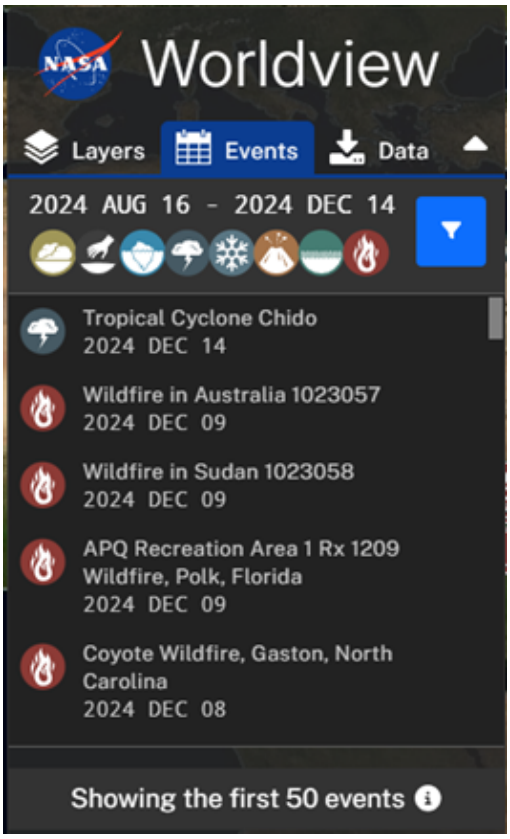


Figure 2.2. Sidebar in NASA Worldview ("NASA Worldview", 2011)

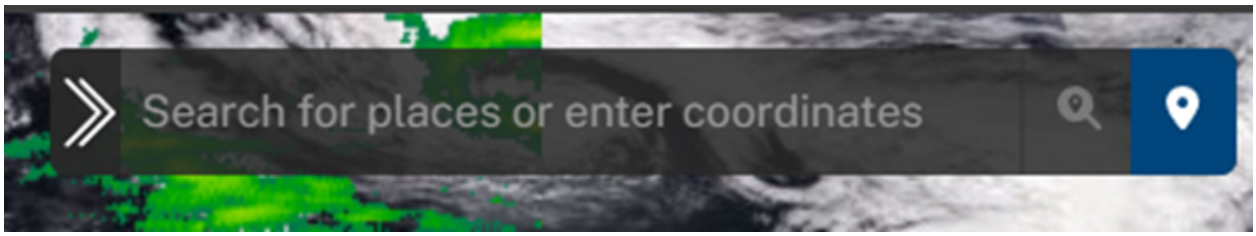


Figure 2.3. Location search in NASA Worldview ("NASA Worldview", 2011)

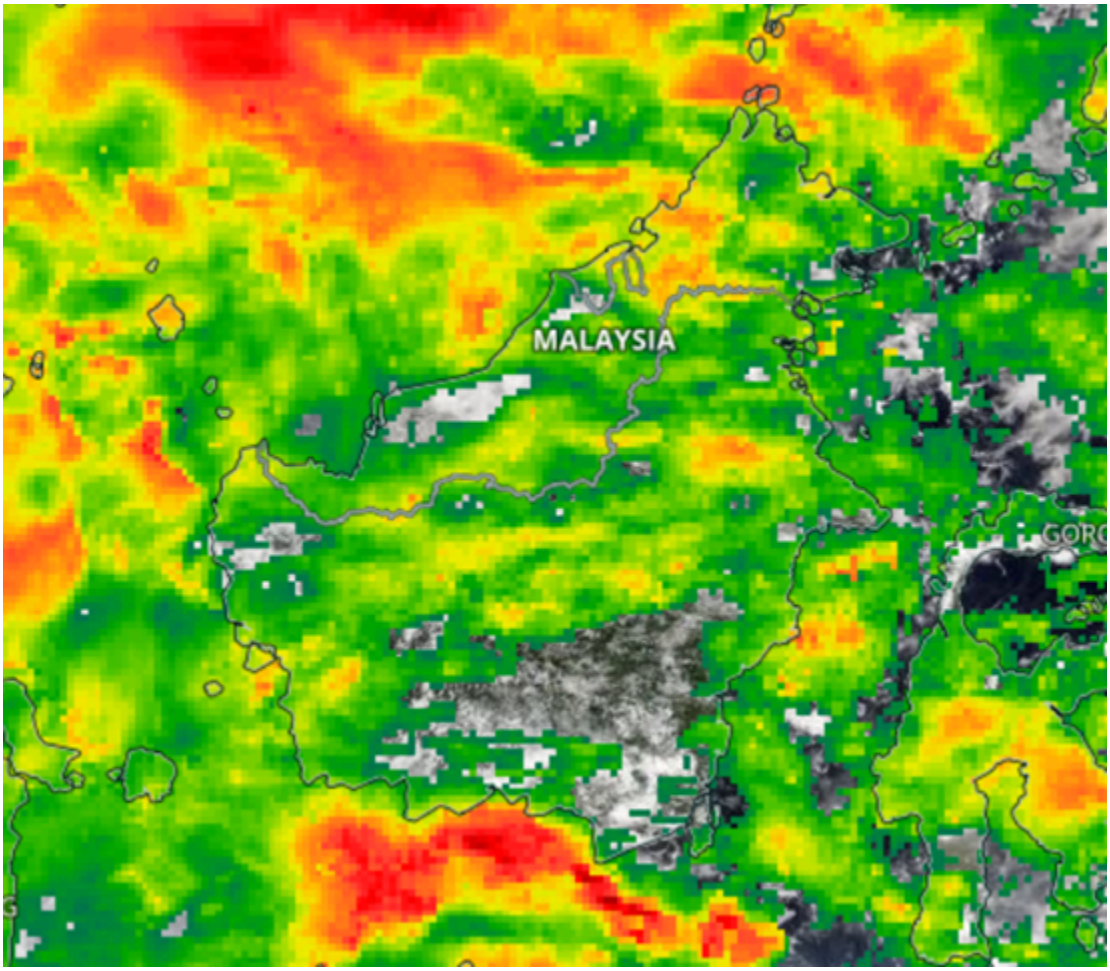


Figure 2.4. Visualisation map in NASA Worldview ("NASA Worldview", 2011)

2.2.1.1 Human Perception

- **Pre-Attentive Processing**: NASA Worldview employs colour intensity and contrast effectively, enabling quick identification of anomalies such as temperature variations or pollution hotspots. However, distinguishing between overlapping data layers, such as vegetation cover and land use, can be challenging due to similar colour schemes.
- **Gestalt Principles**: Continuity in global imagery layers aids in maintaining a cohesive visual flow, but abrupt transitions between datasets occasionally disrupt the user experience.

2.2.1.2 Visual Design

- **Bertin's Visual Variables**: Position and colour are utilized effectively for data representation, but the overuse of saturation complicates the interpretation of subtle variations. Map projections sometimes distort spatial relationships, reducing the precision of data interpretation.
- **Tufte's Principles**: The high data-ink ratio ensures rich detail but introduces visual clutter, violating the principle of avoiding chartjunk.

2.2.1.3 Evaluation

- **Reliability**: Frequently updated, scientifically accurate datasets ensure high reliability.
- **Clarity**: The interface requires advanced technical knowledge, limiting its accessibility for non-experts.
- **Presentation**: Limited interactivity, such as the absence of tooltips or dynamic filtering, restricts engagement and usability.

2.2.2 IQAir

IQAir is a global air quality monitoring platform that provides real-time data on air pollution levels across various regions. It aims to raise awareness of air quality issues and promote actionable steps toward cleaner air. The platform integrates data from its proprietary sensors, government monitoring stations, and community-contributed data. Its features cater to individuals, policymakers, researchers, and organizations seeking to monitor and manage air quality effectively.

Developed by the Swiss-based IQAir Group, a company specializing in air purification systems and environmental technology, IQAir was launched as part of their mission to improve global air quality and provide open access to pollution data for the public. Founded in 1963, IQAir initially focused on air purification and has since expanded into environmental data visualization and technology solutions.

IQAir shows the air quality in the selected city (Figure 2.6) and includes the hourly forecast for that location (Figure 2.7). It also provides a daily forecast and details on air pollutant levels in the chosen city (Figure 2.8). Additionally, the platform features a real-time air pollution map that offers health recommendations for the selected city (Figure 2.9).

Figure 2.5. Homepage of IQAir (“IQAir”, 2024)

Figure 2.6. Air quality in the selected city (“IQAir”, 2024)

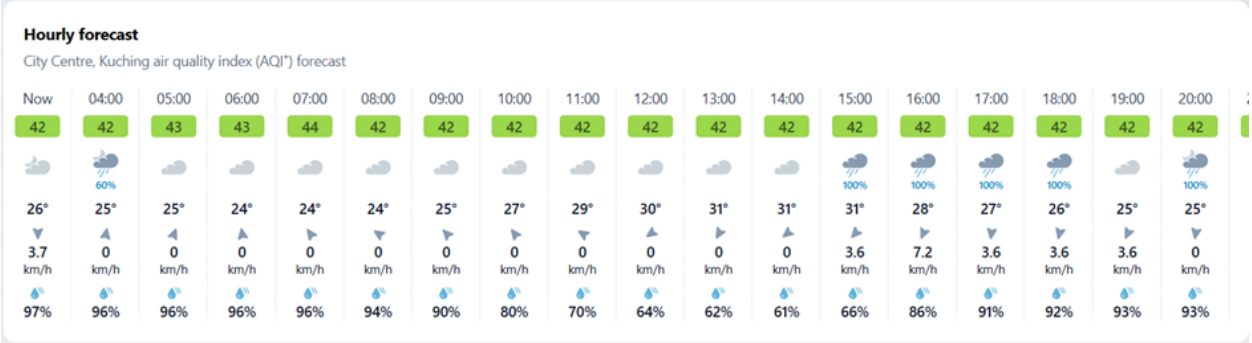


Figure 2.7. Hourly forecast for the selected city (“IQAir”, 2024)

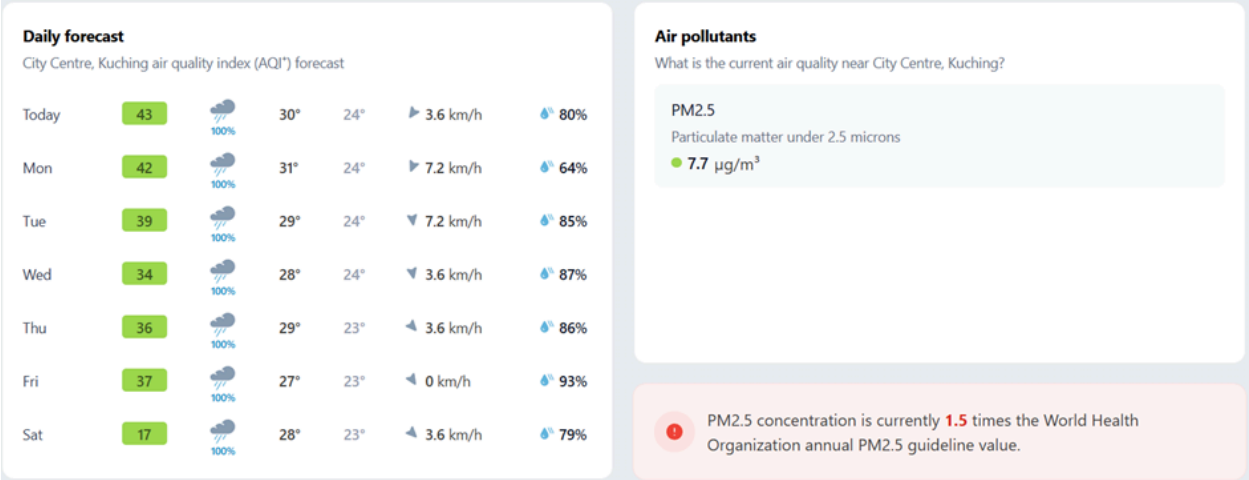


Figure 2.8. Daily forecast and air pollutant levels in the selected city (“IQAir”, 2024)

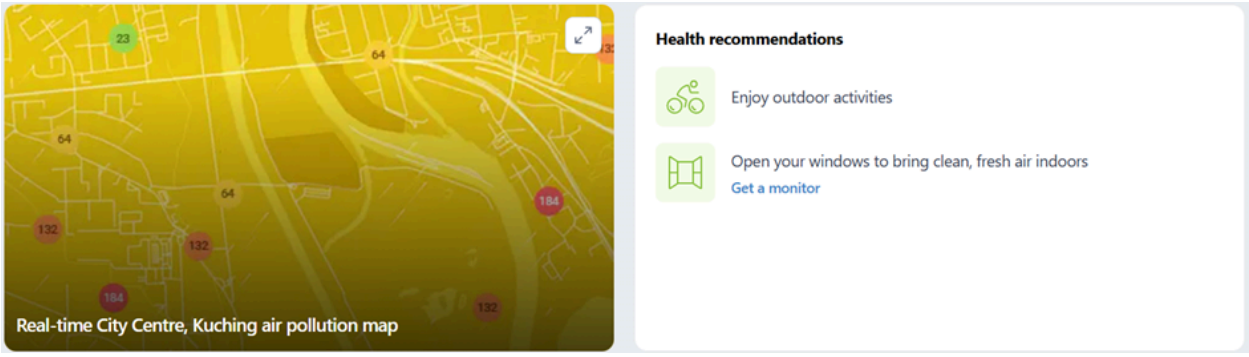


Figure 2.9. Real-time air pollution map with health recommendations for the selected city (“IQAir”, 2024)

2.2.2.1 Human Perception

- **Pre-Attentive Processing**: Colour gradients effectively represent air quality levels, enabling quick identification of highly polluted areas. However, inconsistent colour contrast in some regions reduces legibility.
- **Gestalt Principles**: Colour similarity supports grouping similar pollution levels, though regions with low contrast may hinder user comprehension.

2.2.2.2 Visual Design

- **Bertin's Variables**: Position and size highlight high-pollution zones effectively. Interactive legends and tooltips enhance usability, but inconsistent colour scales between regions can complicate comparisons.
- **Tufte's Principles**: The platform maintains simplicity and avoids unnecessary elements, adhering to functional design principles.

2.2.2.3 Evaluation

- **Reliability**: Regional variation in sensor data accuracy may affect reliability.
- **Clarity**: Clear legends and tooltips improve accessibility for non-experts.
- **Presentation**: Interactive features such as zooming and filtering enhance engagement and customization

2.2.3 No Existing System on Water Quality

Currently, there is no dedicated system or platform available for monitoring water quality metrics such as nutrient levels, pH values, and contaminant concentrations in Malaysia. This gap may be attributed to data fragmentation across various agencies and the lack of standardization, funding, and resources for comprehensive water quality monitoring platforms.

2.2.4 Global Forest Watch (GFW)

Global Forest Watch (GFW) is an open-source web platform developed by the World Resources Institute (WRI) in collaboration with a diverse network of partners, including Google, USAID, the University of Maryland, and Vizzuality. Launched in 2014, GFW integrates satellite imagery, machine learning, and crowdsourced data to offer detailed insights into forest cover, deforestation trends, and land use changes. It is widely used by researchers, policymakers, conservationists, and the public to track deforestation events, analyse forest conditions, and support sustainable land use planning.

The platform offers specific tools for tracking forest changes in Malaysia, such as primary forest loss in the country along with its corresponding map (Figure 2.11). It also highlights tree cover loss in Malaysia (Figure 2.12) and compares forest conditions in Malaysia to other areas, including tree cover data (Figure 2.13). GFW enables users to view the location of tree cover in Malaysia and areas of tree cover loss (Figure 2.14), as well as annual tree cover loss by the dominant driver in Malaysia (Figure 2.15).

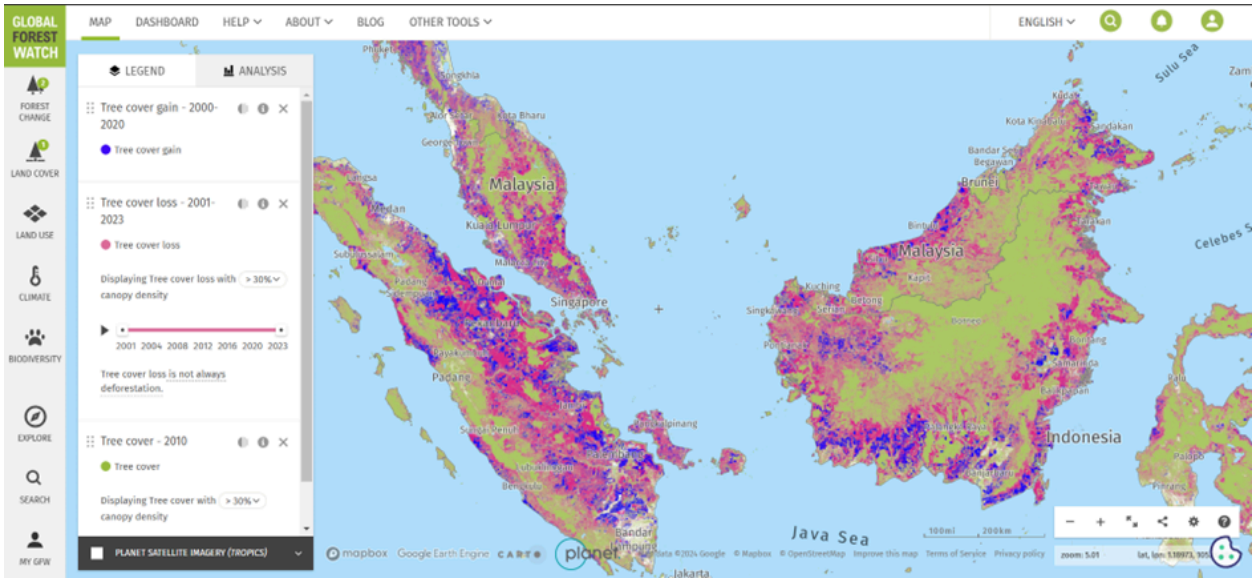


Figure 2.10. Homepage of Global Forest Watch ("Global Forest Watch", 2023)

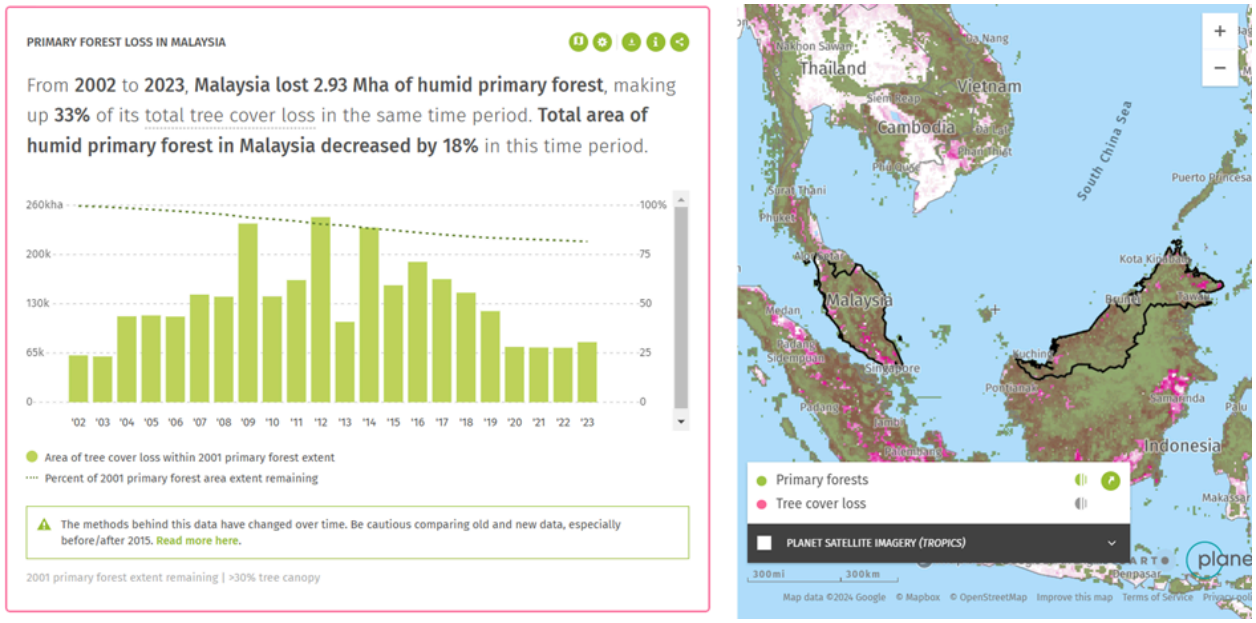


Figure 2.11. Primary forest loss in Malaysia and its corresponding map ("Global Forest Watch", 2023)

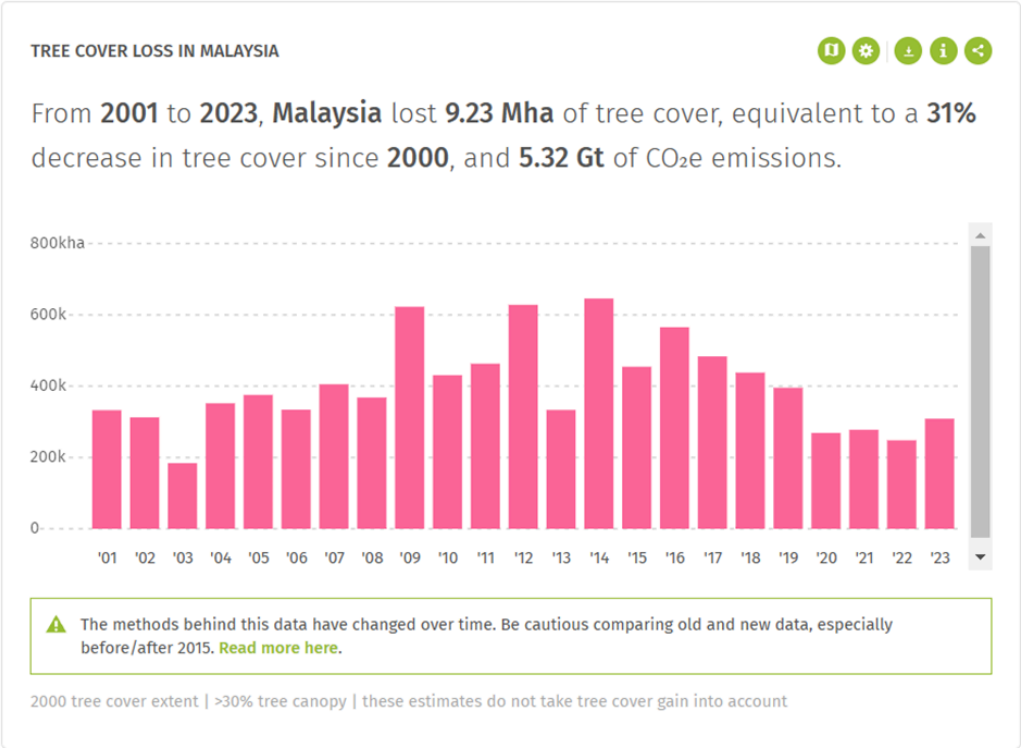


Figure 2.12. Tree cover loss in Malaysia ("Global Forest Watch", 2023)

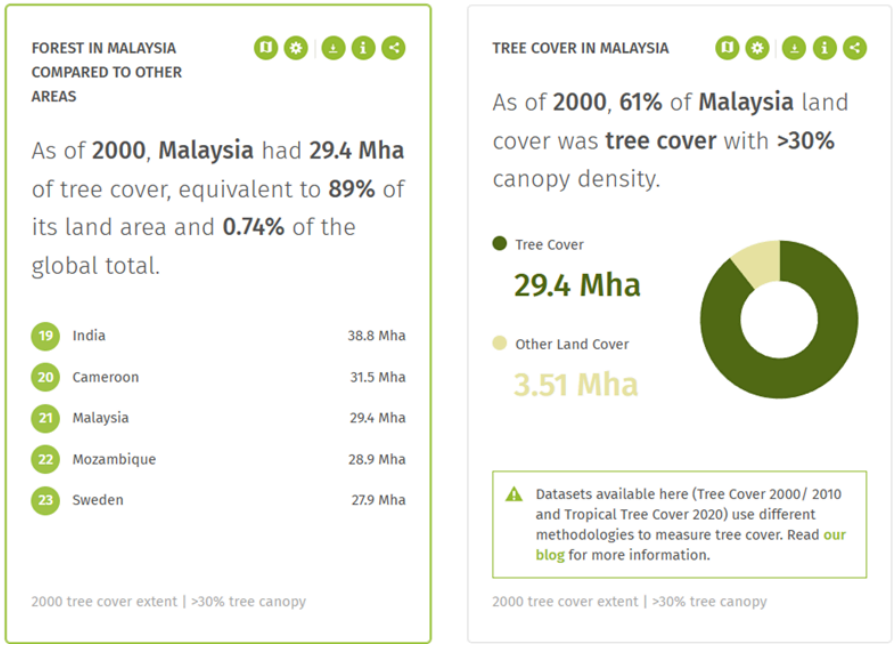


Figure 2.13. Forests in Malaysia compared to other areas, along with tree cover data for Malaysia ("Global Forest Watch", 2023)

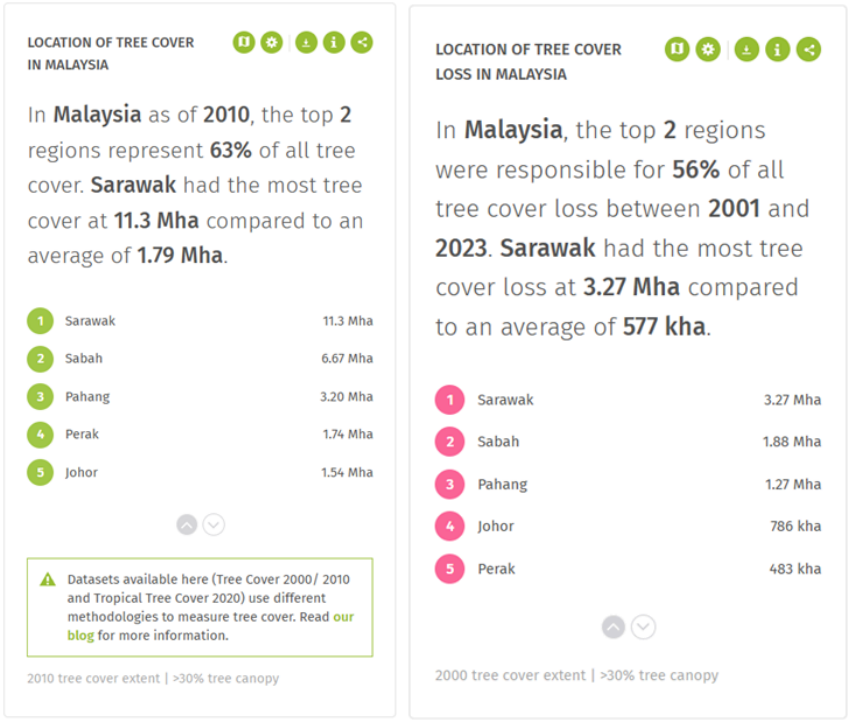


Figure 2.14. The location of tree cover in Malaysia and the areas of tree cover loss ("Global Forest Watch", 2023)

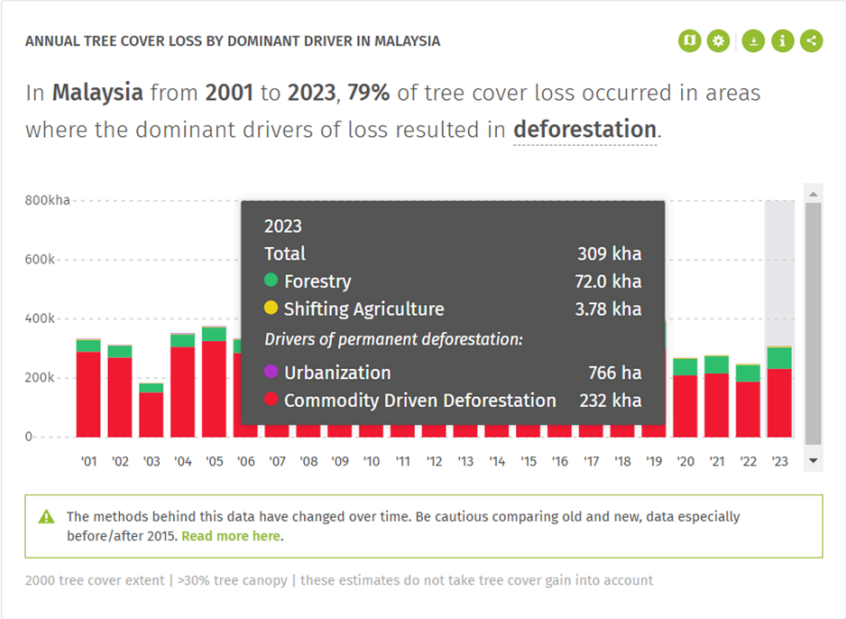


Figure 2.15. Annual tree cover loss by dominant driver in Malaysia ("Global Forest Watch", 2023)

2.2.4.1 Human Perception

- **Pre-Attentive Processing**: Contrasting colours differentiate forest loss and gain effectively, making patterns easy to detect.
- **Gestalt Principles**: Proximity and similarity are well-applied, allowing users to group forest data by region seamlessly.

2.2.4.2 Visual Design

- **Bertin's Variables**: Effective use of colour and position highlights changes in forest cover. However, limited variation in shapes and textures reduces data differentiation. A legend would help clarify forest cover change types.
- **Tufte's Principles**: Overlaid layers of deforestation alerts and forest cover loss sometimes obscure base maps, complicating assessments of forest changes.

2.2.4.3 Evaluation

- **Reliability**: Data sourced from reputable organizations ensures credibility, but infrequent updates may impact timeliness.
- **Clarity**: An intuitive interface is occasionally undermined by overloaded map layers, which may overwhelm users.
- **Presentation**: Strong interactivity, including dataset downloads and customizable visualizations, enhances utility.

2.2.5 Global Plastic Watch (GPW)

Global Plastic Watch (GPW) is an innovative digital platform developed by the Minderoo Foundation, a philanthropic organization based in Australia, in collaboration with Earthrise Media and other partners to map the world's plastic pollution in near real-time. The platform was launched to provide transparent and actionable insights into global plastic pollution. Officially launched in 2021, it uses advanced satellite imagery and artificial intelligence (AI) to identify and map plastic waste pollution globally. The platform provides near real-time data on plastic waste accumulation, aiming to aid governments, environmental organizations, and researchers in combating plastic pollution.

GPW combines high-resolution satellite data with machine learning algorithms to detect and monitor waste sites. By offering a global perspective, it highlights pollution hotspots and provides critical insights for formulating effective waste management and environmental policies. The platform also provides country-specific reports, including the Plastic Waste Makers Index, locations of sites near waterways, and data on leading plastic polymer producers (Figure 2.17). For a more localized view, users can explore site attributes for selected areas in Malaysia, including detailed information on pollution sources (Figure 2.18).

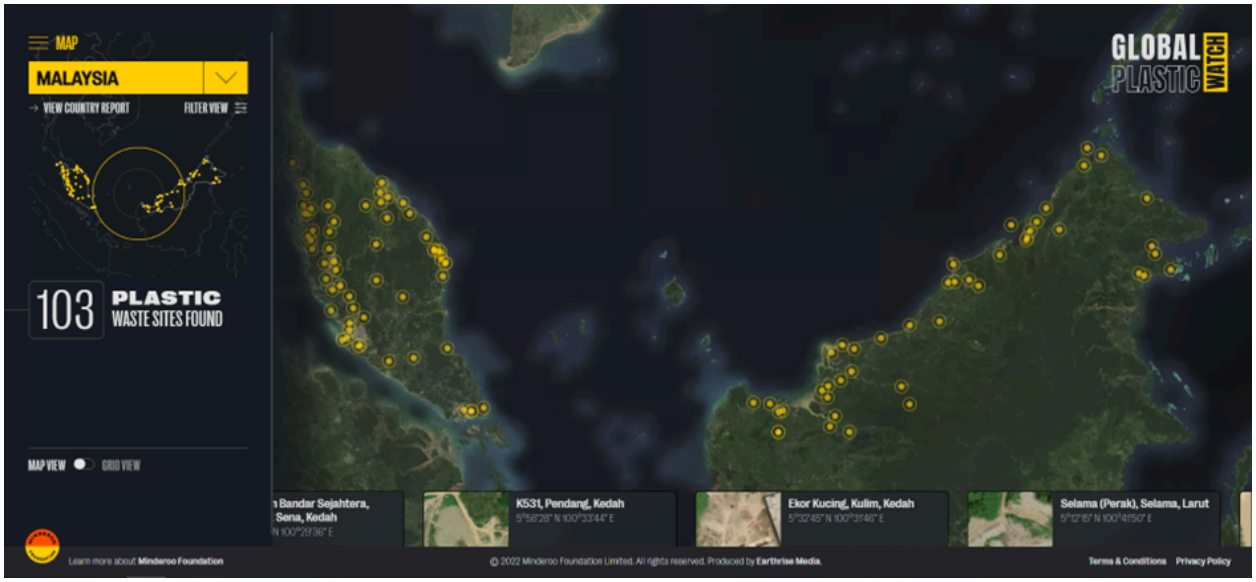


Figure 2.16. Homepage of Global Plastic Watch ("Global Plastic Watch", 2022)

Figure 2.17. Country report including the Plastic Waste Makers Index, sites near waterways, and leading plastic polymer producers ("Global Plastic Watch", 2022)

Figure 2.18. Site attributes of the selected area in Malaysia ("Global Plastic Watch", 2022)

2.2.5.1 Human Perception

- **Pre-Attentive Processing**: Vivid colours effectively identify plastic pollution hotspots, but prolonged viewing may cause visual strain.
- **Gestalt Principles**: Proximity and continuity group data efficiently, helping users identify pollution clusters and trace sources along waterways.

2.2.5.2 Visual Design

- **Bertin's Variables**: Size and colour intensity effectively convey pollution density. However, excessive brightness in colour choices can strain users' eyes.
- **Tufte's Principles**: A minimalist design avoids chartjunk, but limited layering options reduce the depth of data exploration.

2.2.5.3 Evaluation

- **Reliability**: Transparent data collection methods ensure trustworthiness.
- **Clarity**: A visually appealing and straightforward interface improves accessibility for diverse audiences.
- **Presentation**: Limited interactivity, such as the inability to overlay datasets, reduces user engagement

2.3 Comparison on Existing Platforms

Comparison of Existing Platforms summarized in Table 2.1.

Table 2.1. Comparison of Existing Platforms

Criterion	NASA Worldview	IQAir	Global Forest Watch	Global Plastic Watch
Human Perception	Pre-Attentive Processing: Effective colour contrast but lacks closure in incomplete datasets.	Pre-Attentive Processing: Color gradients for air quality levels, but inconsistent contrast in some regions.	Pre-Attentive Processing: Contrasting colors for forest loss/gain, but overloaded map layers	Pre-Attentive Processing: Vivid colors for pollution hotspots, but prolonged viewing causes visual strain.

	Gestalt Principles: Continuity in global imagery layers, but abrupt transitions disrupt flow.	Gestalt Principles: Color similarity groups pollution levels, but low contrast hinders comprehension.	overwhelm users. Gestalt Principles: Proximity and similarity group forest data by region effectively.	Gestalt Principles: Proximity and continuity group pollution clusters effectively.
Visual Design	Bertin's Variables: Position and color used effectively, but saturation complicates subtle variations. Tufte's Principles: High data-ink ratio introduces visual clutter.	Bertin's Variables: Position and size highlight high-pollution zones, but inconsistent color scales complicate comparisons. Tufte's Principles: Minimalist design avoids chartjunk.	Bertin's Variables: Color and position highlight forest changes, but limited shape/texture variation reduces differentiation. Tufte's Principles:	Bertin's Variables: Size and color intensity convey pollution density, but excessive brightness strains users' eyes. Tufte's Principles:

			Overlapping layers obscure base maps.	Minimalist design but lacks layering options.
Reliability of Data	High scientific accuracy, frequently updated.	Sensor-dependent, regional data accuracy varies.	Reliable sources but infrequent updates.	Transparent data collection methods ensure trustworthiness.
Clarity	Complex interface; not user-friendly for non-experts.	Clear legends and tooltips improve accessibility for non-experts.	Intuitive but overloaded maps confuse users.	Visually appealing and straightforward interface.
Interactivity	Limited interaction; no dynamic filtering.	Strong interactivity: zooming, filtering, and tooltips.	Customizable maps but overwhelming layers reduce usability.	Limited interactivity; inability to overlay datasets.

Device Compatibility	Optimized for desktop; limited adaptability on tablets/mobile.	Responsive across desktop, tablet, and mobile; touch gestures enhance usability.	Best experience on desktop; mobile version supports key features but with reduced interactivity.	Optimized for desktop; basic functionality on tablet/mobile with fewer visualization options.

2.4 Discussion of the Proposed Platform

The proposed platform, Enviz, is an interactive web application specifically designed to analyse and visualize environmental data in Malaysia. It consolidates diverse datasets, including climate trends, air quality metrics, and water quality indicators, into a unified, user-friendly interface. Focusing on data from 2004 to 2024, Enviz aims to provide a comprehensive view of Malaysia's environmental landscape.

The platform addresses key challenges observed in existing solutions:

1. **Accessibility**:

   Enviz will feature an intuitive interface optimized for both desktop and mobile devices. This ensures usability across all levels of technical expertise and enhancing accessibility for broader audiences.

2. **Data Integration**:

   By unifying diverse environmental datasets, Enviz enables users to explore

interconnections between various environmental factors. This holistic approach fosters a deeper understanding of Malaysia's environmental challenges and trends.

3. **Visual Design**:

   Adhering to principles of clarity and simplicity, Enviz minimizes visual clutter and maximizes interpretability. Features such as interactive tooltips, zooming, and dynamic filtering enhance user engagement and support exploratory analysis. A consistent application of visual variables ensures clarity without overwhelming users.

4. **Device Compatibility:**

   With a responsive design tailored for desktop, tablet, and mobile devices, Enviz ensures seamless functionality and accessibility across multiple platforms.

By addressing these challenges with a user-centric design, Enviz bridges gaps in existing platforms. It establishes itself as a valuable resource for environmental data analysis, fostering evidence-based decision-making and sustainable action in Malaysia.

2.5 Summary

This chapter reviewed existing web-based platforms for environmental data visualization, analysing their strengths and limitations. It identified the need for a unified platform tailored to Malaysia, integrating climate, air, and water quality data. The proposed system, Enviz, addresses these gaps by providing interactive visualizations, dynamic filtering, and predictive analytics in a user-friendly format.

Chapter 3: Requirement Analysis and Design

3.1 Introduction

This chapter delves into the methodological approach employed for the development of "Enviz," an interactive web-based platform designed to analyse and visualize environmental data in Malaysia. Effective software development necessitates a well-defined methodology that guides the process from initial conception to final implementation. This chapter will outline the Agile methodology, emphasizing its iterative and flexible nature, and discuss its suitability for the development of "Enviz." Furthermore, this chapter will explore the key stages of the development process, including requirement analysis and system design, outlining the steps involved in translating user needs and project objectives into a functional and user-friendly platform.

3.2 Methodology: Agile Methodology

This project will employ an Agile development methodology, prioritizing iterative development and continuous feedback. Agile methodologies emphasize flexibility and adaptability, allowing for changes in requirements and adjustments to the development process as the project progresses. This approach is particularly suitable for this project due to the dynamic nature of software development and the potential for unforeseen challenges or the need to incorporate new insights during the development process.

The Agile approach will be implemented through a series of iterative cycles, or sprints, each focused on delivering a specific set of functionalities. This iterative approach allows for early and frequent feedback, enabling the development team to address issues, incorporate user feedback, and make necessary adjustments throughout the project lifecycle.

Following Agile principles, the project will be divided into three key phases:

1. Requirements Analysis and Data Collection
2. Platform Design and Development
3. Platform Evaluation and Refinement

3.2.1 Phase 1 - Requirements Analysis and Data Collection

In this phase, the primary focus is on gathering and analysing the requirements for the "Enviz" platform. The goal is to understand the needs, preferences, and expectations of users. Data collection will involve surveys to capture both functional and non-functional requirements. These inputs will provide a comprehensive view of the platform's desired features, performance criteria, and usability standards. Additionally, relevant environmental data sources will be identified and evaluated for integration into the platform. This foundational phase ensures that the project aligns with user needs and sets the direction for the design and development phases.

3.2.1.1 Analysis of Collected Data

3.2.1.1.1 Demographic Background Analysis

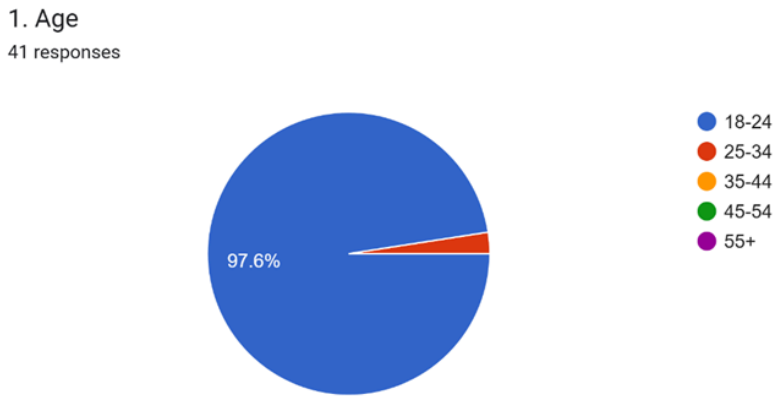


Figure 3.1. Age Distributions Pie Chart

Based on the data collected from 41 respondents, Figure 3.1 shows the age distribution of the participants. The majority of respondents (97.6%, 40 respondents) are between 18 and 24 years old, while only a small percentage (2.4%, 1 respondent) fall within the 25–34 age group. This indicates that the survey primarily captured the perspectives of younger individuals.

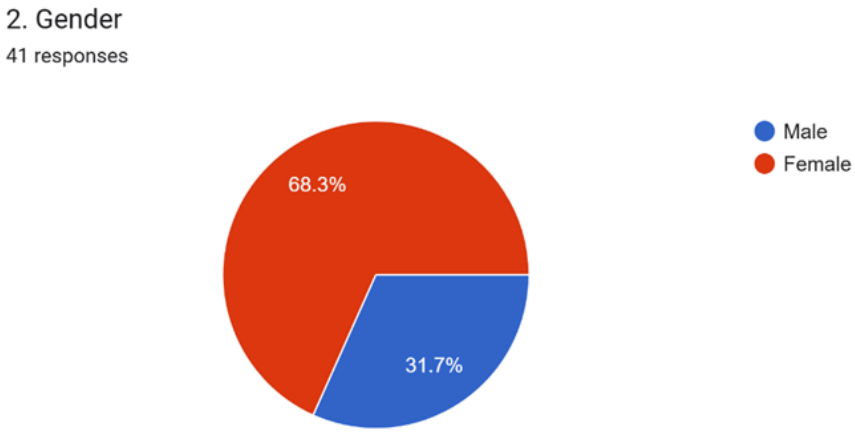


Figure 3.2. Gender Distributions Pie Chart

Based on the data collected from 41 respondents, Figure 3.2 illustrates the gender distribution of the participants. The majority of respondents (68.3%, 28 respondents) identify as female, while a smaller percentage (31.7%, 13 respondents) identify as male. This suggests a higher representation of female participants in the survey.

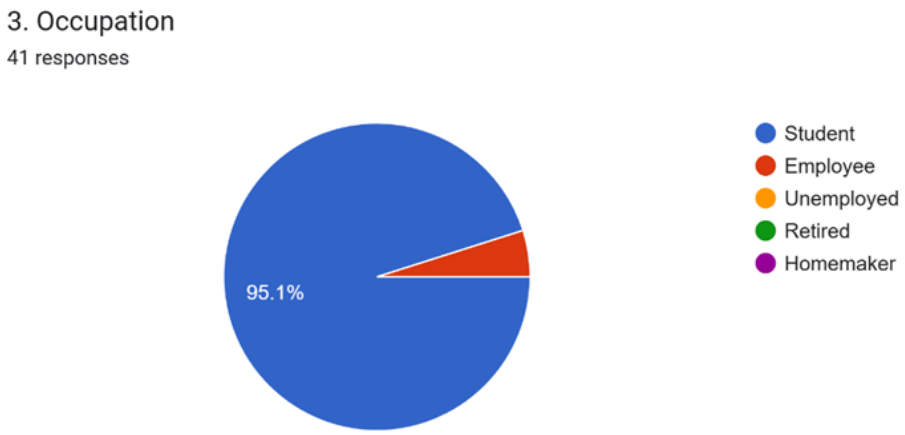


Figure 3.3. Occupation Distributions Pie Chart

Based on the data collected from 41 respondents, Figure 3.3 displays the occupation distribution of the participants. The vast majority (95.1%, 39 respondents) are students, while only a small percentage (4.9%, 2 respondents) are employed. This highlights that the survey responses are predominantly from individuals in an academic setting.

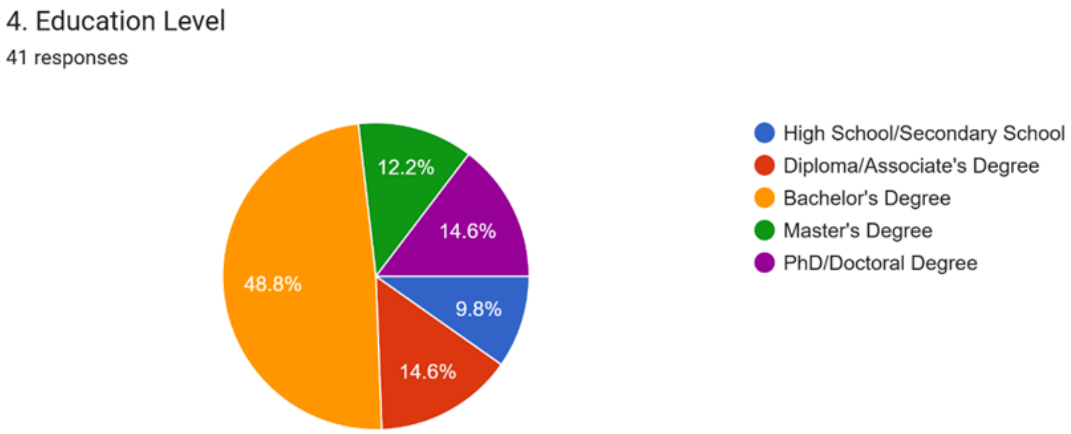


Figure 3.4. Education Level Distributions Pie Chart

Based on the data collected from 41 respondents, Figure 3.4 presents the education level distribution of the participants. The largest group (48.8%, 20 respondents) holds a Bachelor's degree, followed by those with a Diploma/Associate's degree (14.6%, 6 respondents), a Master's degree (12.2%, 5 respondents), and a PhD/Doctoral degree (14.6%, 6 respondents). A smaller percentage (9.8%, 4 respondents) have completed high school or secondary school. This indicates a well-educated sample, with most respondents having at least a tertiary education.

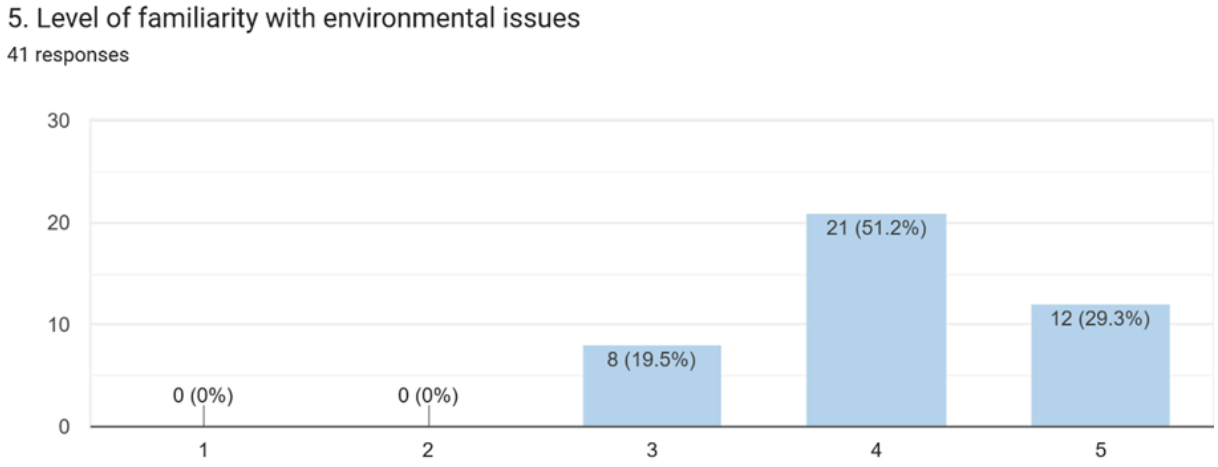


Figure 3.5. Level of Familiarity with Environmental Issues Bar Chart

Based on the data collected from 41 respondents, Figure 3.5 shows the participants' level of familiarity with environmental issues. The majority (51.2%, 21 respondents) report being familiar with environmental issues, while 29.3% (12 respondents) indicate they are very familiar. A smaller percentage (19.5%, 8 respondents) describe themselves as moderately familiar. This suggests that most respondents have a good understanding of environmental topics, which could influence their responses to the survey.

3.2.1.1.2 User Needs and Expectations Analysis

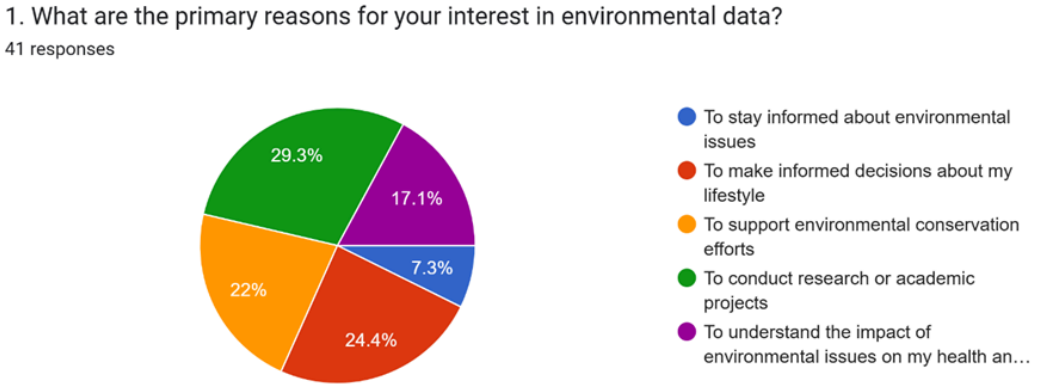


Figure 3.6. Primary Motivations for Engaging with Environmental Data Distributions Pie Chart

Based on the data collected from 41 respondents, Figure 3.6 highlights the primary motivations for engaging with environmental data. The largest group (29.3%, 12 respondents) expressed interest in using environmental data for research or academic projects, followed by those who aim to support environmental conservation efforts (22%, 9 respondents). Additionally, 24.4% (10 respondents) are motivated to make informed lifestyle decisions, while 17.1% (7 respondents)

seek to understand the impact of environmental issues on their health and well-being. A smaller percentage (7.3%, 3 respondents) engage with environmental data simply to stay informed.

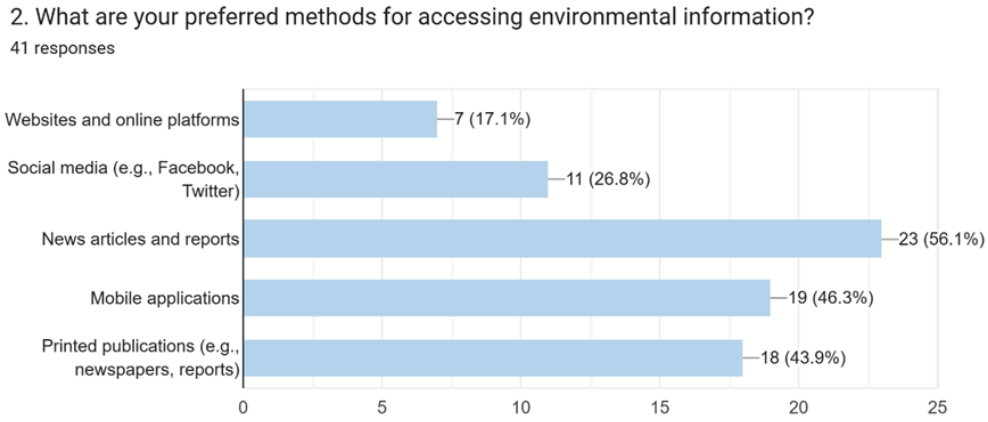


Figure 3.7. Preferred Channels for Accessing Environmental Information Bar Chart

Based on the data collected from 41 respondents, Figure 3.7 illustrates the preferred channels for accessing environmental information. News articles and reports are the most popular choice (56.1%, 23 respondents), followed by mobile applications (46.3%, 19 respondents) and printed publications (43.9%, 18 respondents). Social media platforms, such as Facebook and Twitter, are preferred by 26.8% (11 respondents), while websites and online platforms are the least preferred (17.1%, 7 respondents). This indicates a preference for traditional and easily accessible sources of information.

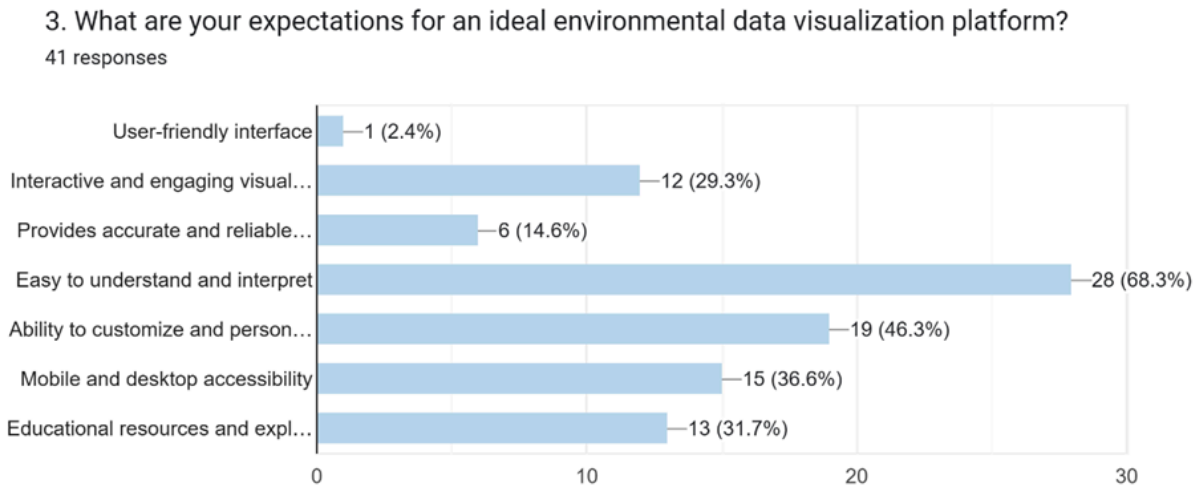


Figure 3.8. Key Features Desired in an Environmental Data Visualization Platform Bar Chart

Based on the data collected from 41 respondents, Figure 3.8 outlines the key features desired in an ideal environmental data visualization platform. The most important feature is ease of understanding and interpretation (68.3%, 28 respondents), followed by interactive and engaging visualizations (29.3%, 12 respondents). Customization and personalization options are also highly valued (46.3%, 19 respondents), as are mobile and desktop accessibility (36.6%, 15 respondents). Educational resources and explanations are desired by 31.7% (13 respondents), while only 2.4% (1 respondent) prioritize a user-friendly interface.

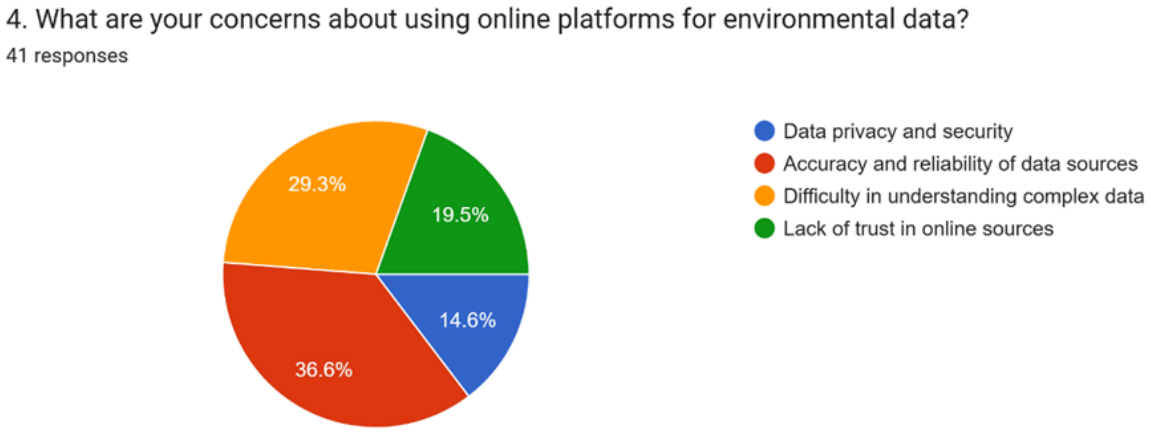


Figure 3.9. Concerns Regarding Online Environmental Platforms Distribution Pie Chart

Based on the data collected from 41 respondents, Figure 3.9 highlights the concerns about using online platforms for environmental data. The most common concern is the accuracy and reliability of data sources (36.6%, 15 respondents), followed by difficulty in understanding complex data (29.3%, 12 respondents). Data privacy and security are concerns for 14.6% (6 respondents), while 19.5% (8 respondents) express a lack of trust in online sources. These findings suggest that users prioritize data credibility and clarity when engaging with online environmental platforms.

3.2.1.1.3 Platform Features and Functionality Analysis

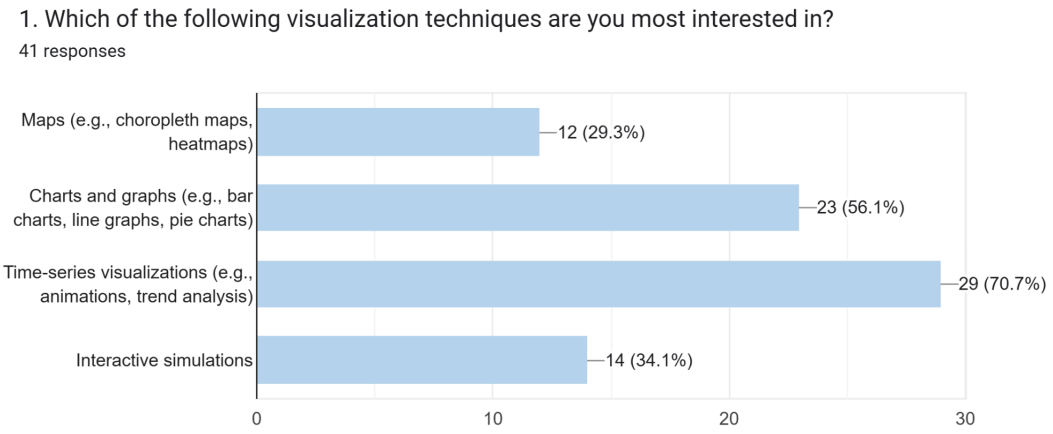


Figure 3.10. Visualization Techniques that Respondents are Interested In

Based on the data collected from 41 respondents, Figure 3.10 highlights the visualization techniques that participants are most interested in. The majority (70.7%, 29 respondents) prefer time-series visualizations, such as animations and trend analysis, followed by charts and graphs (56.1%, 23 respondents). Maps, including choropleth maps and heatmaps, are favored by 29.3% (12 respondents), while interactive simulations are of interest to 34.1% (14 respondents). This indicates a strong preference for dynamic and easily interpretable visualization methods.

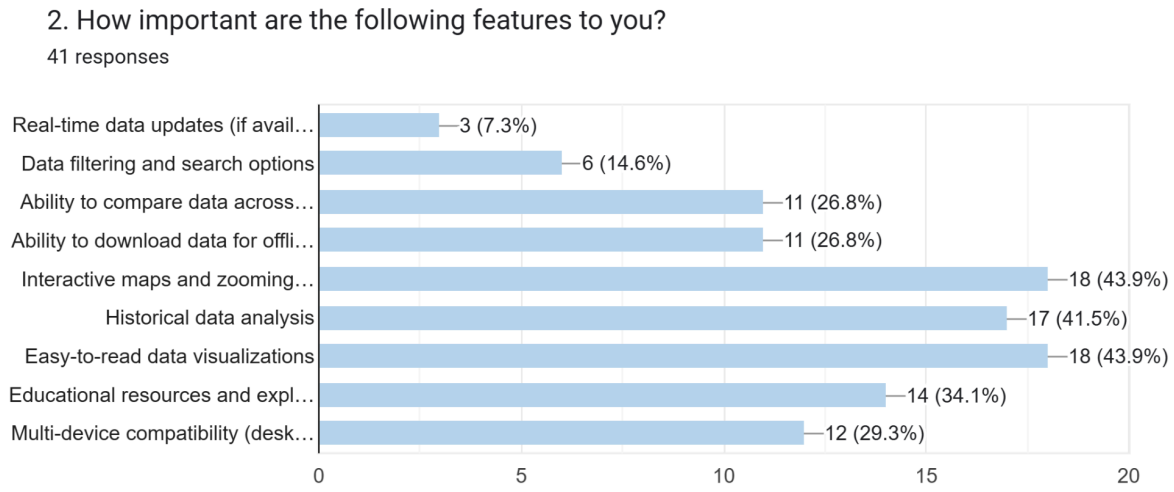


Figure 3.11. Insights about Features

Based on the data collected from 41 respondents, Figure 3.11 outlines the importance of various features in an environmental data platform. The most valued features are easy-to-read data visualizations (43.9%, 18 respondents) and interactive maps with zooming capabilities (43.9%, 18 respondents). Historical data analysis is also important to 41.5% (17 respondents), while 34.1% (14 respondents) value educational resources and explanations. Multi-device compatibility is important to 29.3% (12 respondents), and 26.8% (11 respondents) each prioritize the ability to compare data across locations or time periods and the ability to download data for offline use. Real-time data updates are the least prioritized (7.3%, 3 respondents).

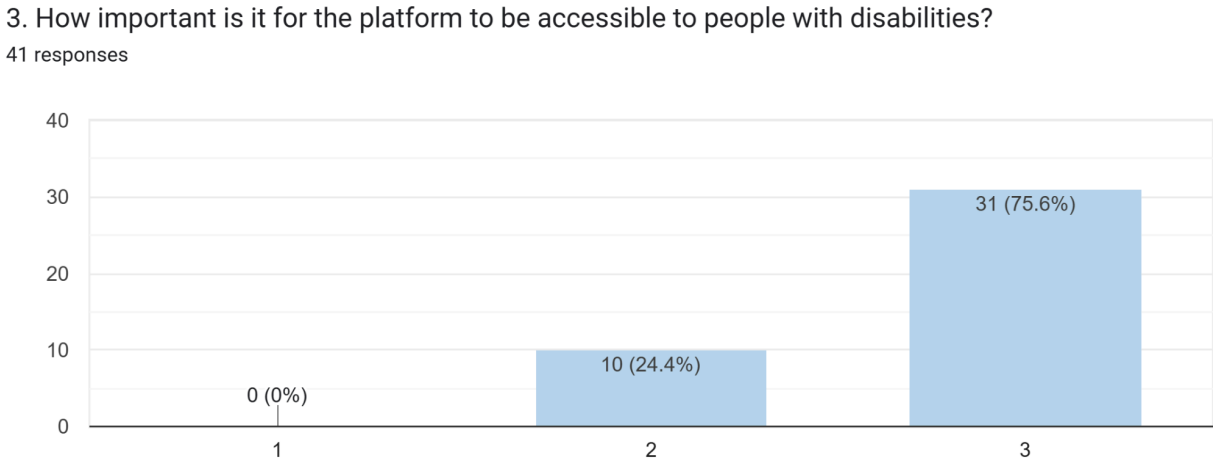


Figure 3.12. Concerns Regarding Importance of Accessibility of the Platform

Based on the data collected from 41 respondents, Figure 3.12 highlights the importance of accessibility for people with disabilities. The vast majority (75.6%, 31 respondents) consider it

very important for the platform to be accessible, while 24.4% (10 respondents) remain neutral. This underscores the need for inclusive design to ensure the platform is usable by all individuals, regardless of their abilities.

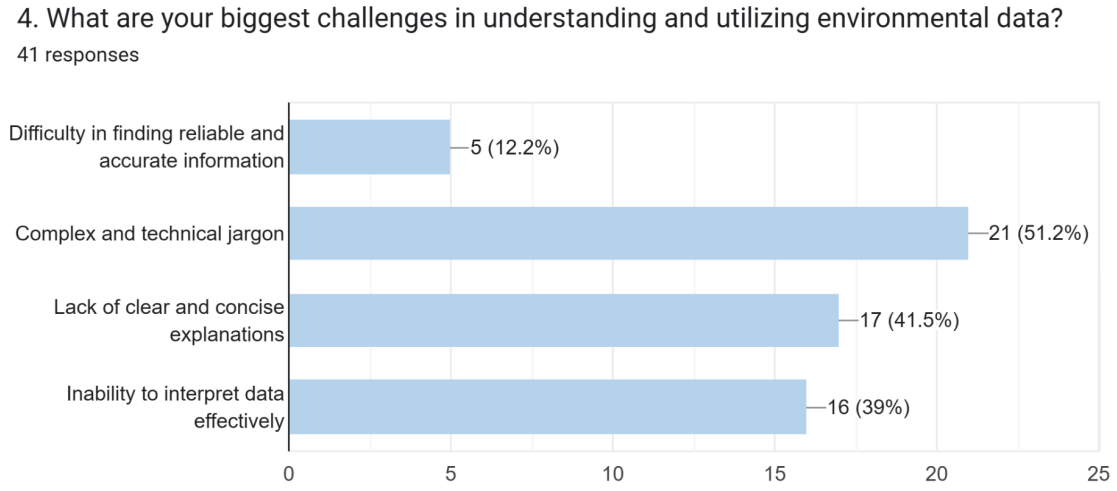


Figure 3.13. Challenges of Respondents in Understanding and Utilizing Environmental Data

Based on the data collected from 41 respondents, Figure 3.13 identifies the biggest challenges participants face in understanding and utilizing environmental data. The most common challenge is complex and technical jargon (51.2%, 21 respondents), followed by the inability to interpret data effectively (39%, 16 respondents) and a lack of clear and concise explanations (41.5%, 17 respondents). A smaller percentage (12.2%, 5 respondents) struggle with finding reliable and accurate information. These findings emphasize the need for simplified language, clear explanations, and user-friendly tools to improve data comprehension.

3.2.1.2 Functional Requirement

Based on the feedback and results of the questionnaire, the proposed system (Enviz) should enable users to:

1. Explore Environmental Data Through Visualizations
    - Access interactive visualizations, such as time-series graphs, heatmaps, and choropleth maps.
    - Interact with dynamic charts and simulations to better understand environmental trends and impacts.
2. Filter and Search Data
    - Use advanced search and filtering options to refine results based on location, time period, or type of data (e.g., air quality, water quality).
3. Customize the Visualization Experience
    - Personalize the display of visualizations by selecting themes, colors, and chart types.
    - Adjust data parameters (e.g., date ranges, data granularity) for tailored insights.
4. Access Informative and Educational Content
    - Access a glossary of terms and definitions related to environmental science.
    - View explanatory tooltips and guides embedded within visualizations for enhanced understanding.
5. Download and Share Data
    - Export visualizations and data summaries as PDF or image files.
    - Share visualizations directly to social media or via email.
6. Multi-Device Compatibility

- Seamlessly use the platform on mobile, tablet, and desktop devices with a responsive design.

3.2.1.3 Non-Functional Requirement

1. Reliability
    - All visualizations and data outputs shall be accurate and free from discrepancies caused by system errors.
2. Clarity
    - Visualizations shall prioritize clear and concise representation of data to enhance user understanding.
    - Labels, legends, and axes in all charts and graphs shall be properly defined and legible across all devices.
3. User-Friendly Interface
    - The platform shall feature an intuitive and straightforward design, making it easy for users to navigate.
    - Buttons, menus, and interactions shall follow standard usability principles to minimize learning curves.
4. Accessibility
    - The platform shall be accessible to users with disabilities, adhering to accessibility guidelines (e.g., WCAG).
5. Availability
    - The platform shall be available 24/7, with downtime limited to scheduled maintenance periods.

- Users shall have access to the platform from any location, provided there is a stable internet connection.
- A redundant server infrastructure shall ensure the platform remains operational during unexpected outages or high traffic.

3.2.1.4 Software Requirement

Table 3.1. Software Requirements

Software Specification	**Requirements**
Operating System	Windows 10
Web Development Tools	Visual Studio Code
Web Development and Design languages	PHP, JavaScript, HTML, CSS
Web Browser	Google Chrome
Database	MySQL
Version Control	Git

3.2.1.5 Hardware Requirement

Table 3.2. Hardware Requirements

Hardware Specification	**Requirements**
Processor	AMD Ryzen 5

RAM	8 GB or higher
Storage	256 GB SSD or higher
Display	1080p or higher resolution, with support for multiple displays
Network	Stable internet connection

3.2.2 Phase 2 - Platform Design and Development

This phase focuses on designing the proposed system both logically and physically. The logical design involves the use of Unified Modeling Language (UML) diagrams to model the system's structure and behavior (LUPASC, 2021). These diagrams include Activity Diagrams, Use Case Diagrams, Sequence Diagrams and Class Diagrams. In addition to logical design, the physical design is developed by creating wireframes to represent the system's interface layout and functionality. These wireframes offer a visual blueprint of the user interface, ensuring the design is intuitive and aligns with user expectations. By combining logical and physical design, this phase ensures the proposed system is well-structured, user-friendly, and ready for development.

3.2.2.1 Activity Diagram

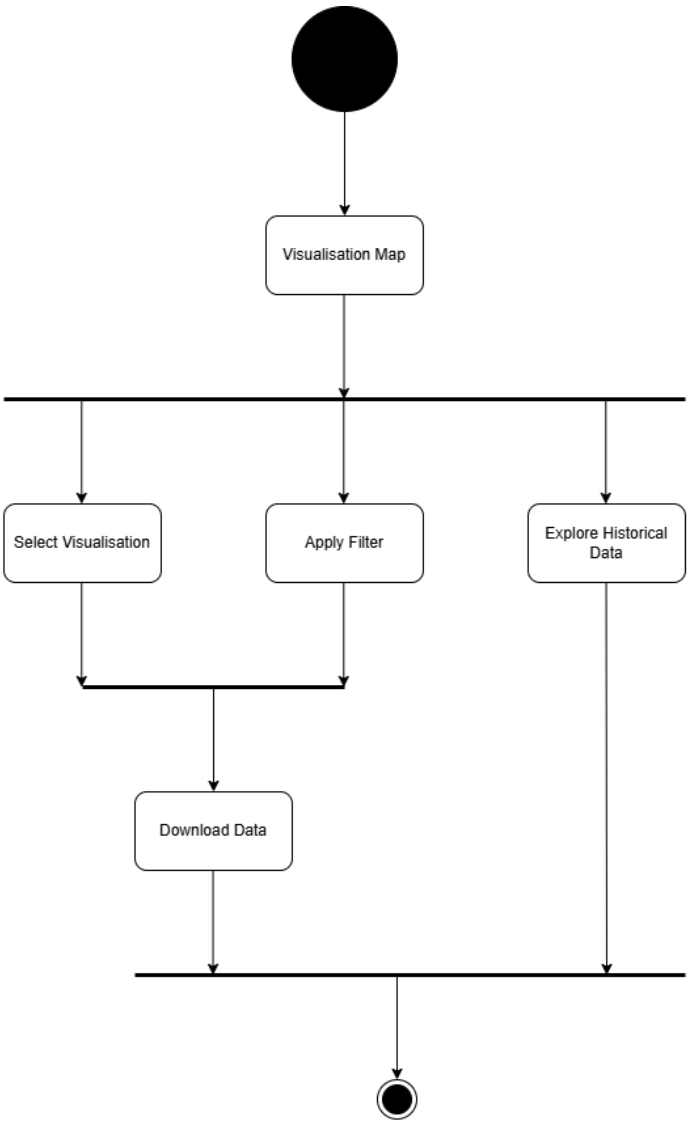


Figure 3.14. Activity Diagram for Enviz

An activity diagram is a visual representation of the workflows and processes within a system. It illustrates the sequence of activities, decision points, and the flow of control from one action to another. Activity diagrams are used to model dynamic aspects of a system, showcasing how tasks and actions progress and interact. These diagrams are particularly effective for understanding

complex processes and ensuring that all scenarios are accounted for during system design (Xu et al., 2024).

Figure 3.14 depicts the activity diagram for the proposed system, "Enviz." The process begins with the user landing on the visualization map of Malaysia. From this point, users can either select specific visualizations or apply filters to customize the displayed data based on their preferences. Both options enable users to focus on particular environmental aspects of interest. Additionally, users have the option to explore historical data for deeper insights. Once the desired visualizations are finalized, users can download the data for offline analysis. This structured and user-friendly flow ensures that exploring, filtering, and obtaining environmental data is intuitive and efficient.

3.2.2.2 Use Case Diagram

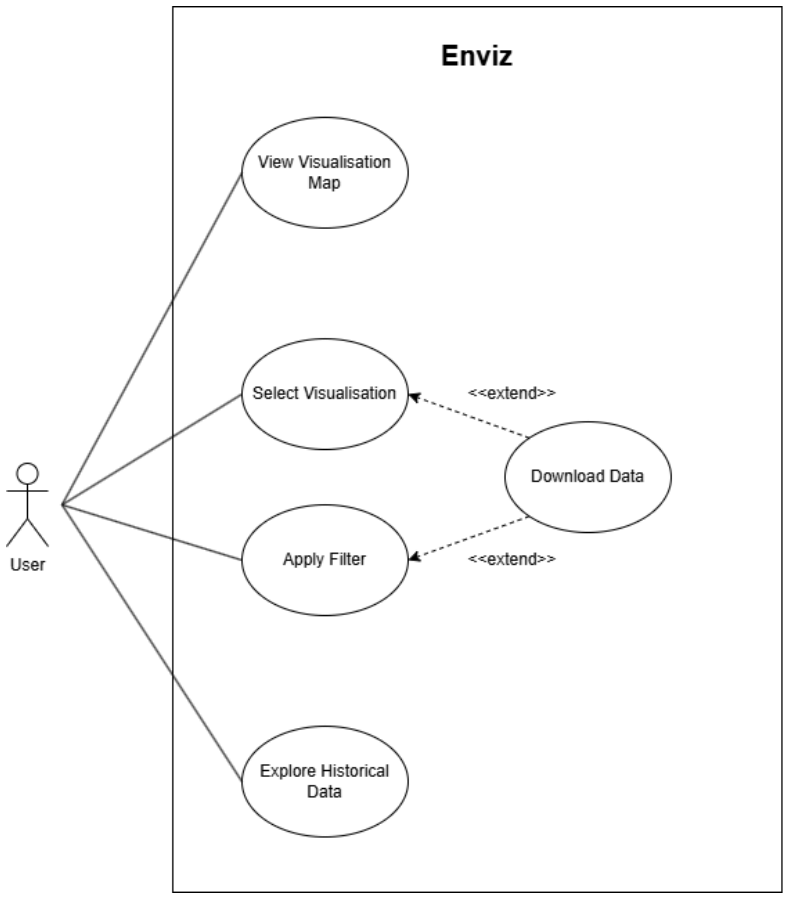


Figure 3.15. Use Case Diagram for Enviz

A use case diagram provides a high-level representation of a system's functionality and its interactions with users or other systems. It outlines the various use cases (functionalities) of the system and identifies the actors (users or external systems) that interact with these functionalities. These diagrams are essential for defining the scope of the system and understanding user requirements (Kumar et al., 2023). By offering a clear and concise overview of the system's features, use case diagrams facilitate communication between stakeholders and development teams.

Figure 3.15 illustrates the use case diagram for this project, showcasing the key interactions between users and the proposed system, "Enviz." The primary use cases include "View Visualization Map," which enables users to explore an interactive map of Malaysia, and "Select Visualization," allowing users to choose specific datasets for visualization. Users can also "Apply Filter" to customize data views according to their preferences. Both the "Select Visualization" and "Apply Filter" use cases connect to the "Download Data" use case, providing users with the option to obtain the displayed data for offline analysis. Additionally, the system features the "Explore Historical Data" use case, granting access to past environmental trends and patterns. Collectively, these use cases establish a robust and user-centered framework for the system's functionality.

3.2.2.3 Sequence Diagram

A sequence diagram is a dynamic modeling tool used to depict the interaction between objects in a system over time. It outlines the sequence of messages exchanged among various system components and illustrates how they collaborate to fulfill a specific functionality or process (Rathinasabapathy, 2015). Sequence diagrams are valuable for understanding the dynamic behavior of a system, ensuring that the workflow is logical, and identifying potential integration points or issues.

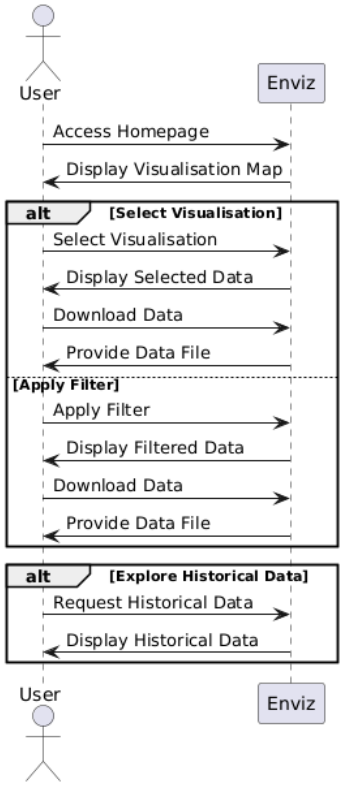


Figure 3.16. Sequence Diagram for Enviz

Description:

1. The user accesses the Enviz homepage, where the system displays a visualization map of Malaysia, providing an overview of environmental data.
2. The user can choose to interact with the system through multiple options:
    - Select Visualisation:
        1) The user selects specific datasets they wish to visualize.
        2) Enviz processes the request and displays the selected data.
        3) The user can then choose to download the data for offline analysis.
        4) Upon request, the system generates and provides the data file for download.

- Apply Filter:
    1) The user applies filters to refine and customize the data visualizations based on specific criteria.
    2) Enviz updates the visualization to reflect the applied filters.
    3) Similar to the visualisation selection, the user can download the filtered data.
    4) The system generates and provides the filtered data file for download.

3. Alternatively, the user can explore historical environmental data
    - Explore Historical Data:
        1) The user requests to view past environmental trends and patterns.
        2) Enviz retrieves and displays the historical data for the user's exploration.
4. The system ensures seamless navigation between these functionalities, allowing users to derive insights and access required data efficiently.

3.2.2.4 Class Diagram

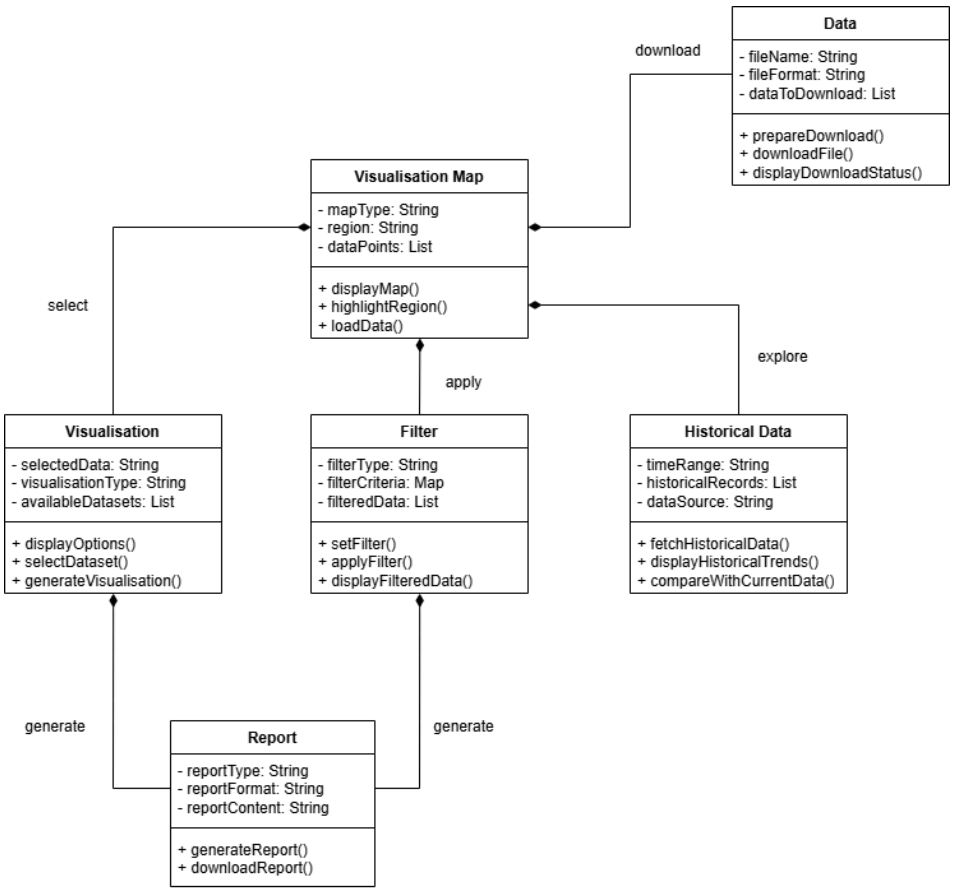


Figure 3.17. Class Diagram for Enviz

The class diagram is a critical part of the system design, offering a blueprint of the system's structure by defining its key classes, their attributes, methods, and relationships. It represents the static view of the system, focusing on the organization of the software's components and how they interact with each other (Di Felice et al., 2022). By using UML (Unified Modeling Language), a class diagram provides a detailed understanding of the system's architecture, enabling developers to ensure that the software components align with the overall system requirements. The class diagram helps identify the classes, their functionalities, and how data is passed between them, facilitating a clearer design before the actual implementation phase.

The Visualisation Map class is the core component of the system, displaying the map of Malaysia with environmental data. It loads and updates the map based on user inputs, serving as a gateway for users to explore various visualizations. From this map, users can trigger either the Select Visualisation or Apply Filter classes to refine or customize the data view. The Select Visualisation class allows users to choose different datasets, while the Apply Filter class lets them apply specific criteria to the data. Both classes can generate downloadable reports based on the selected or filtered data.

The Historical Data class provides access to past environmental trends, allowing users to analyze long-term changes in various factors. Finally, the Download Data class enables users to download the generated data or reports for offline use, ensuring flexibility for further analysis outside the platform.

3.2.2.5 Incorporating Best Practices from Existing Platform

Enviz is designed to incorporate the best features of existing environmental data platforms while addressing their limitations. Below, we outline how Enviz leverages UI/UX principles and features from platforms like NASA Worldview, IQAir, Global Forest Watch, and Global Plastic Watch:

3.2.2.5.1 Human Perception and Visual Design:

- **Pre-Attentive Processing:** Enviz uses high-contrast color schemes to enable users to quickly identify patterns and anomalies in environmental data. For example, air quality

data is represented using a gradient from green (good) to red (hazardous), ensuring quick interpretation.

- **Gestalt Principles:** Enviz applies proximity and similarity to group related data (e.g., air quality metrics by region) and uses continuity to ensure smooth transitions between datasets. This addresses the abrupt transitions seen in NASA Worldview.
- **Bertin's Visual Variables:** Enviz uses position, color, and size effectively to represent data. For example, the size of data points on the map corresponds to pollution levels, and color intensity indicates severity.
- **Tufte's Principles:** Enviz minimizes chartjunk by avoiding unnecessary decorative elements and maintaining a high data-ink ratio. This ensures that the visualizations are clear and focused.

3.2.2.5.2 Interactivity:

- **Dynamic Filtering:** Enviz allows users to filter data by location, time period, and data type (e.g., air quality, water quality). This feature is inspired by IQAir's filtering capabilities but extends it to include more diverse datasets.
- **Interactive Tooltips:** Enviz includes tooltips that provide additional information when users hover over data points. This improves upon GPW's limited interactivity by making the platform more engaging and informative.
- **Zooming and Panning:** Enviz supports zooming and panning on maps, similar to IQAir, but ensures that the interface remains intuitive and responsive across all devices.

3.2.2.5.3 Device Compatibility:

- **Responsive Design:** Enviz is optimized for desktop, tablet, and mobile devices, ensuring a seamless user experience across all platforms. This addresses the limitations of NASA Worldview and GFW, which are primarily designed for desktop use.

3.2.2.5.4 Data Integration and Reliability:

- **Unified Data Sources:** Enviz integrates data from multiple verified sources (e.g., government agencies, research institutions) to ensure accuracy and reliability. This addresses the fragmented data sources seen in IQAir and GFW.

3.2.2.6 Proposed System Wireframe

The proposed system wireframe visually represents the interface layout and functionality, playing a crucial role in the design phase. It helps conceptualize the user experience (UX) and ensures the system's interface meets user expectations (Gudoniene et al., 2023). Wireframes offer an early visualization of the platform's structure, guiding the development of an intuitive, user-friendly interface. They illustrate how elements such as buttons, navigation, and content are organized, providing stakeholders with a clear understanding and allowing for feedback before full-scale development.

Figure 3.18. Visualisation Map for Enviz

Figure 3.18 shows the visualization map, which serves as the homepage. It displays an interactive map of Malaysia, allowing users to view various environmental data visualizations across different regions. The map interface highlights Malaysia's geographical regions with overlays of environmental data, and users can click on specific regions for detailed information on environmental parameters.

Figure 3.19. Filtering Section for Enviz

Figure 3.19 depicts the filtering section, where users can customize their visualizations. The filter panel, located at the top-left of the screen, offers options to filter data by criteria such as date range and data type. The "Apply Filter" button updates the map or data visualization based on the selected filters.

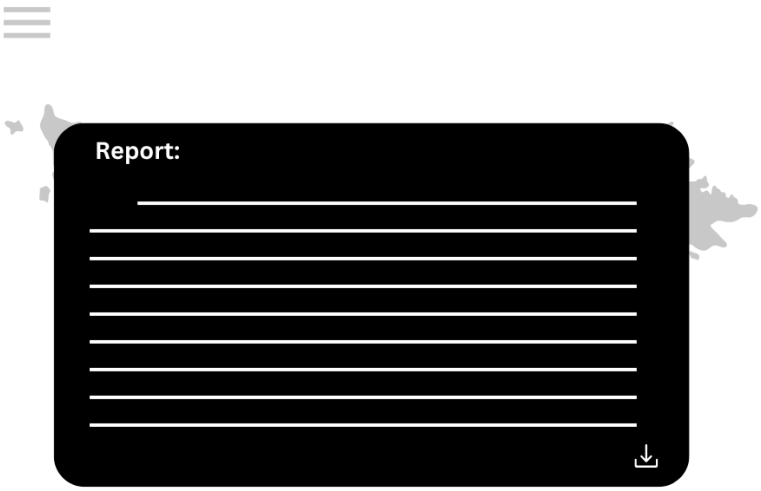


Figure 3.20. Report Generation for Enviz

Figure 3.20 illustrates the report generation feature, enabling users to create reports based on visualized and filtered data. A preview section allows users to view a sample report before finalizing it. The "Download Report" button allows users to download the finalized report for offline use or further analysis.

3.2.3 Phase 3 - Platform Evaluation and Refinement

This phase centers on evaluating and refining the "Enviz" platform based on user feedback and performance analysis.

- User Testing:

  Rigorous testing will be conducted with a diverse group of participants, including representatives from the target audience. Feedback will be collected through

observations, interviews, and surveys to assess usability, user experiences, and identify areas for improvement.

- Performance Testing:

  The platform will undergo comprehensive testing to assess its response times, stability, and scalability under varying load conditions. This will help identify and address any performance bottlenecks or issues.

- Data Validation and Quality Assurance:

  Data validation checks will be performed to ensure the accuracy and reliability of the information presented on the platform. Quality control mechanisms will be implemented to maintain data integrity over time.

- Refinement and Iteration:

  Based on insights from user testing, performance testing, and data validation, the platform will be refined iteratively. This may involve UI adjustments, enhancements to data visualizations, improvements to functionality, and bug fixes.

3.3 Summary

Chapter 3 focuses on the Requirement Analysis and Design phases of the development of the "Enviz" platform, which aims to provide an interactive tool for exploring environmental data in Malaysia. This chapter outlines the approach taken to define the project's objectives, structure, and design elements. It highlights the use of the Agile methodology, emphasizing iterative development, user feedback, and continuous refinement.

In this chapter, the system's functional and non-functional requirements were identified, followed by the design of key components using Unified Modeling Language (UML) diagrams.

These diagrams, including activity, use case, sequence, and class diagrams, helped visualize the internal structure and interactions within the platform. Additionally, wireframes were developed to illustrate the system's interface, ensuring that the platform's design was user-friendly and aligned with the project's objectives. The chapter provides a clear framework for how the platform will be constructed and tested in the upcoming phases of development.

Chapter 4: System Implementation

4.1 Introduction

This chapter outlines the implementation phase of the proposed web-based platform for visualizing environmental insights in Malaysia, developed in accordance with the design and requirements discussed in Chapter 3. The implementation covers both the frontend interface and data processing logic, with a focus on building an interactive, user-friendly platform capable of visualizing complex climate, water, and air environmental datasets.

The development process leverages modern web technologies, including React.js for the frontend framework, and robust libraries such as Chart.js, D3.js, Recharts, Papa Parse, React Router DOM, React Icons, React Range, jsPDF, and html2canvas for graphical visualization and utility. The system integrates environmental datasets, primarily in CSV format, and presents them through interactive charts and visual dashboards. Key interactive features implemented include dynamic tooltips, responsive line highlighting, customized data mapping, advanced data filtering and search options, play/pause functionality for time-series data, sortable tables, and data download/export capabilities (PDF/CSV). This chapter discusses the development environment setup, the tools and libraries used, and the implementation of various modules categorized under climate, water quality, and air quality insights.

4.2 Installation and Configuration of Software and Tools Used

This section details the software, tools, and libraries utilized during the development of the Enviz platform, along with their installation and configuration steps.

4.2.1 Development Environment

The primary integrated development environment (IDE) used for building the Enviz platform was **Visual Studio Code (VS Code)**. VS Code provided a rich set of features, including intelligent code completion, debugging tools, and integrated terminal, which streamlined the development workflow. **Node.js** was also installed to provide the JavaScript runtime environment necessary for running React applications and managing project dependencies via npm (Node Package Manager).

4.2.2 Core Technologies and Libraries

The Enviz platform was developed as a single-page application (SPA) using **React.js**, a popular JavaScript library for building user interfaces. React's component-based architecture facilitated modular development and efficient management of the UI. The core programming languages used were **JavaScript**, **HTML**, and **CSS**. For navigation within the multi-page application structure (e.g., Climate, Water, Air sections), **React Router DOM** was used, enabling declarative routing and seamless transitions between different views without full page reloads.

4.2.3 Data Handling and Visualization Libraries

To effectively process and visualize the environmental datasets, several specialized libraries were integrated: data not easily to found, data not completed, API called limited, validation of data, chart decision to display the data

- **Papa Parse**: This library was crucial for efficiently parsing CSV (Comma Separated Values) files, which served as the primary format for all environmental data in the project. It allowed for easy conversion of raw CSV data into usable JavaScript objects.
- **Chart.js**: Chart.js provided a flexible and responsive framework for drawing common chart types such as line charts and bar charts. It was instrumental in visualizing time-series data and comparing different environmental metrics.
- **Recharts**: Recharts is a composable charting library built on React and D3.js. It offered a declarative way to create responsive charts like ComposedChart (combining Line and Bar charts), providing robust components for axes, tooltips, and legends, which enhanced the presentation of climatology data.
- **D3.js**: D3.js's powerful data-driven document manipulation capabilities allowed for precise control over the visualization of heat risk categorization, including dynamic color scales and interactive elements.

4.2.4 Utility and UI Libraries

To enhance the user experience and add specific functionalities, the following utility and UI libraries were incorporated:

- **React Icons**: This library provided a wide array of customizable SVG icons, used for various UI elements such as download buttons (FaDownload), play/pause controls (FaPlay, FaPause), and sort indicators (FaSortUp, FaSortDown).
- **React Range**: React Range offered a highly customizable component for creating interactive range sliders, allowing users to select specific time periods or data ranges.

- **jsPDF** and **html2canvas**: These libraries were combined to enable the client-side generation and download of PDF reports. html2canvas was used to render HTML content into a canvas image, which jsPDF then used to create a printable PDF document, providing users with the ability to export visualized data and tables.

4.2.5 Version Control

Git was used as the version control system throughout the project. It facilitated collaborative development, tracked changes to the codebase, and allowed for efficient management of different development stages and iterations.

4.3 Implementation of the System

This section details the implementation of Enviz, a web-based environmental visualization platform. Enviz features various interactive modules designed to offer insights into Malaysia's environmental conditions through intuitive data visualization and user-friendly interfaces. The following sub-sections outline the system's key pages, their core functionalities, navigation structures, and visual elements.

The implemented pages within Enviz include:

1. Dashboard Page
2. Climate Insights Page
3. Sea Level Change Historical Page
4. Sea Level Change Projections Page

5. Heat Risk Page
6. Historical Natural Hazards Page
7. Current Climate Climatology Page
8. Trends and Significant Change against Natural Variability Page
9. Water Quality Insights Page
10. Water Consumption Page
11. Water Production Page
12. Access to Treated Water Page
13. Air Pollution Insights Page
14. Greenhouse Gas Emissions Page
15. Monthly Air Pollution Page

4.3.1 Dashboard Page

Figure 4.1 illustrates the interactive Malaysia Map, which functions as the dashboard. Three buttons located in the top-left corner allow users to select "climate," "water," and "air" data categories. When users hover over a state on the map, its name and corresponding data are displayed (Figure 4.1). Clicking on a state navigates the user to a detailed data view (Figure 4.2). At the bottom of the dashboard, a legend provides data layer selection, a color scale or gradient for the selected data layer, and an animation feature to visualize changes in the selected data layer across the map (Figure 4.3).

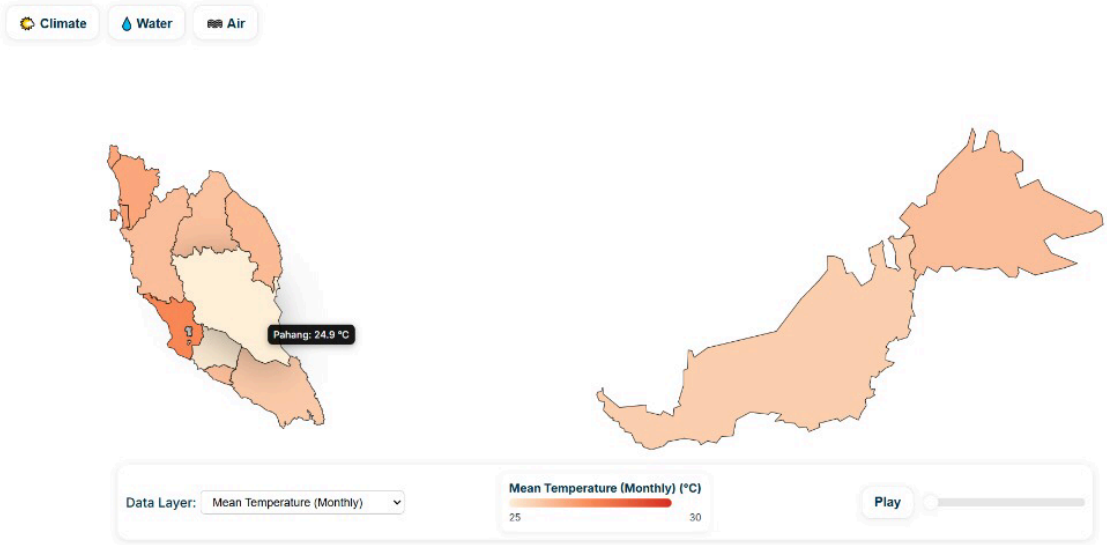


Figure 4.1. Interactive Map with Hover-Over Details.

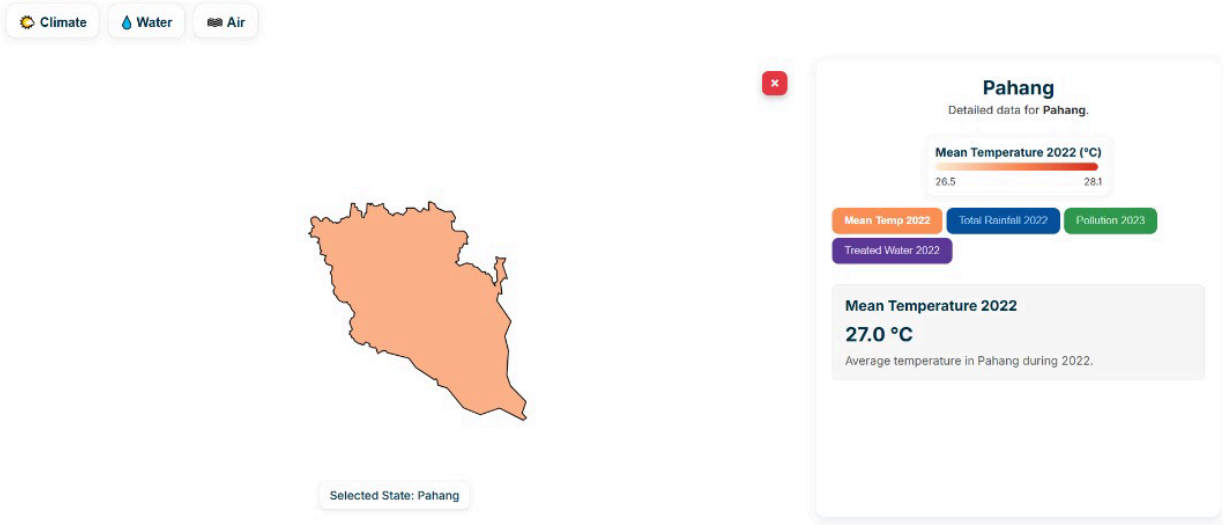


Figure 4.2. Map Navigation to State-Specific Data View.

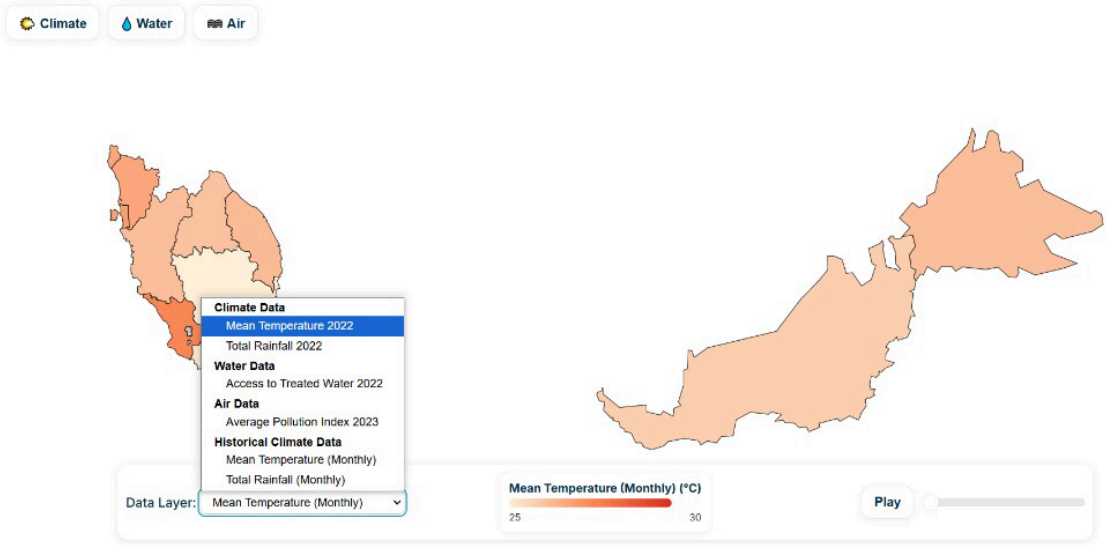


Figure 4.3. Dashboard Legend: Data Layer Selection, Color Scale, and Animation Controls.

4.3.2 Climate Insights Page

The Climate Insights page features three category buttons, each with two sub-categories (Figure 4.4). These include "Sea Level Change" (Historical and Projections), "Risk" (Heat Risk and Historical Natural Hazards), and "Current Climate" (Climatology and Trends & Variability). Each selection directs the user to its specific page.

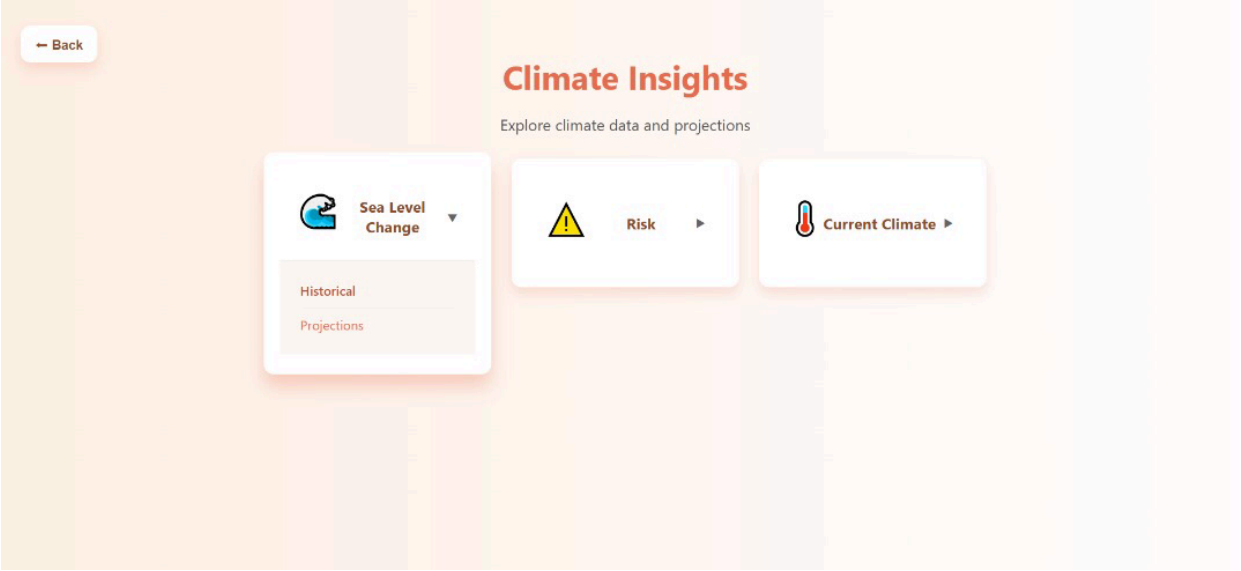


Figure 4.4. Climate Insights Page: Category and Sub-Category Selection.

4.3.2.1 Sea Level Change Historical Page

This page enables the visualization of total sea level change by month within the Malaysian Exclusive Economic Zone, spanning from 1993 to the present (Figure 4.5). Each line on the graph represents a specific year, distinguished by a unique color. A four-class color gradient categorizes data from 1992-2000, 2001-2010, 2011-2020, and 2021-2024. Hovering over a data point on the line displays its month, year, and corresponding sea level value (Figure 4.6).

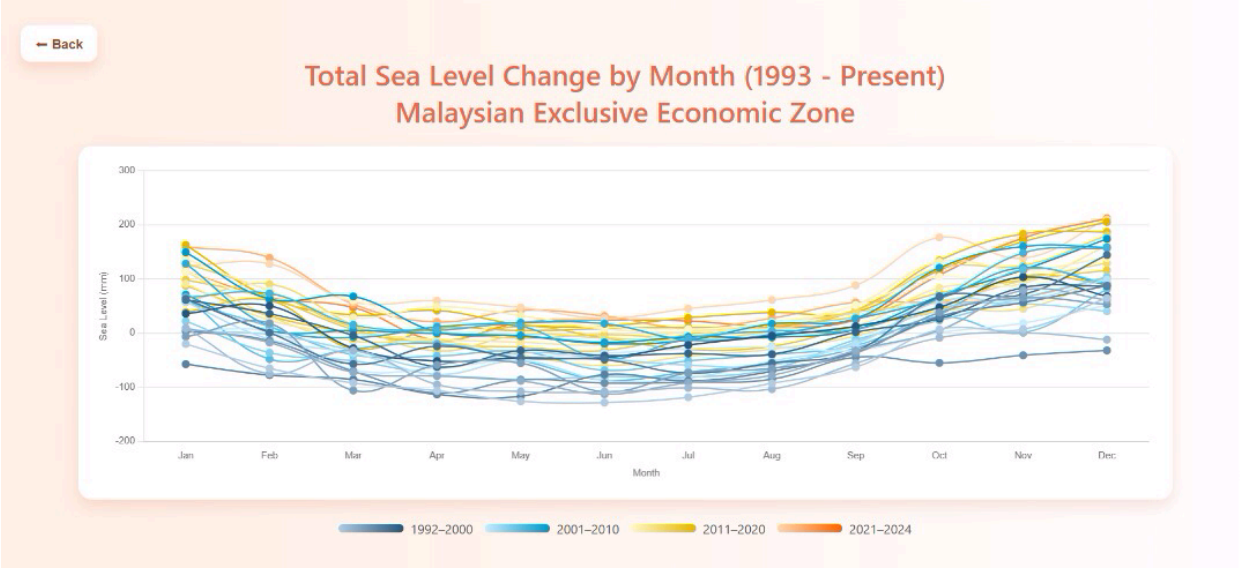


Figure 4.5. Monthly Sea Level Change in Malaysian EEZ (1993-Present).

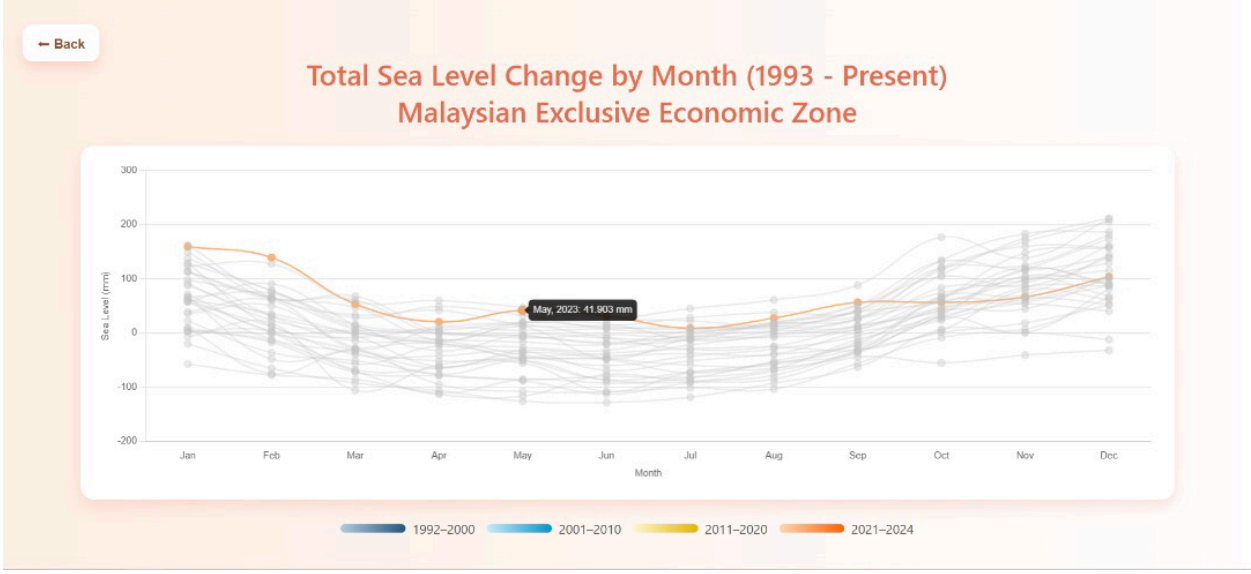


Figure 4.6. Sea Level Change Chart: Data Point Details on Hover.

4.3.2.2 Sea Level Change Projections Page

The Sea Level Change Projections page illustrates the various contributors to sea level change, including Thermal & Ocean Circulation Dynamics, Antarctica Ice Sheet, Glaciers, Greenland Ice

Sheet, Vertical Land Motion, and Landwater Storage (Figure 4.7). Bar charts are grouped by year, from 2020 to 2150, showcasing the six contributors for each year. Hovering over a bar group for a specific year reveals a tooltip displaying the year, the 50th percentile for each contributor, and the 17th-83rd percentile range (Figure 4.8). Figure 4.9 shows that hovering over a legend item highlights its corresponding contributor bar while fading others. Figure 4.10 shows that toggling off a legend item hides its category bar, and the legend item appears grayed out.

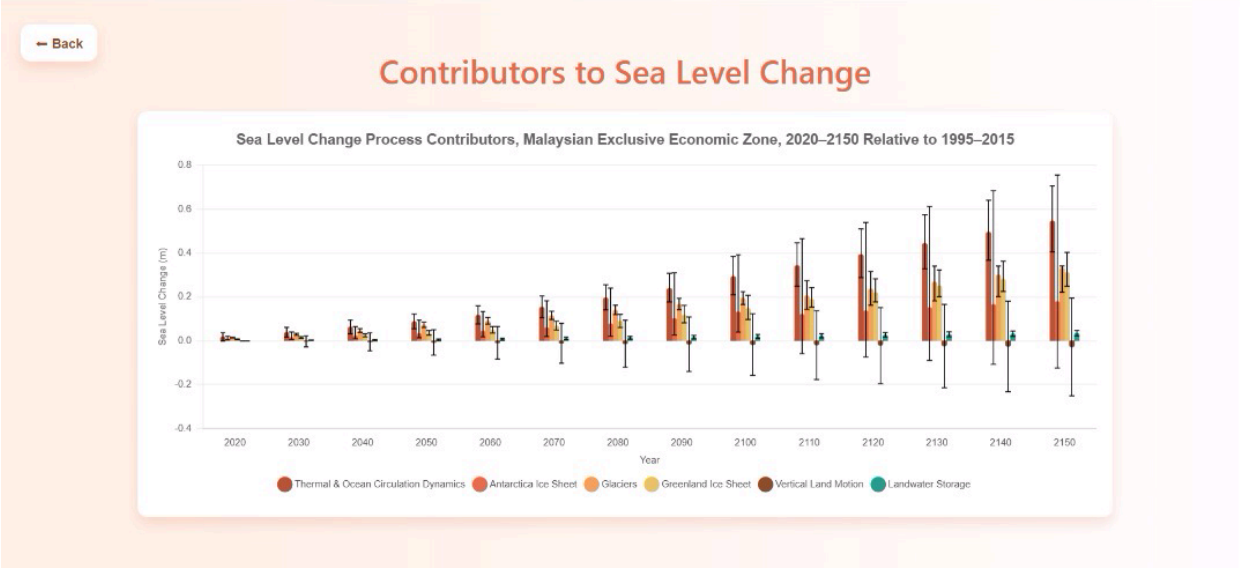


Figure 4.7. Sea Level Change Projections: Contributing Factors.

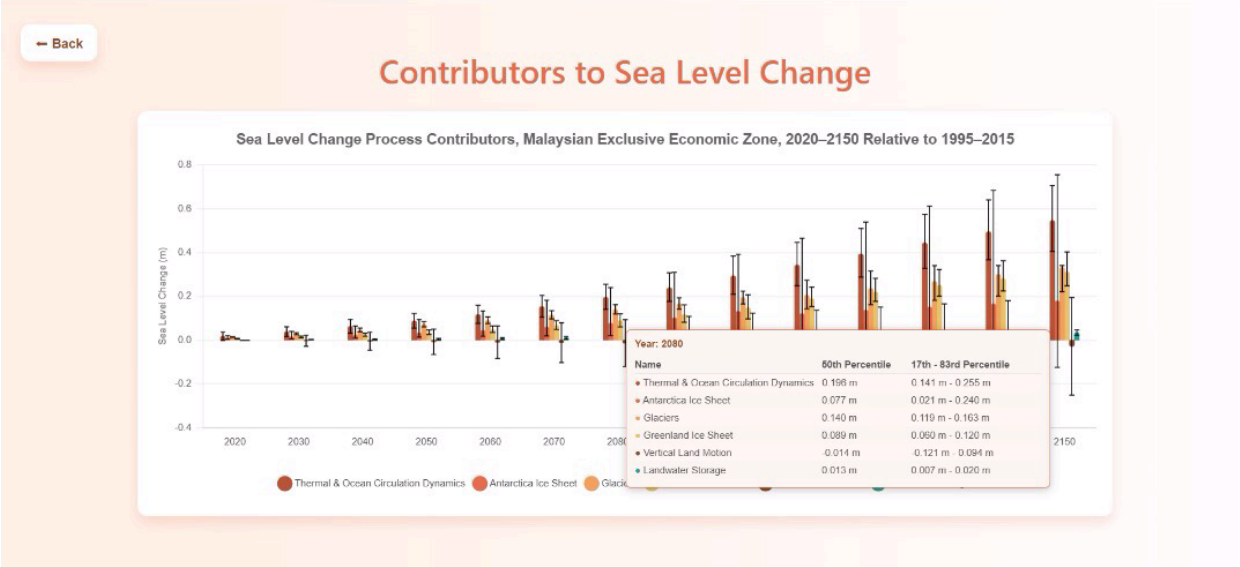


Figure 4.8. Sea Level Projections Bar Chart: Detailed Contributor Data on Hover.

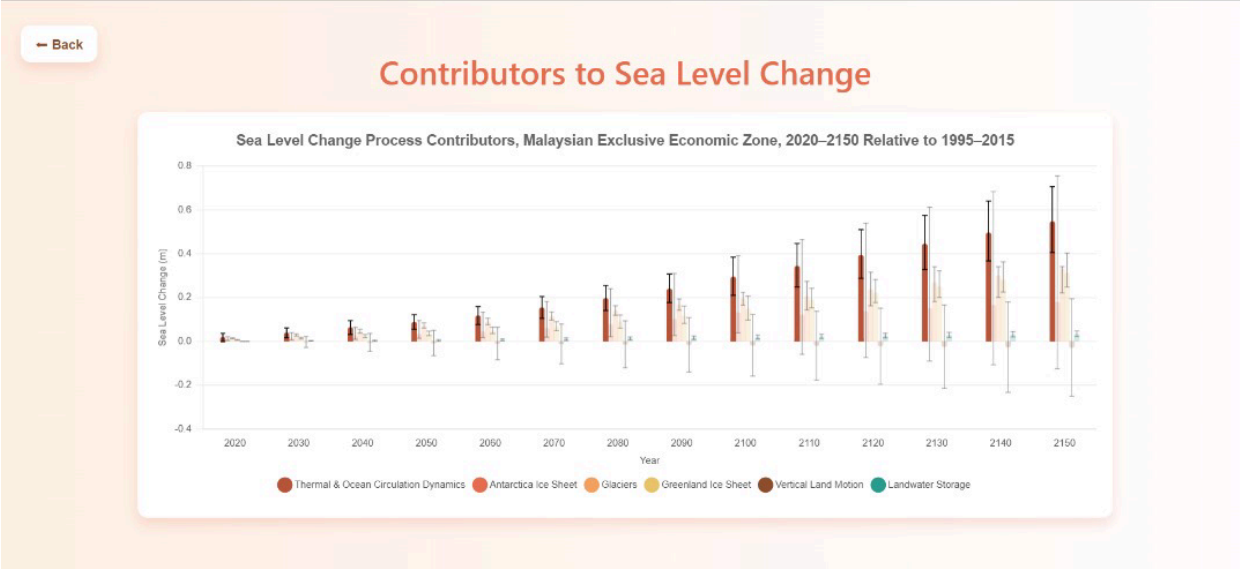


Figure 4.9. Sea Level Projections: Legend Hover Highlighting.

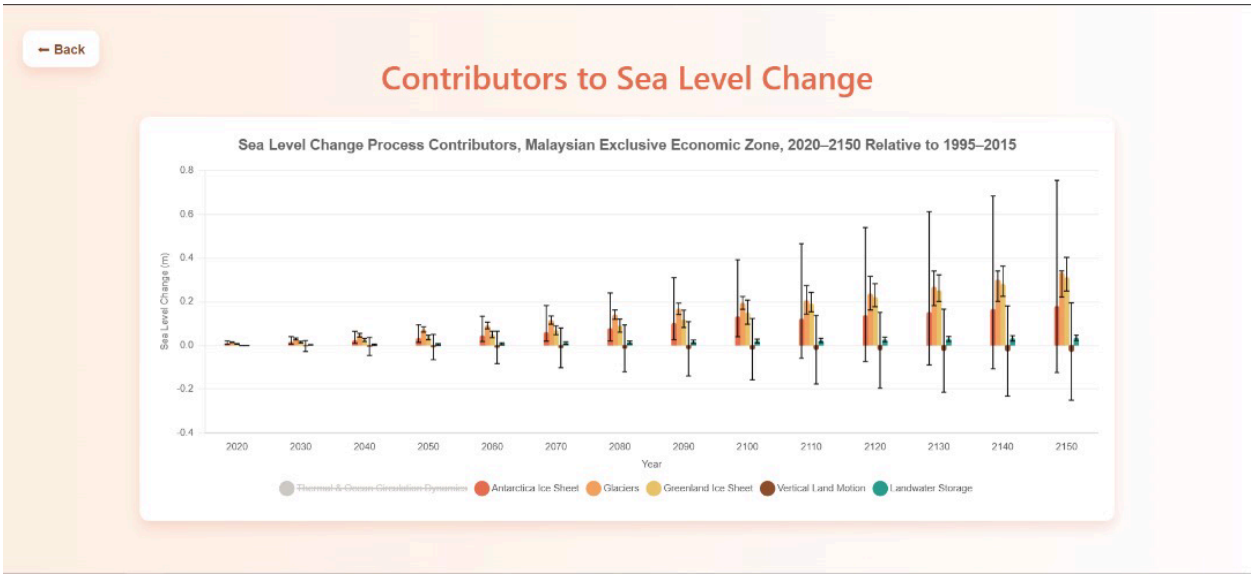


Figure 4.10. Legend Toggle: Hiding Category Bars.

4.3.2.3 Heat Risk Page

The Heat Risk page provides a heatmap visualization for Malaysia (Figure 4.11). Users can select a "Heat Condition Categorization" from a dropdown menu, with options such as Hot Day Heat Risk Categorization, Tropical Night Heat Risk Categories, Heat Index Heat Risk Categorization, Number of Hot Days and Tropical Nights, and Number of Hot Days and Tropical Nights with Humidity (Figure 4.12). Hovering over the heatmap displays the year range, month, and its corresponding risk factor (Figure 4.13). A scale at the bottom of the page helps users understand the risk factor categorization from 0 to 4.

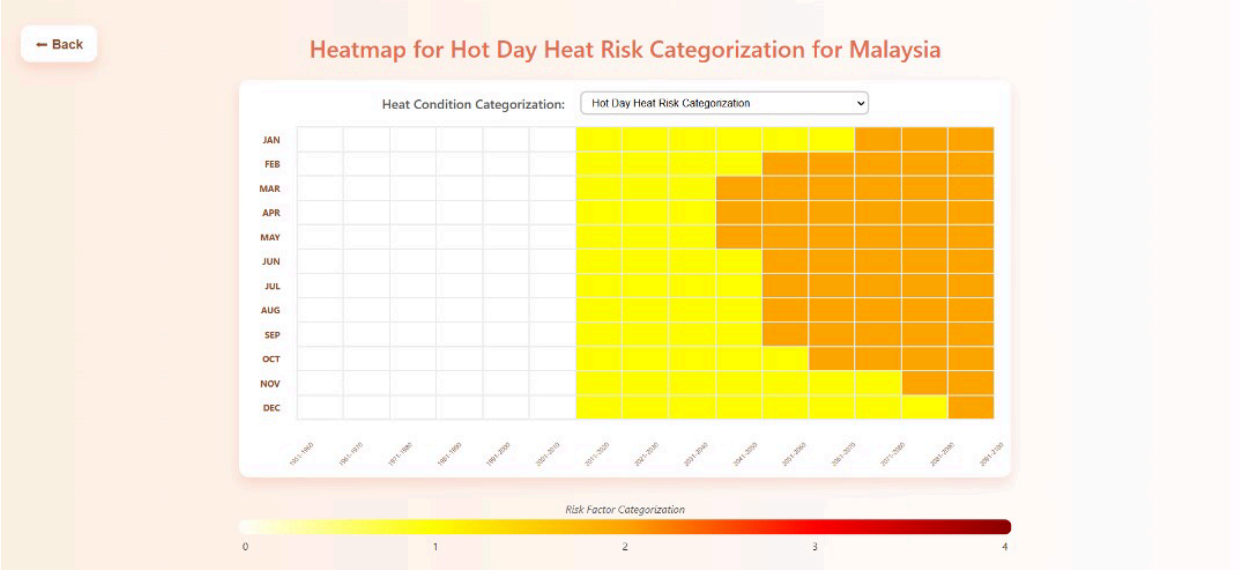


Figure 4.11. Heat Risk Page: Heatmap Visualization for Malaysia.

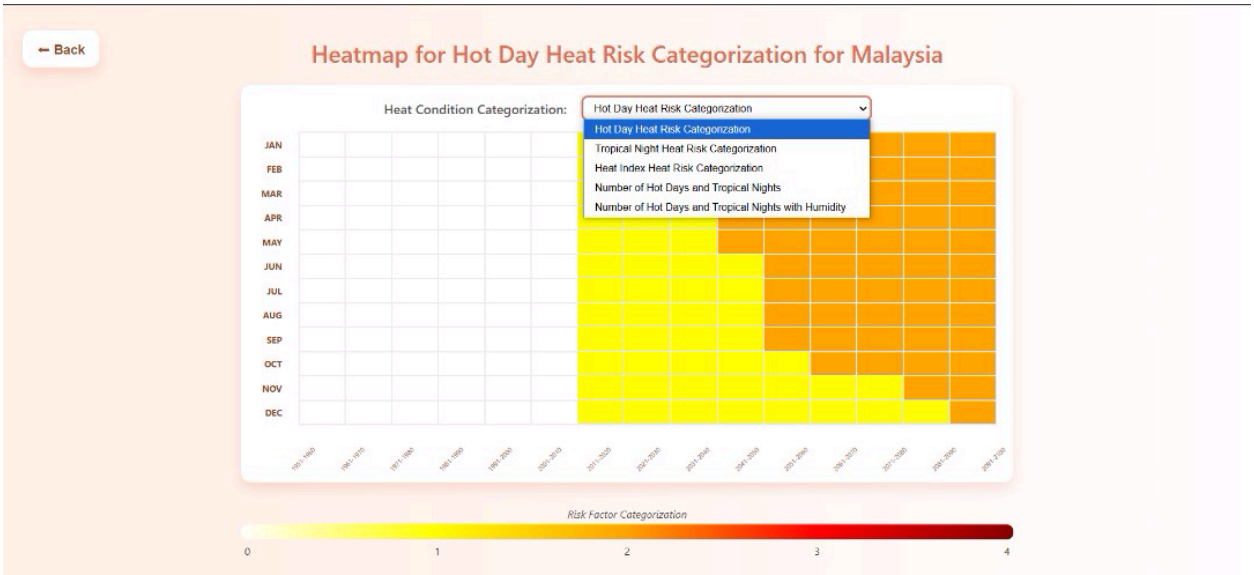


Figure 4.12. Heat Risk Page: Heat Condition Categorization Dropdown.

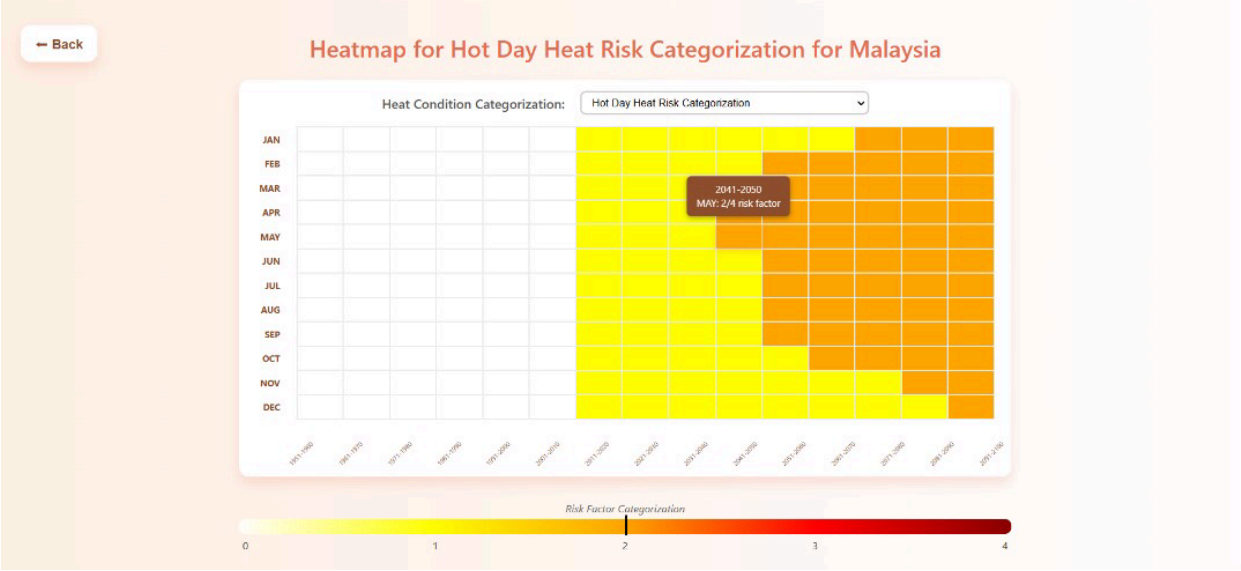


Figure 4.13. Heatmap Interaction: Risk Factor Details on Hover.

4.3.2.4 Historical Natural Hazards Page

This page illustrates key natural hazard statistics from 1980 to 2020, focusing on the number of people affected (Figure 4.14). A stacked bar chart displays each category's impact from 1980-2020. Hoverable bars show the category, the number of people affected, and their percentage within the total stacked bar. A toggleable legend allows control over the visibility of categories (Figure 4.15).

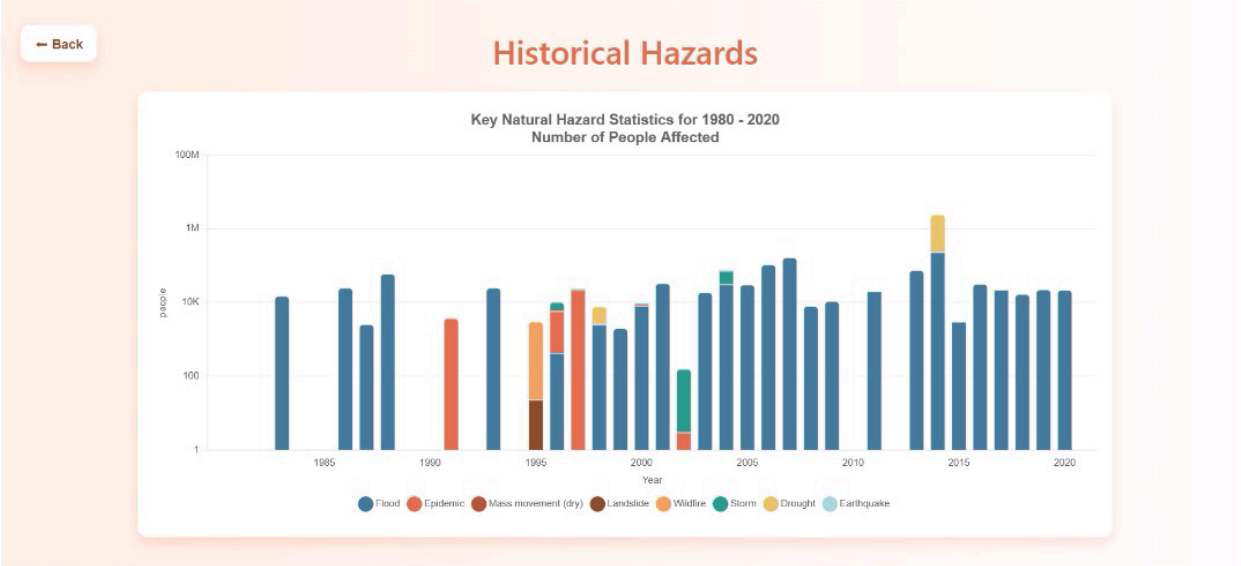


Figure 4.14. Natural Hazards Statistics: People Affected (1980-2020).

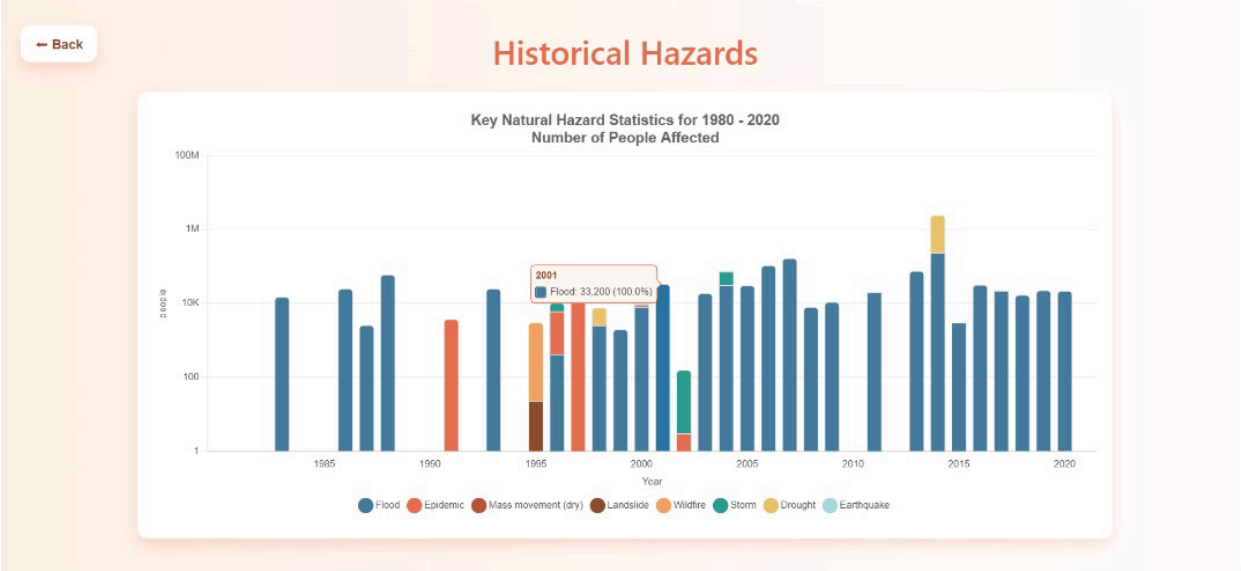


Figure 4.15. Interactive Legend: Category Visibility Toggle.

4.3.2.5 Current Climate Climatology Page

The Current Climate Climatology page displays monthly climatology data (Figure 4.16). Four data layers are available: Average Maximum Surface Air Temperature (red), Average Mean Surface Air Temperature (orange), Average Minimum Surface Air Temperature (orange), and Precipitation (mint). Users can select a time period ranging from 1901 to 2020 (Figure 4.17). Temperature data is represented by a line graph, while precipitation is shown with a bar graph. A tooltip appears when users hover over a month's line or bar chart, displaying the four data layers for the hovered month (Figure 4.18).

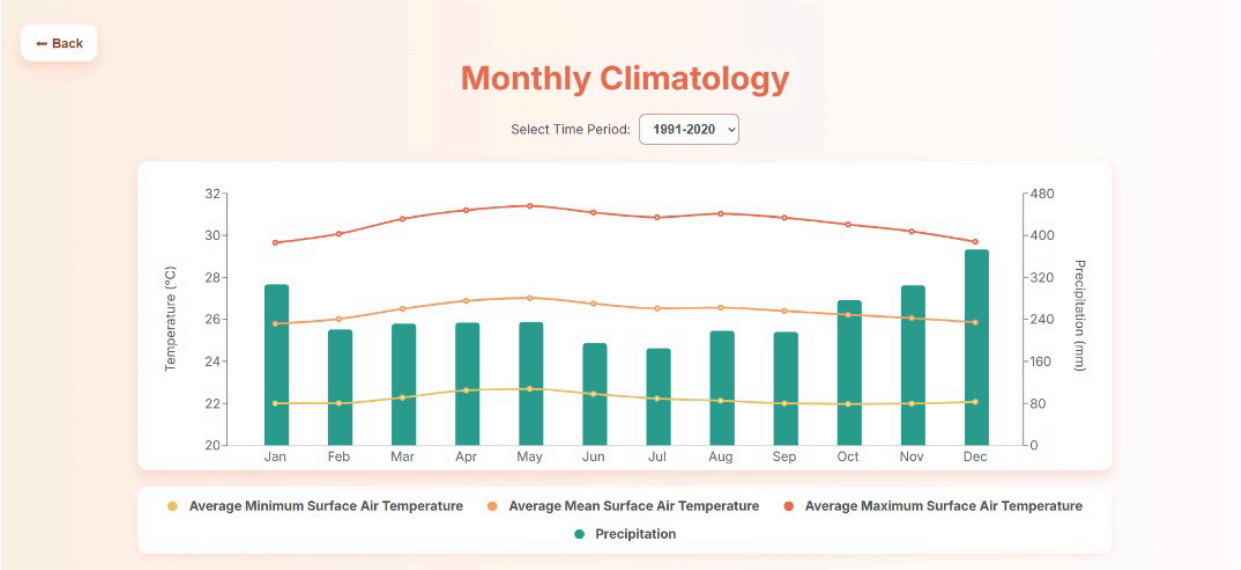


Figure 4.16. Current Climate Climatology: Monthly Data Display.

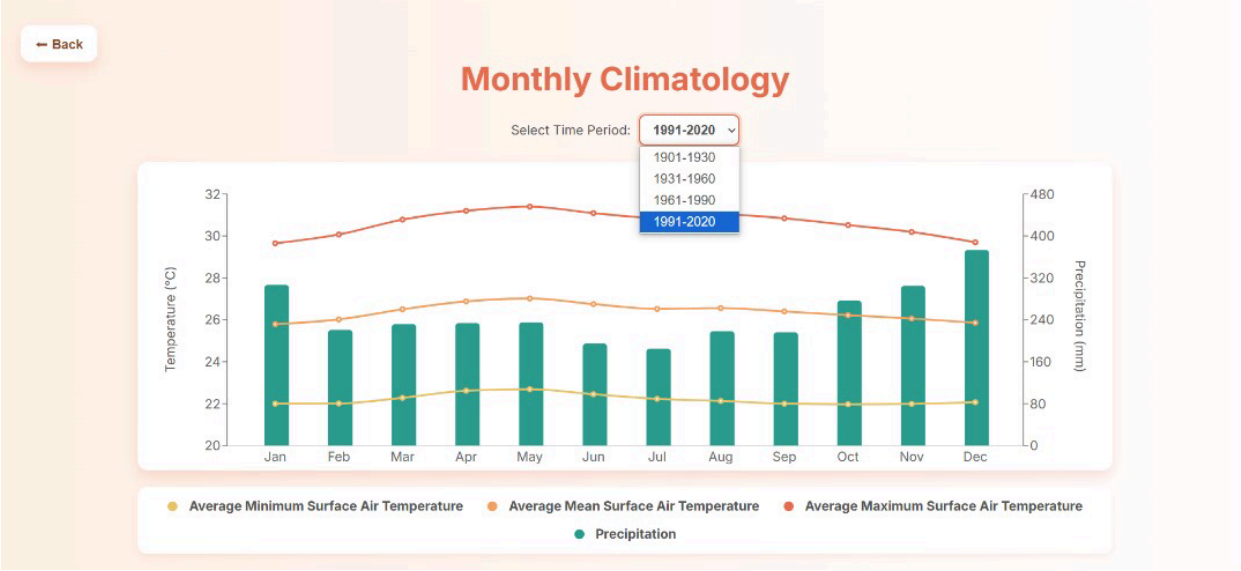


Figure 4.17. Climate Climatology: Time Period Selection (1901-2020).

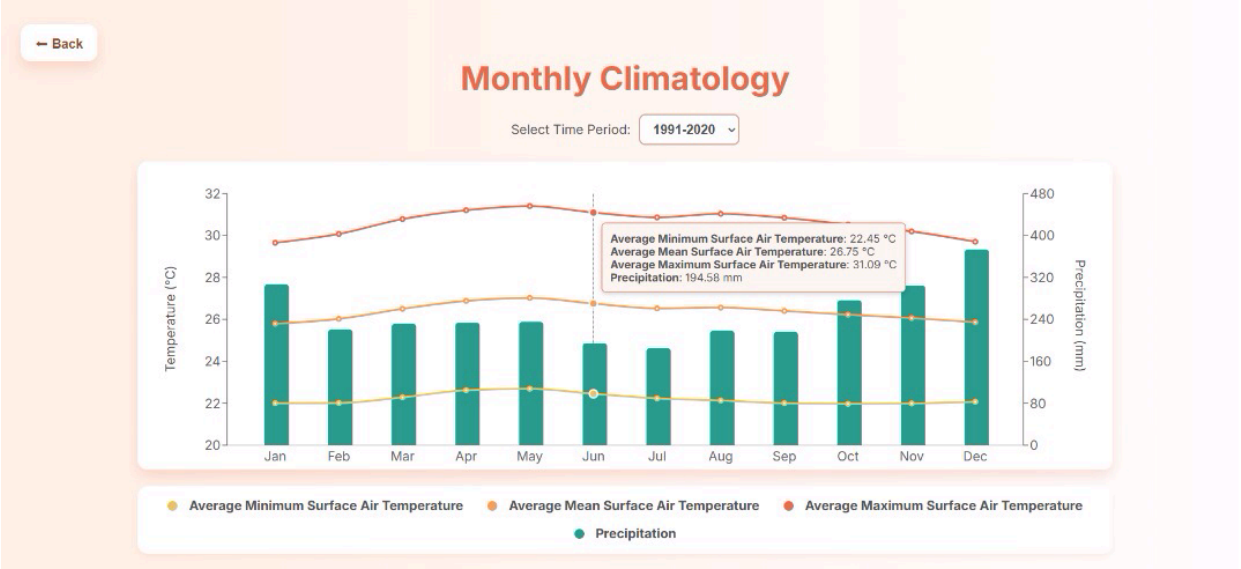


Figure 4.18. Monthly Climatology Chart: Data Layer Tooltip on Hover.

4.3.2.6 Trends and Significant Change against Natural Variability Page

This page presents trends within natural variability and their significance (Figure 4.19). It features a dotted chart for yearly air temperature and a line graph for Current Climatology Trend (1991-2020). Three dropdown selections are available for variables: Average Mean Surface Air Temperature, Average Maximum Surface Air Temperature, and Average Minimum Surface Air Temperature (Figure 4.20). Figure 4.21 shows that hovering over a legend highlights its corresponding data while other data fades. When hovering over a data point, a tooltip displays the year and the surface air temperature data (Figure 4.22).

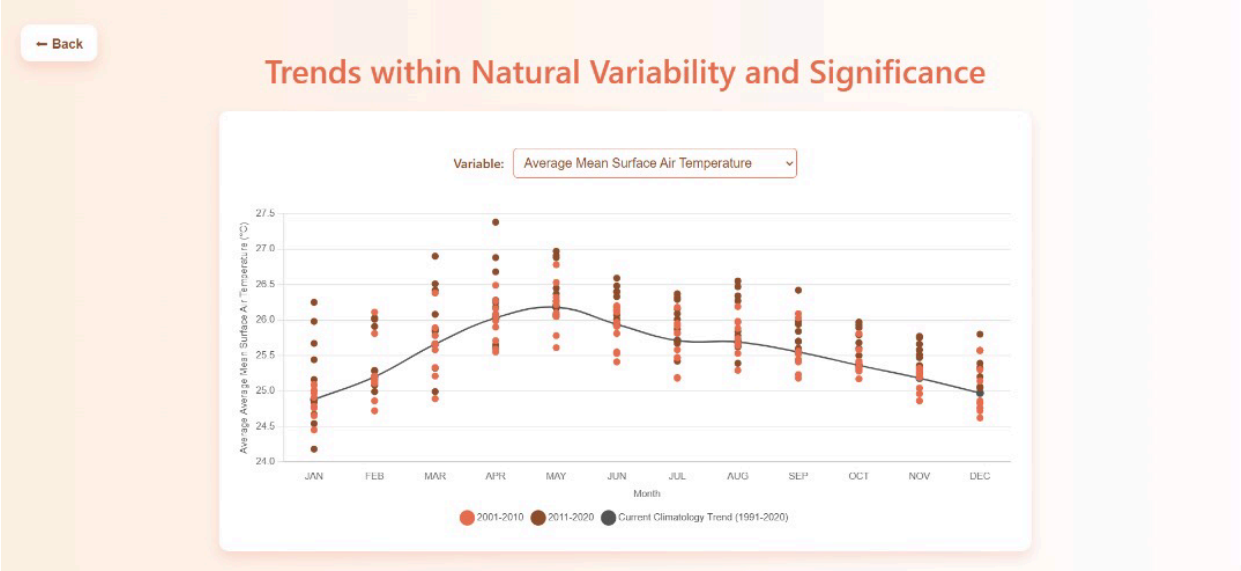


Figure 4.19. Natural Variability Trends and Significance.

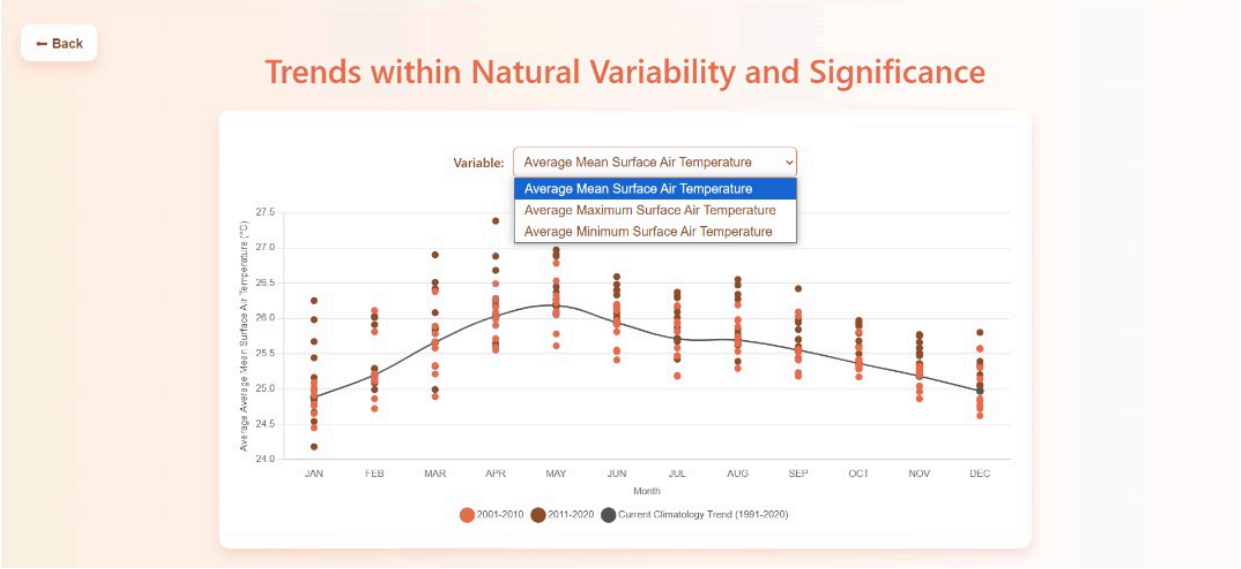


Figure 4.20. Natural Variability Trends: Temperature Variable Selection.

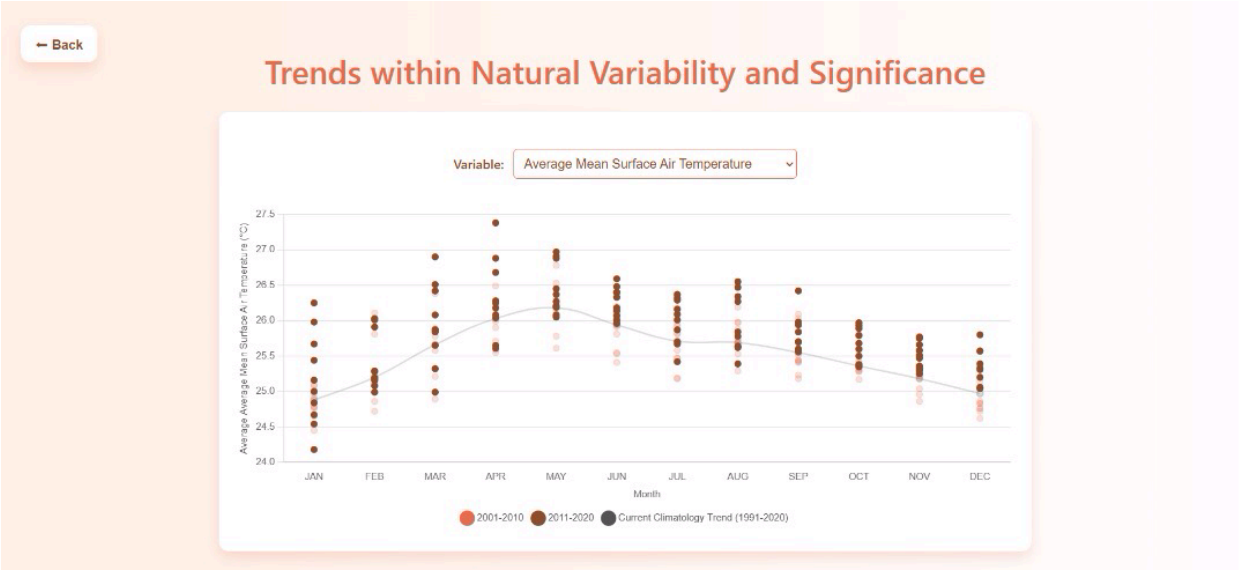


Figure 4.21. Interactive Chart: Legend Hover Highlighting.

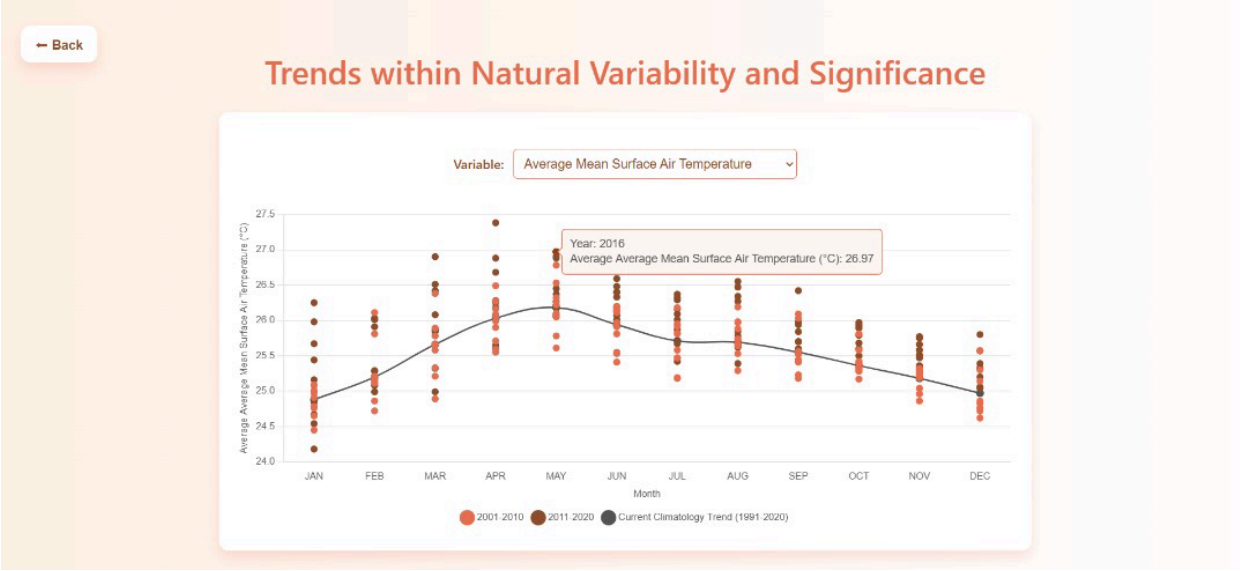


Figure 4.22. Interactive Chart: Tooltip Displaying Year and Surface Air Temperature Data.

4.3.3 Water Quality Insights Page

The Water Quality Insights page provides three buttons for users to select: Water Consumption, Water Production, and Access to Treated Water, each leading to its respective page, as shown in Figure 4.23.

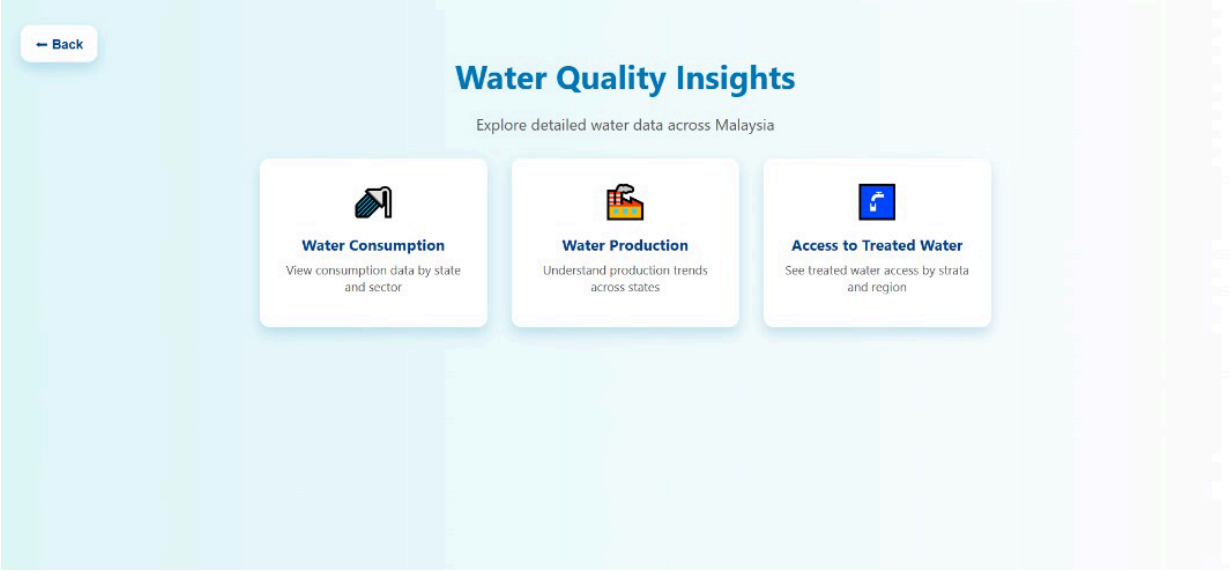


Figure 4.23. Water Quality Insights Page: Data Category Selection.

siapa

4.3.3.1 Water Consumption Page

This page displays annual water consumption by state, categorized into domestic and non-domestic sectors (Figure 4.24). Figure 4.25 and Figure 4.26 show that data is presented in a table format, allowing for filtering by state and sector, table sorting, and data searching (Figure 4.27). A function to download the full dataset in CSV format is available (Figure 4.28). Users can also choose to view the data in a chart format, with an animation feature to visualize year-to-year changes (Figure 4.29). A tooltip appears on the chart when users hover over it, showing the corresponding year and its concentration (Figure 4.30). Chart data can be downloaded as a PNG image or as a full dataset in CSV format (Figure 4.31).

Figure 4.24. Water Consumption by State: Domestic and Non-Domestic (Annual).

Figure 4.25. Tabular Data: Filtering, Sorting, and Searching Functionality.

Figure 4.26. Tabular Data: Filtering, Sorting, and Searching Functionality.

Figure 4.27. Tabular Data: Filtering, Sorting, and Searching Functionality.

Figure 4.28. Data Download Functionality: Full Dataset in CSV Format.

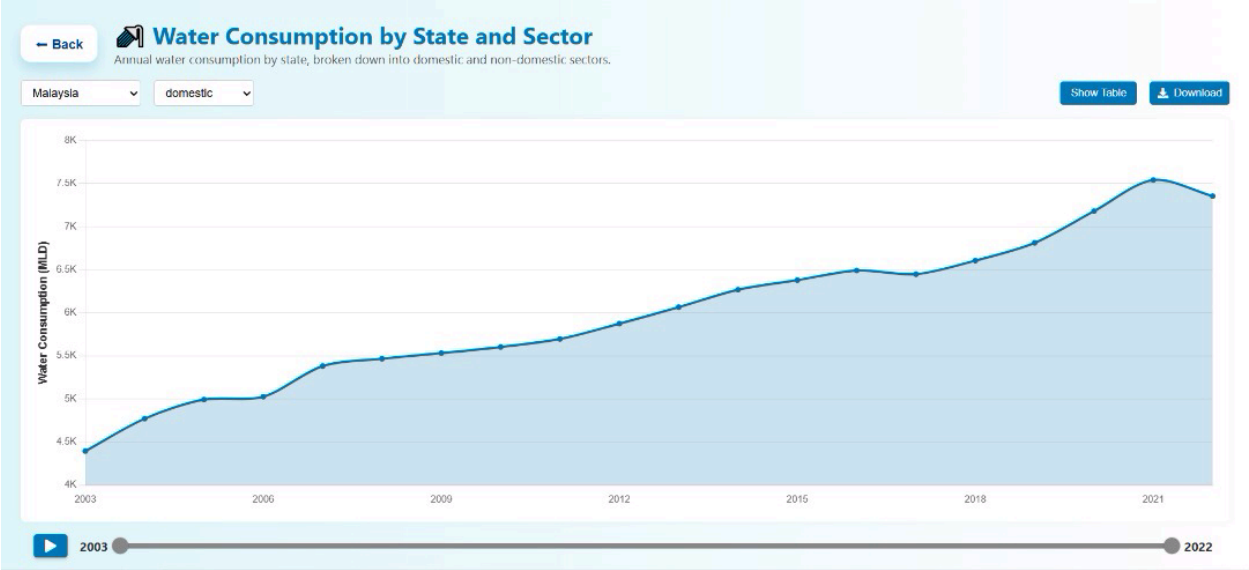


Figure 4.29. Water Data Visualization: Animated Chart for Year-to-Year Changes.

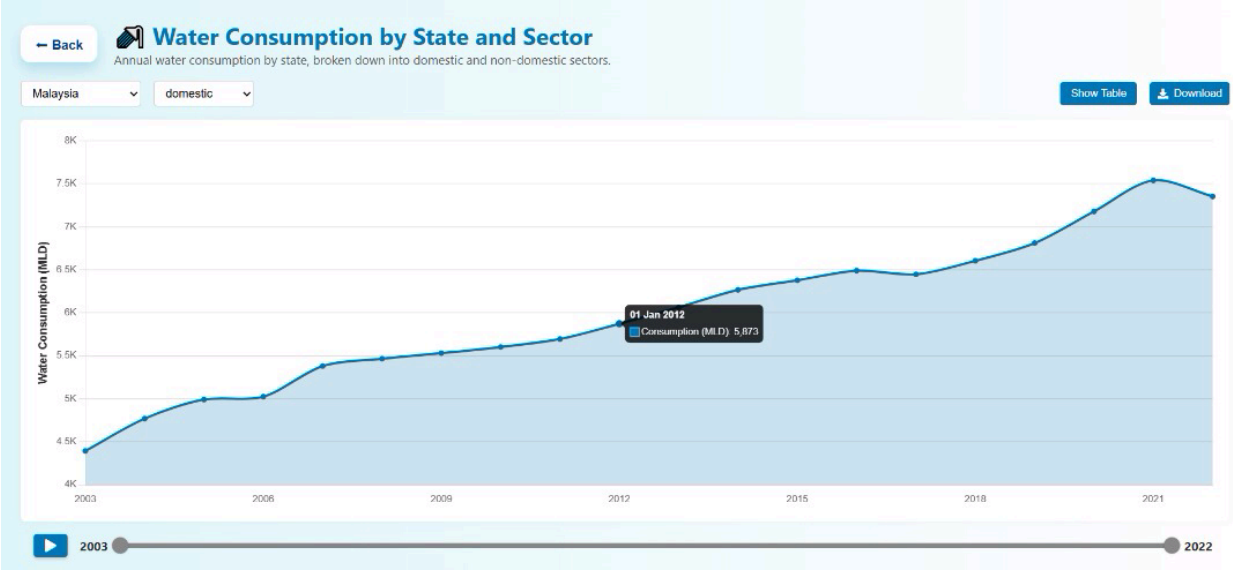


Figure 4.30. Water Data Chart: Year and Concentration on Hover.

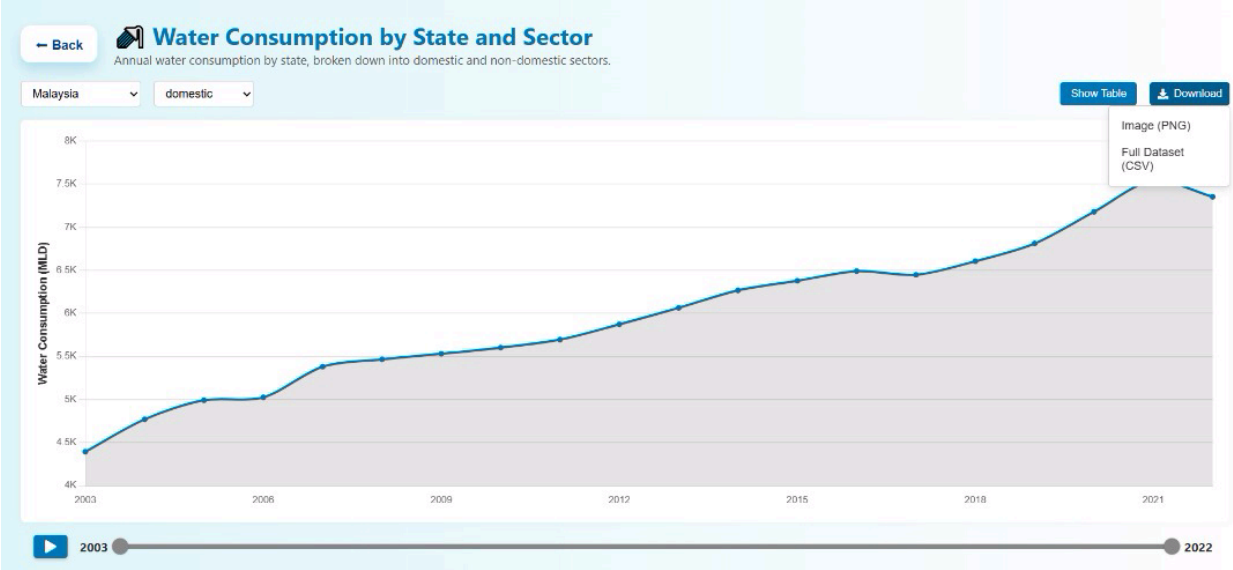


Figure 4.31. Chart Data Download Options: PNG Image and CSV Dataset.

4.3.3.2 Water Production Page

The Water Production page displays annual water production by state (Figure 4.32). Data is presented in a table format, allowing for filtering by state (Figure 4.33), table sorting, and data

searching (Figure 4.34). A function to download the full dataset in CSV format is available (Figure 4.35). Users can also choose to view the data in a chart format, with an animation feature to visualize year-to-year changes (Figure 4.36). A tooltip appears on the chart when users hover over it, showing the corresponding year and its production (Figure 4.37). Chart data can be downloaded as a PNG image or as a full dataset in CSV format (Figure 4.38).

Figure 4.32. Water Production Page: Annual Water Production by State.

Figure 4.33. Tabular Data: Filtering by State.

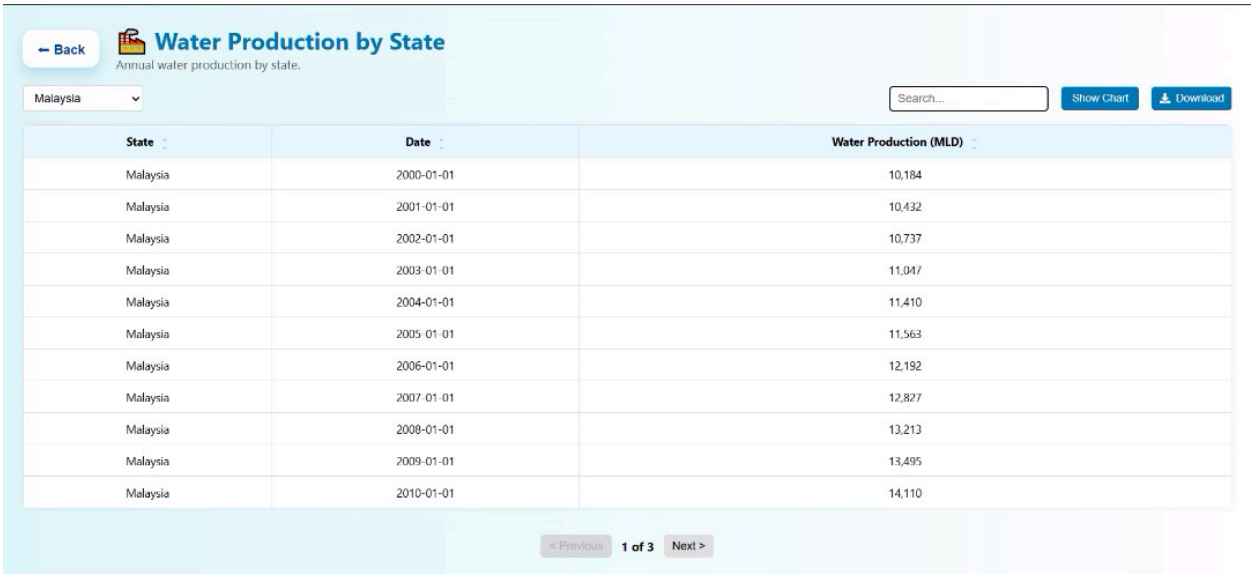


Figure 4.34. Tabular Data: Sorting and Search Functionality.

Figure 4.35. Data Download Functionality: Full Dataset in CSV Format.

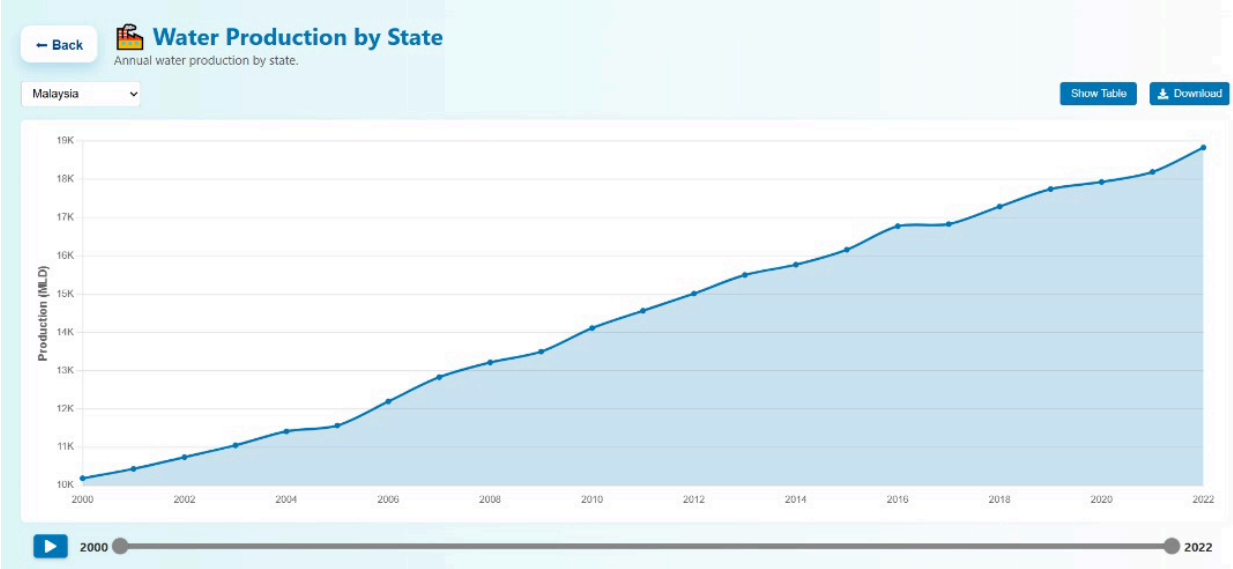


Figure 4.36. Water Production Visualization: Animated Chart for Year-to-Year Changes.

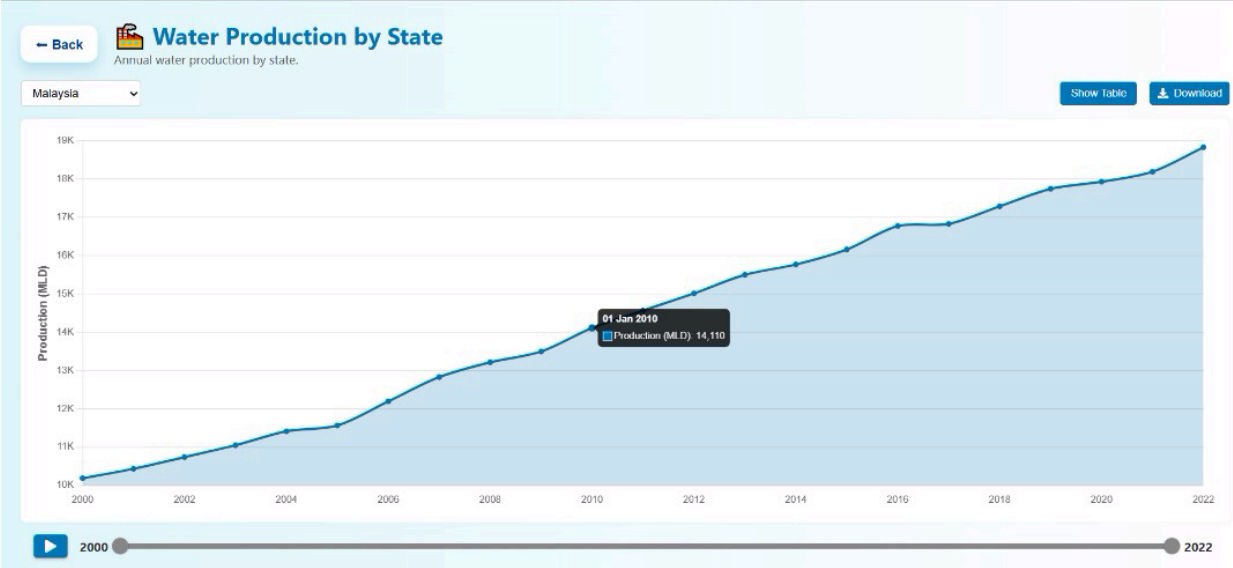


Figure 4.37. Water Production Chart: Year and Production Value on Hover.

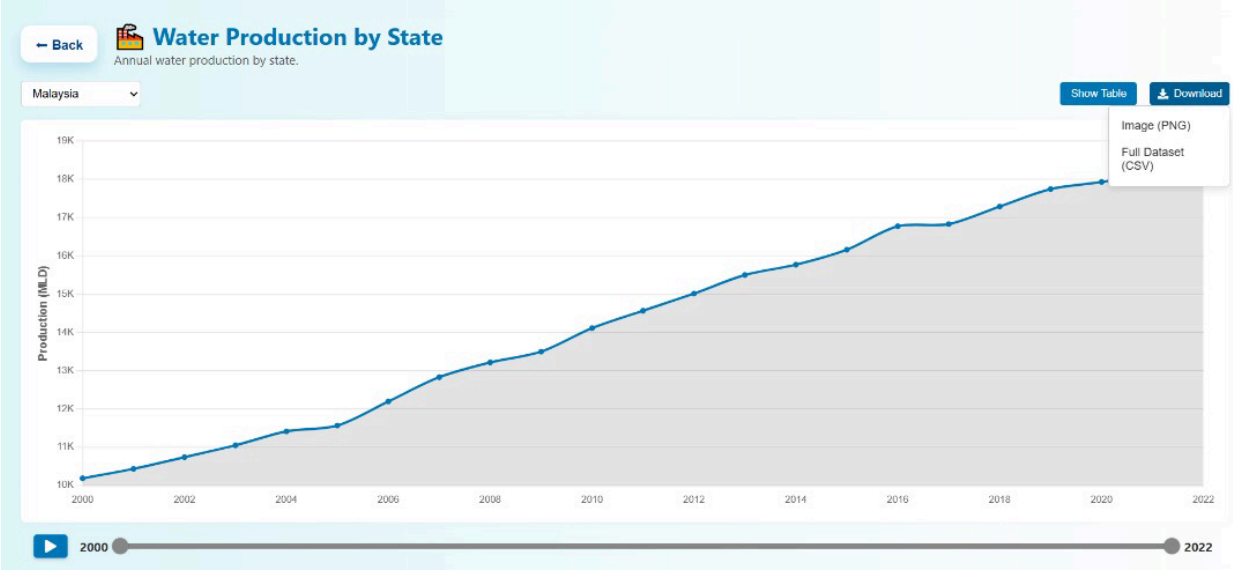


Figure 4.38. Chart Data Download Options: PNG Image and CSV Dataset.

4.3.3.3 Access to Treated Water Page

This page displays annual access of households to treated piped water by state and strata (Figure 4.39). Data is presented in a table format, allowing for filtering by state (Figure 4.40) and strata (Figure 4.41), table sorting, and data searching (Figure 4.42). A function to download the full dataset in CSV format is available (Figure 4.43). Users can also choose to view the data in a chart format, with an animation feature to visualize year-to-year changes (Figure 4.44). A tooltip appears on the chart when users hover over it, showing the corresponding year and its percentage of access to treated water (Figure 4.45). Chart data can be downloaded as a PNG image or as a full dataset in CSV format (Figure 4.46).

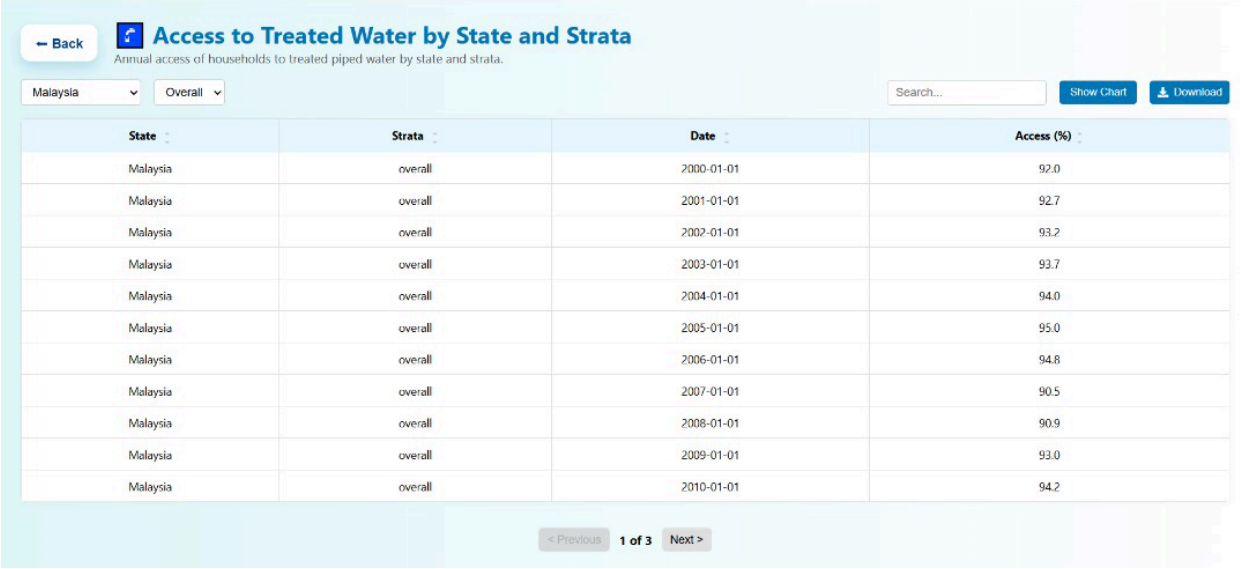


Figure 4.39. Access to Treated Water Page: Annual Household Access by State and Strata.

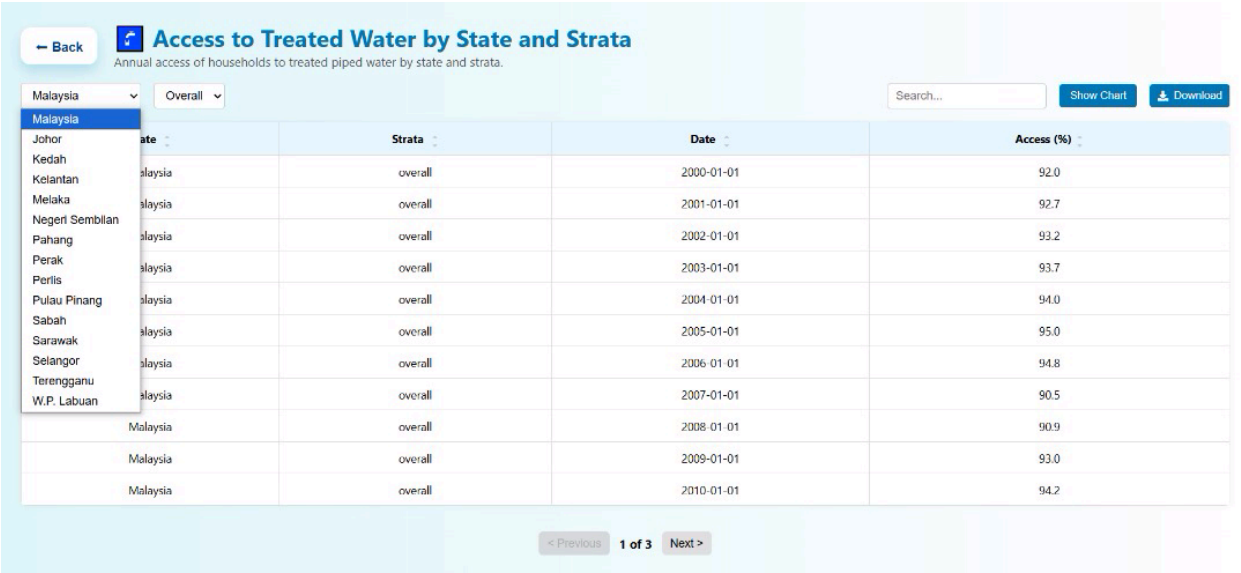


Figure 4.40. Tabular Data: Filtering by State.

Figure 4.41. Tabular Data: Filtering by Strata.

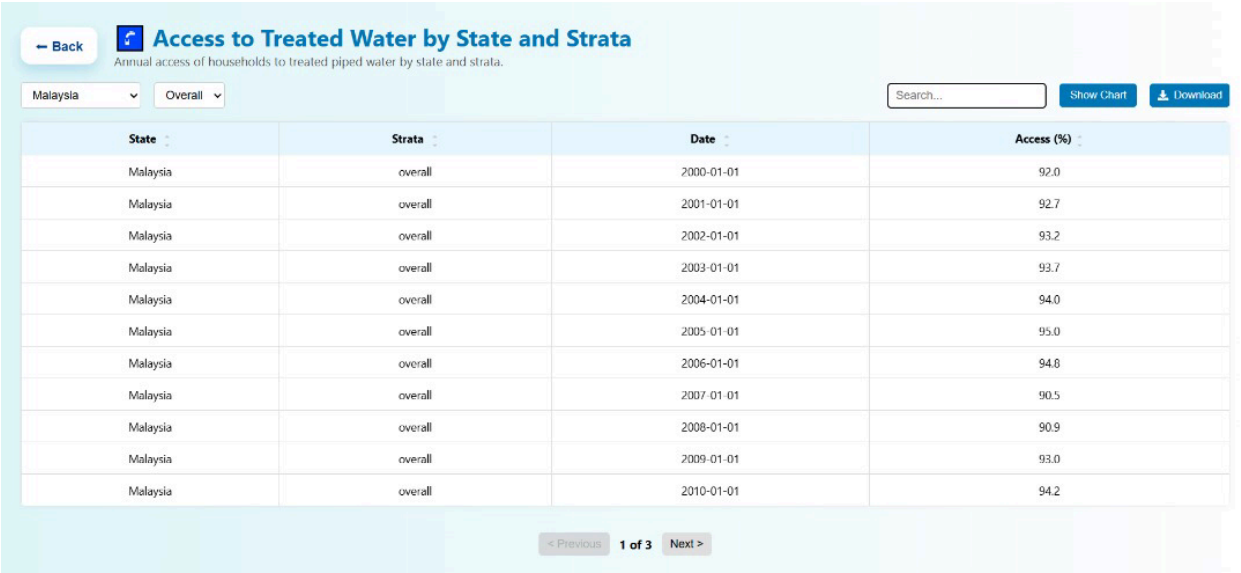


Figure 4.42. Tabular Data: Sorting and Search Functionality.

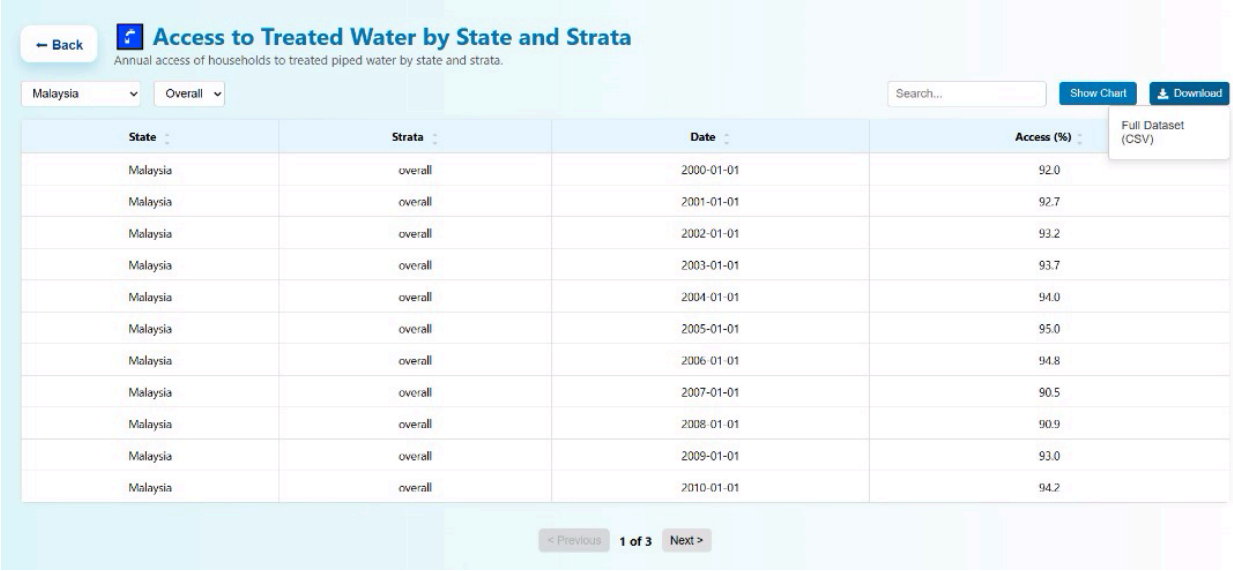


Figure 4.43. Data Download Functionality: Full Dataset in CSV Format.

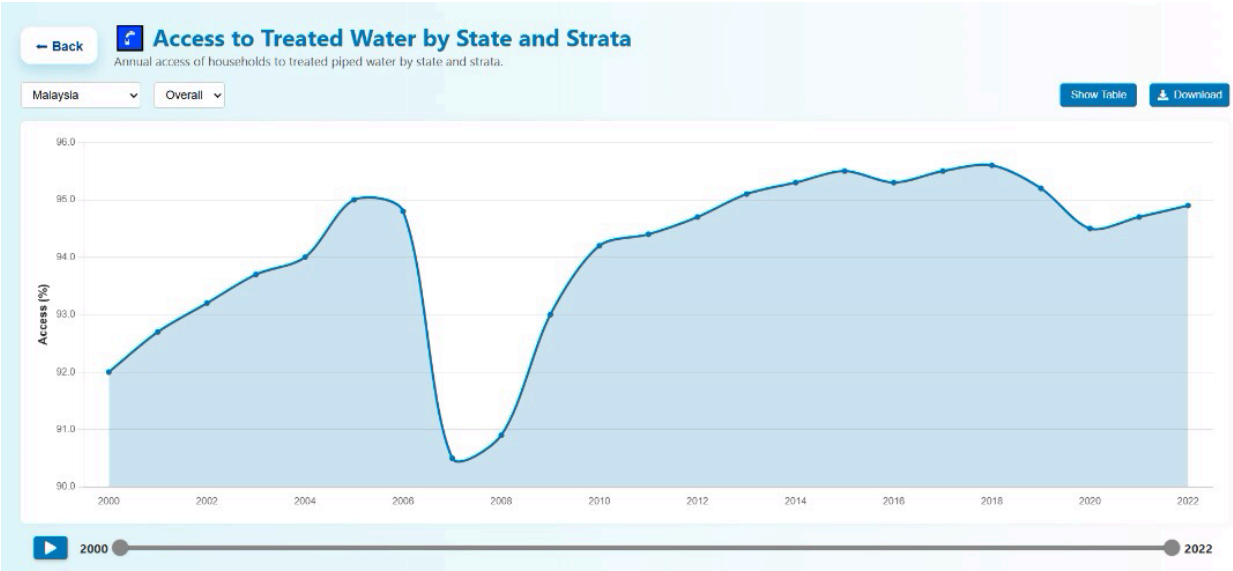


Figure 4.44. Access to Treated Water: Animated Chart for Year-to-Year Changes.

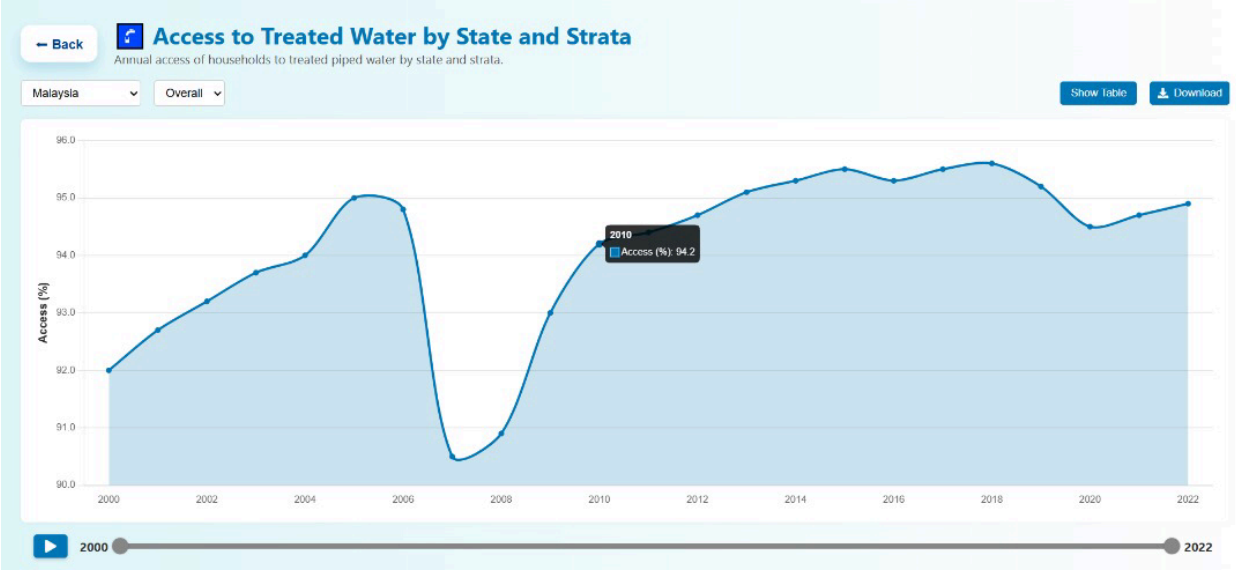


Figure 4.45. Access to Treated Water Chart: Year and Percentage on Hover.

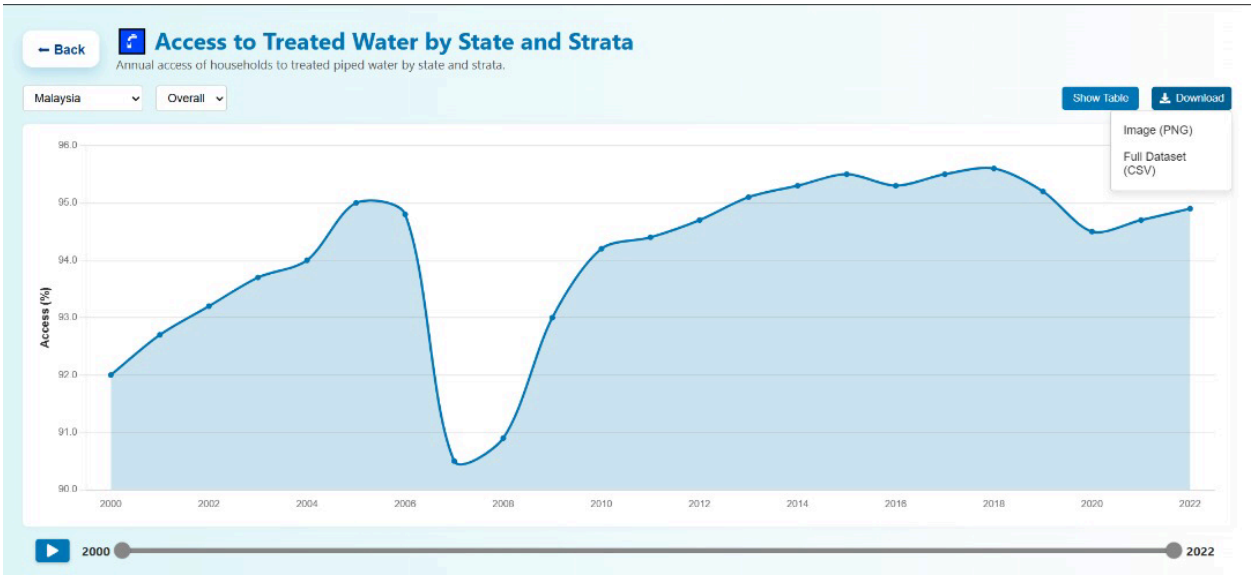


Figure 4.46. Chart Data Download Options: PNG Image and CSV Dataset.

4.3.4 Air Pollution Insights Page

The Air Pollution Insights page allows users to explore either Greenhouse Gas Emissions or Monthly Air Pollution by clicking the corresponding button, which directs them to the relevant section (Figure 4.47).

Figure 4.47 Air Pollution Insights Page: Greenhouse Gas and Monthly Pollution Selection.

4.3.4.1 Greenhouse Gas Emissions Page

This page displays annual greenhouse gas (GHG) emissions by sources (Figure 4.48). Data is presented in a table format, allowing for filtering by source, including Total Emissions (excluding LULUCF), Net Emissions (including LULUCF), Energy, Industrial Processes, Agriculture, Waste, and Land Use, Land-Use Change, and Forestry (Figure 4.49). Table sorting and data searching functions (Figure 4.50) are available. A function to download the full dataset in CSV format is provided (Figure 4.51). Users can also choose to view the data in a chart format, with an animation feature to visualize year-to-year changes (Figure 4.52). A tooltip

appears on the chart when users hover over it, showing the corresponding year and its emission (Figure 4.53). Chart data can be downloaded as a PNG image or as a full dataset in CSV format (Figure 4.54).

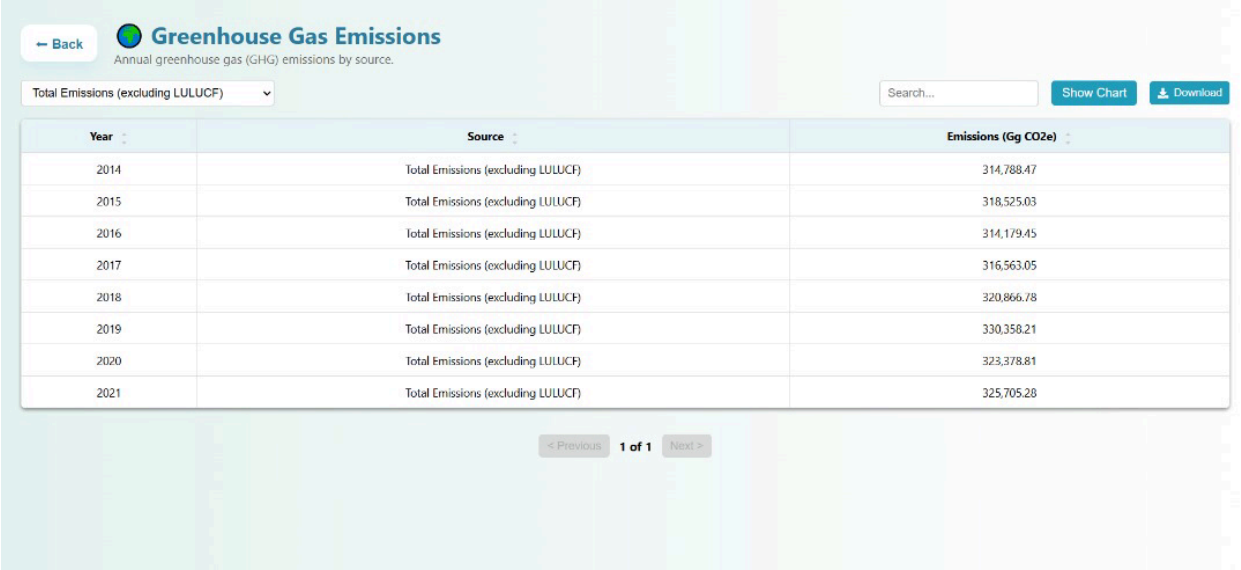


Figure 4.48. Greenhouse Gas Emissions: Annual Emissions by Sources.

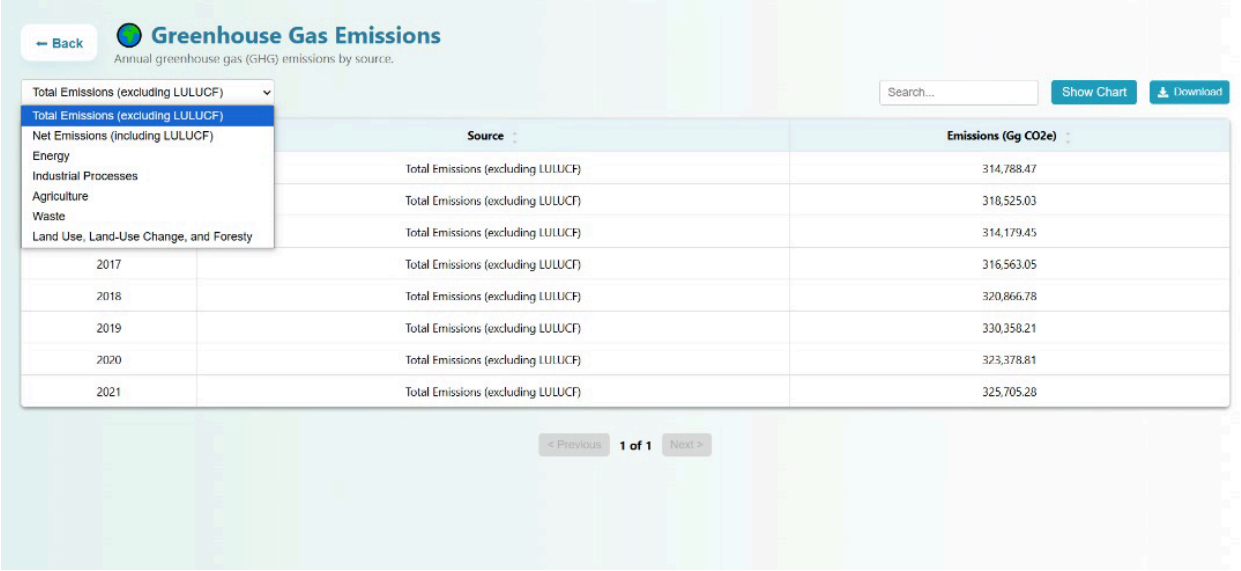


Figure 4.49. Tabular Data: Filtering Greenhouse Gas Emissions by Source.

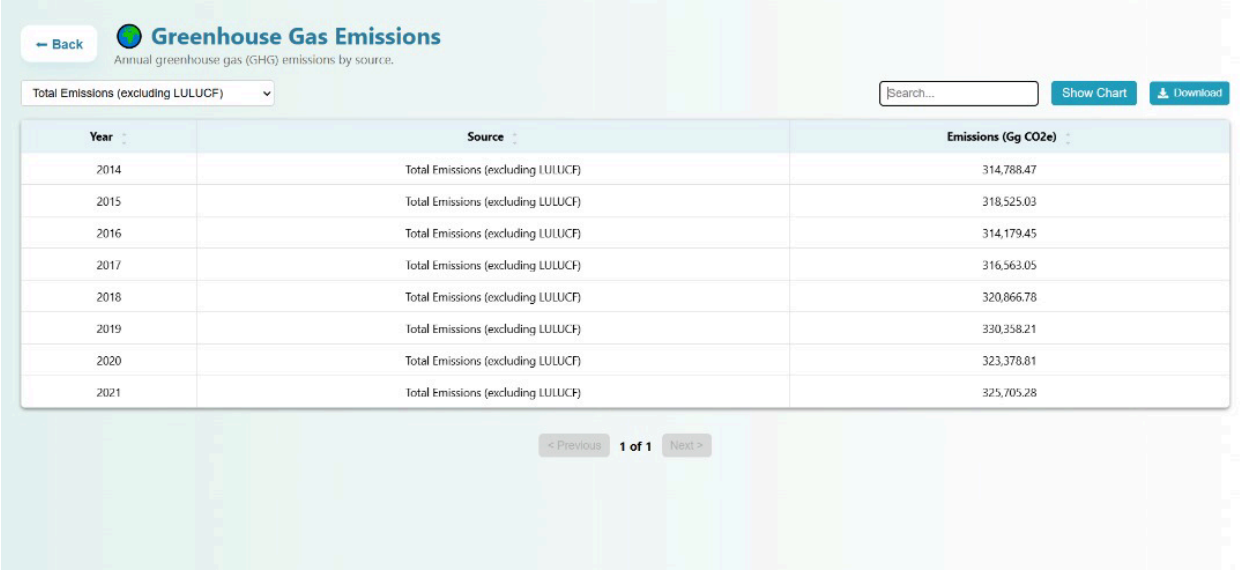


Figure 4.50. Tabular Data: Sorting and Search Functions for GHG Emissions.

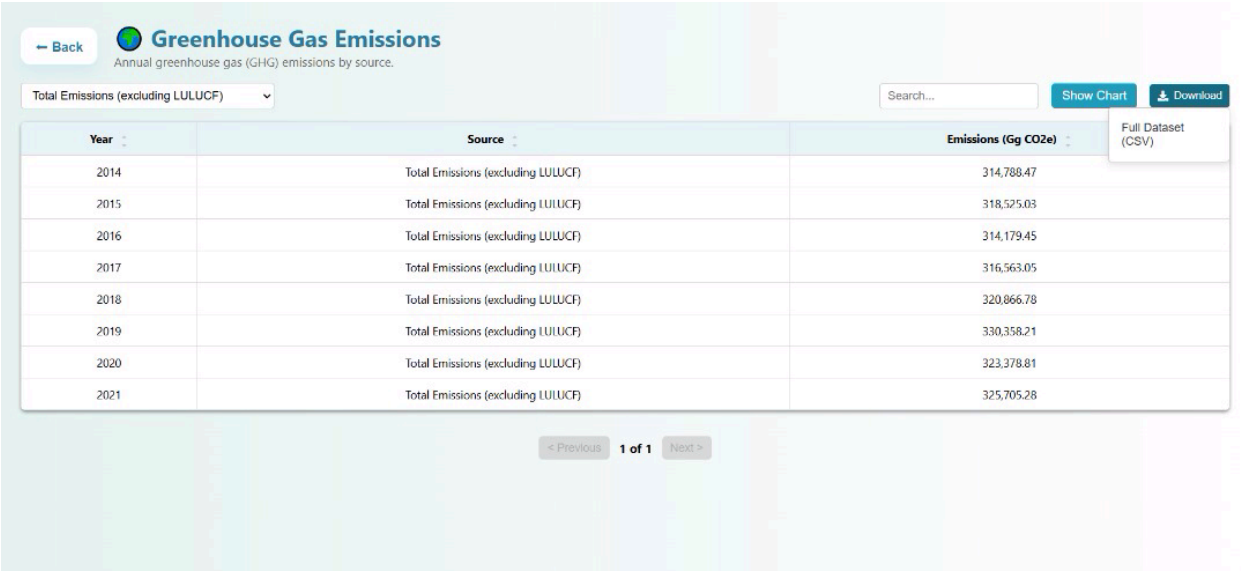


Figure 4.51. Data Download Functionality: Full GHG Emissions Dataset in CSV Format.

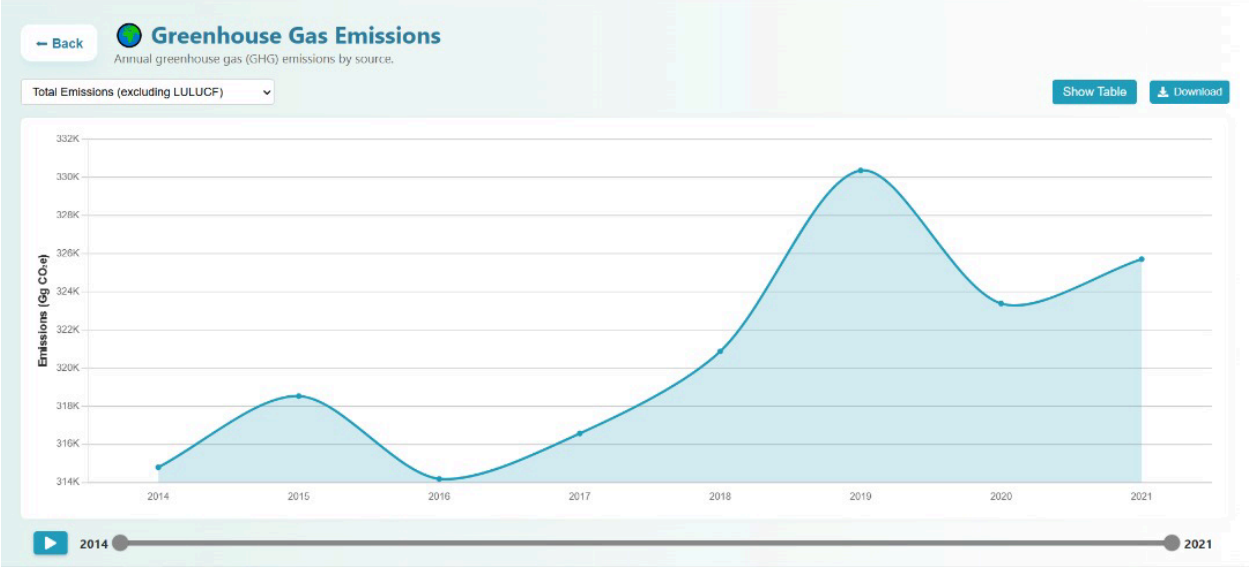


Figure 4.52. Greenhouse Gas Emissions: Animated Chart for Year-to-Year Changes.

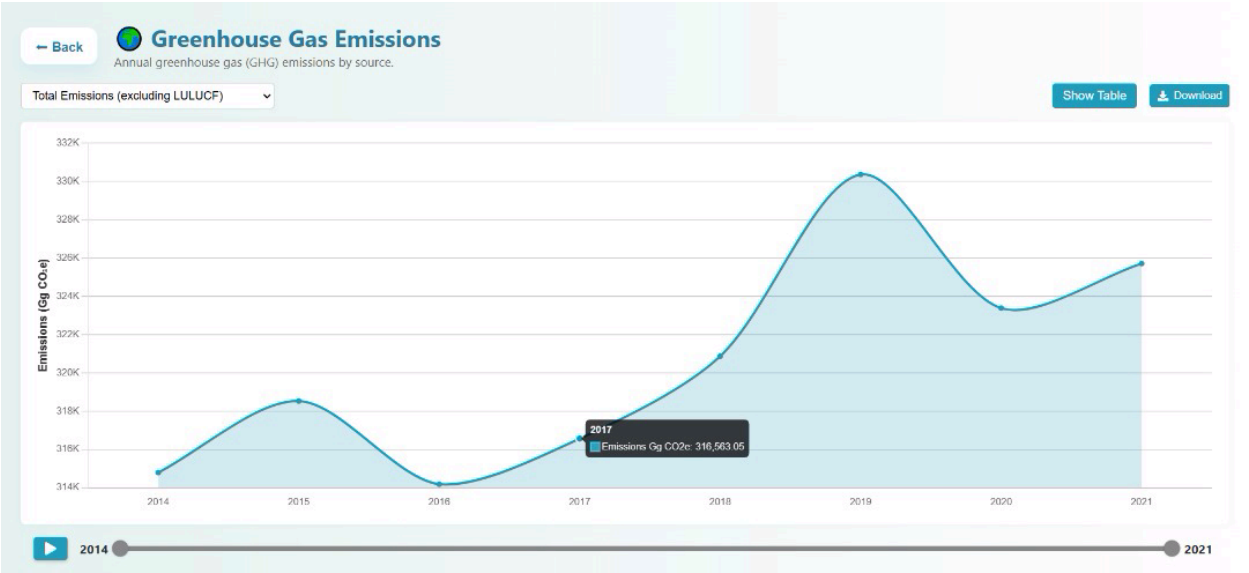


Figure 4.53. Greenhouse Gas Emissions Chart: Year and Emission Value on Hover.

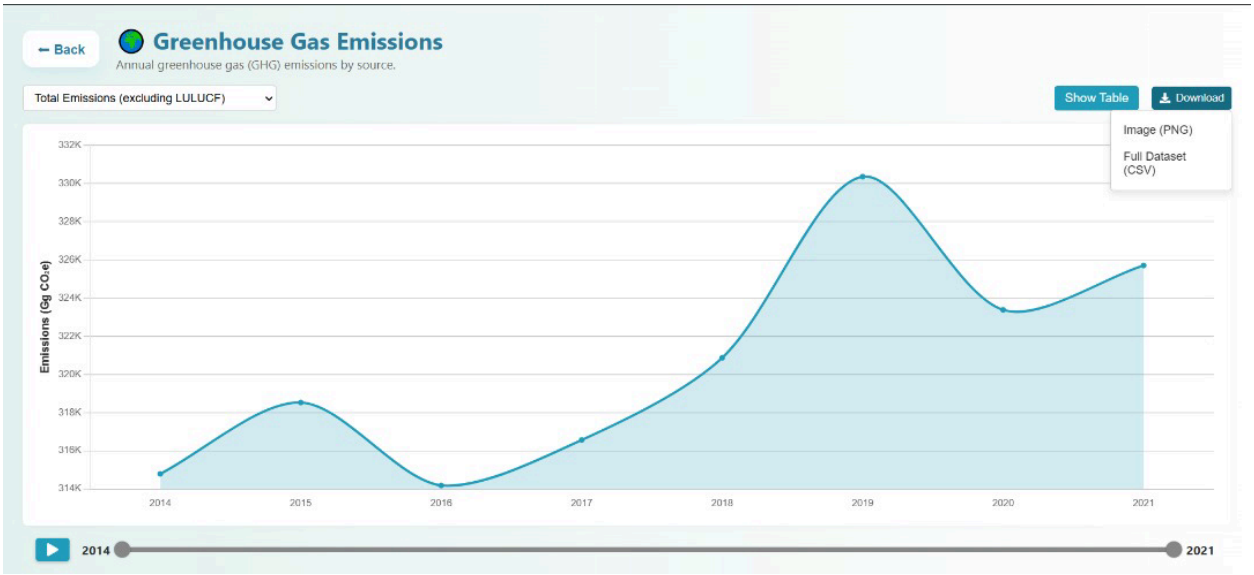


Figure 4.54. Chart Data Download Options: GHG Emissions as PNG or CSV.

4.3.4.2 Monthly Air Pollution Page

This page displays the average monthly concentration of key air pollutants (Figure 4.55). Figure 4.56 shows that data is preble format, allowing for filtering by pollutants (Carbon Monoxide, Nitrogen Dioxide, Ozone, Particulate Matter, and Sulfur Dioxide). Next, Figure 4.57 shows that the table sorting and data searching functions are available. A function to download the full dataset in CSV format is provided (Figure 4.58). Users cansented in a ta also choose to view the data in a chart format, with an animation feature to visualize year-to-year changes (Figure 4.59). A tooltip appears on the chart when users hover over it, showing the corresponding year and its concentration (Figure 4.60). Chart data can be downloaded as a PNG image or as a full dataset in CSV format (Figure 4.61).

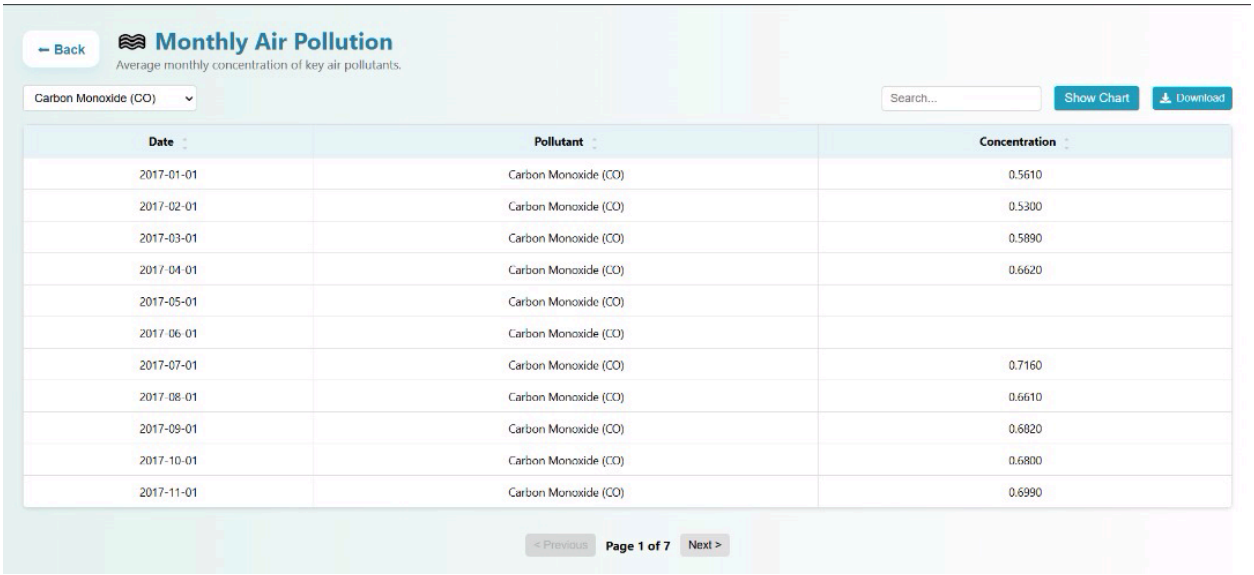


Figure 4.55. Monthly Air Pollution: Average Monthly Pollutant Concentration.

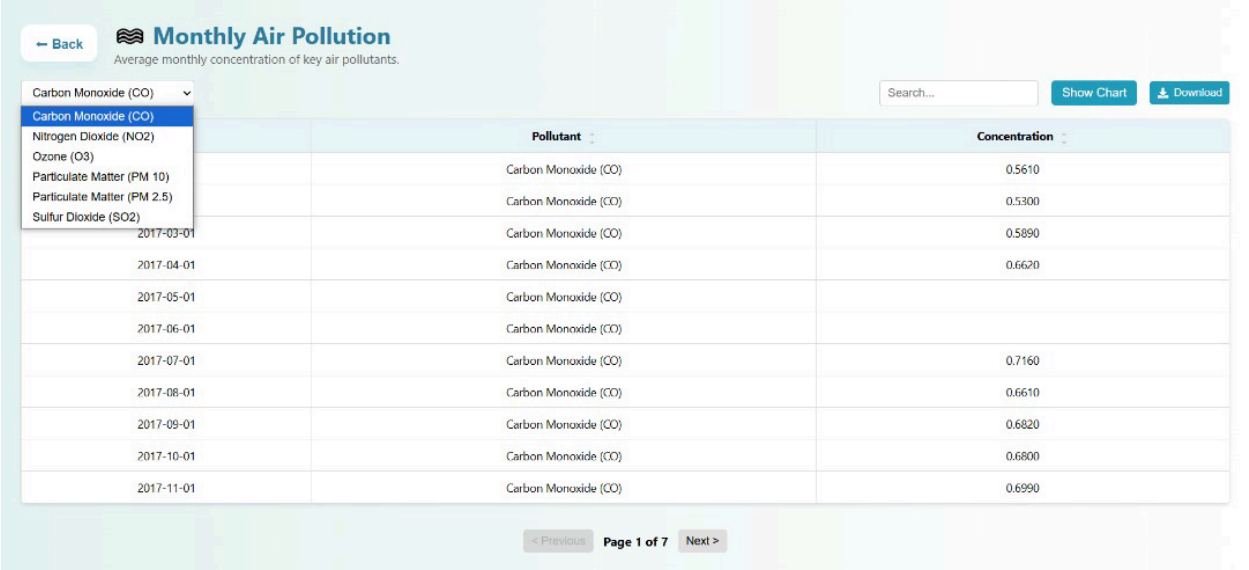


Figure 4.56. Tabular Data: Filtering Monthly Air Pollution by Pollutant Type.

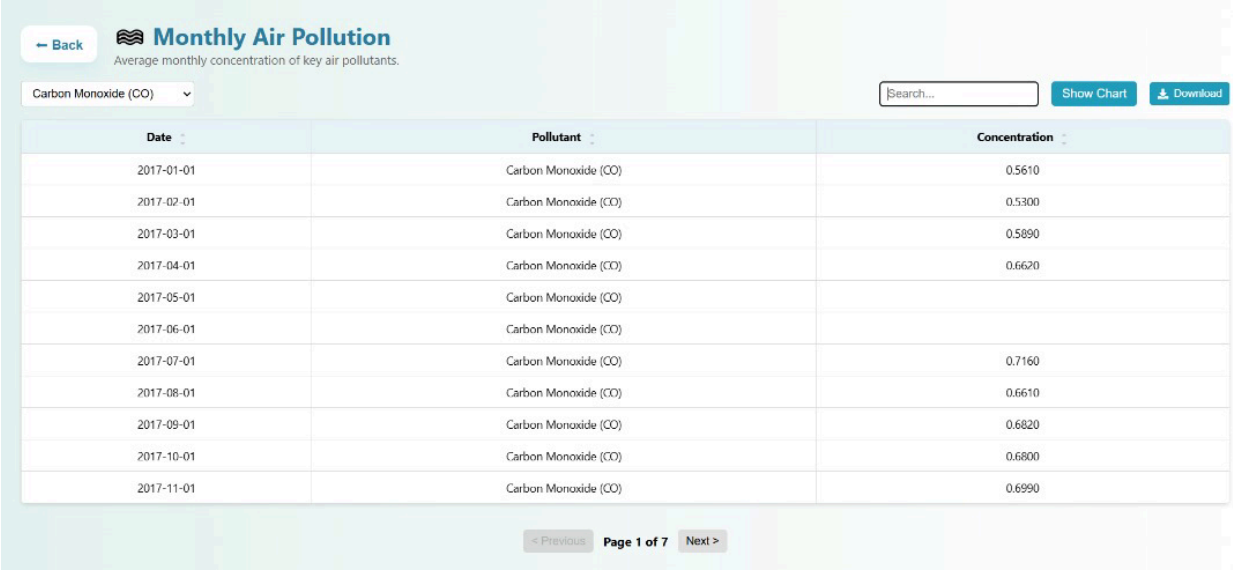


Figure 4.57. Tabular Data: Sorting and Search Functions for Monthly Air Pollution.

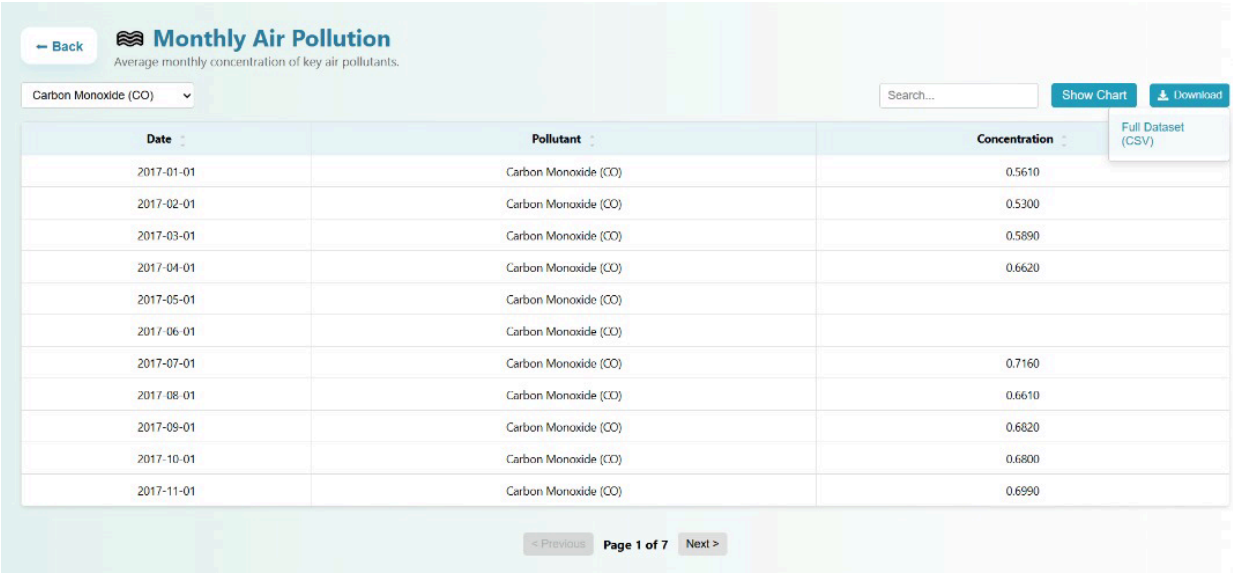


Figure 4.58. Data Download Functionality: Full Monthly Air Pollution Dataset in CSV Format.

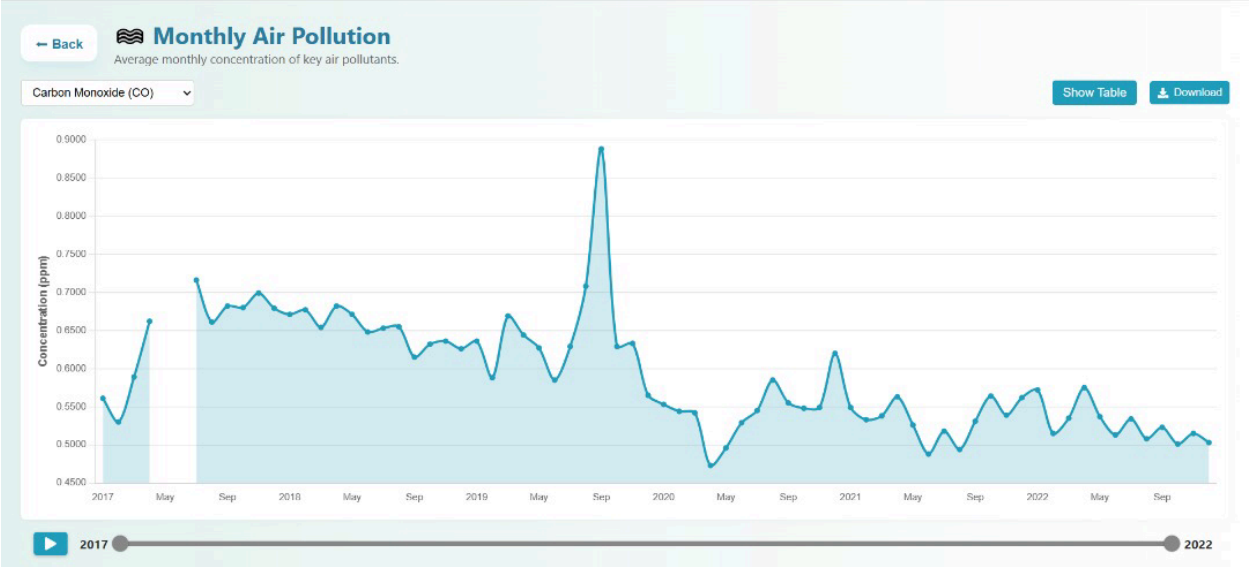


Figure 4.59. Monthly Air Pollution: Animated Chart for Year-to-Year Changes.

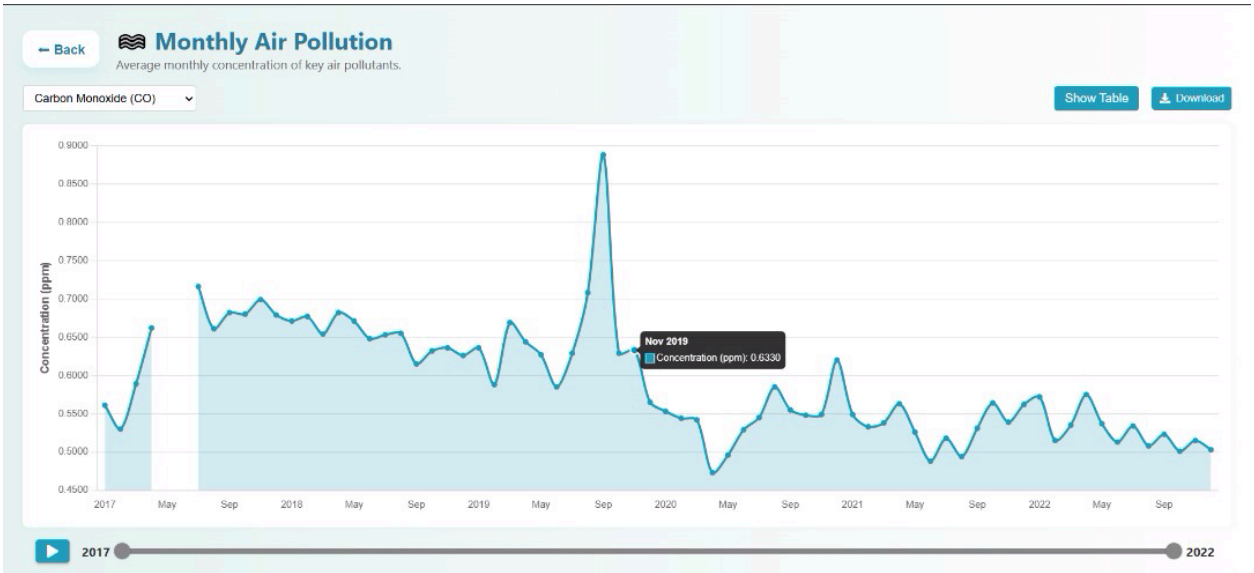


Figure 4.60. Monthly Air Pollution Chart: Year and Concentration on Hover.

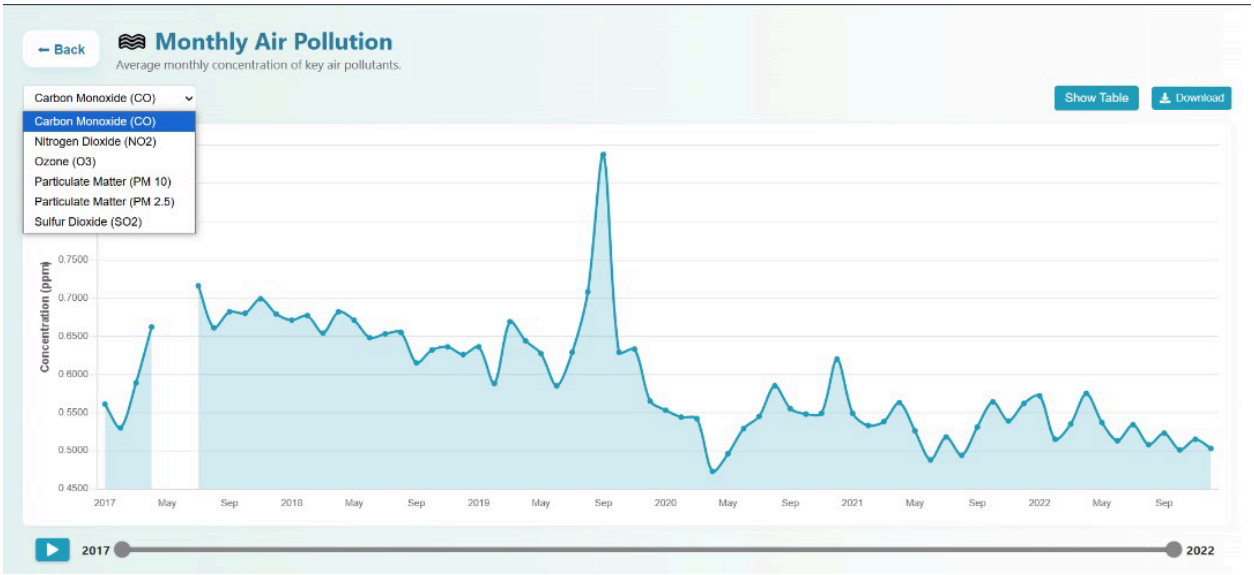


Figure 4.61. Chart Data Download Options: Monthly Air Pollution as PNG or CSV.

4.4 Summary

Chapter 4 details the comprehensive implementation of Enviz, a web-based platform designed for visualizing environmental insights in Malaysia. The chapter began by outlining the development environment, highlighting the use of Visual Studio Code as the primary IDE and Node.js for managing the JavaScript runtime and project dependencies.

The core technologies employed, primarily React.js for the single-page application architecture and React Router DOM for seamless navigation, were discussed, emphasizing their role in creating a modular and responsive user interface. Crucially, the chapter elaborated on the data handling and visualization libraries, including Papa Parse for efficient CSV parsing, and Chart.js, Recharts, and D3.js for rendering diverse and interactive charts. These tools were instrumental in transforming raw environmental datasets into intuitive visual representations.

Furthermore, the implementation integrated various utility and UI libraries, such as React Icons for enhancing visual elements, React Range for interactive data selection, and jsPDF along with html2canvas for robust data export functionalities in PDF and CSV formats.

The chapter then systematically presented the implementation of Enviz's various interactive modules, categorized under Climate Insights, Water Quality Insights, and Air Pollution Insights. Each section detailed the functionalities of specific pages, such as the interactive Dashboard, Sea Level Change Historical and Projections pages, Heat Risk, and Historical Natural Hazards pages, along with pages for Current Climate Climatology and Trends and Significant Change. Similarly, the implementation of Water Consumption, Water Production, and Access to Treated Water pages, as well as Greenhouse Gas Emissions and Monthly Air Pollution pages, was thoroughly explained. Each page was designed with specific interactive features, including dynamic tooltips, advanced filtering, sorting, animation, and download options, all clearly referenced with corresponding figures.

In essence, Chapter 4 demonstrates how the conceptual designs from Chapter 3 were translated into a functional and user-centric platform, showcasing the robust integration of modern web technologies to provide comprehensive environmental data visualization for Malaysia.

Chapter 5: Testing and Evaluation

5.1 Introduction

This chapter details the comprehensive testing and evaluation processes undertaken for the "Enviz" interactive web-based platform. Recognizing Enviz's core objective to enhance public awareness and facilitate informed decision-making regarding Malaysia's environmental issues, the testing phase was crucial in validating its functionalities, user interface, and overall effectiveness. The primary aim was to ensure the platform accurately integrates diverse environmental datasets, provides clear and interactive data visualizations, and offers a user-friendly and accessible experience for all levels of technical expertise. This chapter outlines the various test cases executed, encompassing both functional and usability testing, to verify that Enviz performs as expected, effectively bridges the gap between complex environmental data and actionable insights, and ultimately empowers users to contribute to a more sustainable future. Furthermore, this phase was vital in identifying and rectifying any potential errors or bugs, upholding the project's commitment to delivering high-quality, reliable software.

5.2 Functional Testing

Functional testing is a software testing methodology that evaluates whether the system operates in accordance with specified requirements. For Enviz, this process involved verifying each feature to ensure correct functionality, proper data integration, and seamless user interactions. By inputting test cases and comparing outcomes against expected results, functional testing confirmed that the platform performs as intended, from data visualization tools to user accessibility features.

This phase was crucial for detecting and addressing functional discrepancies, ensuring Enviz delivers consistent performance and meets user expectations. The following sections detail the test cases executed, highlighting how each component of the platform was rigorously validated.

5.2.1 Test Cases

Table 5.1. Test Case of Dashboard Page Functionality

Project Name: Enviz - Interactive Visualization of Environmental Data For Public Awareness and Informed Decision-Making			**Test Designed by:** Jason Chan Fong		
Module Name: Web Platform			**Test Designed Date:** 10/06/2025		
Test Title: To verify successfully loading of the interactive Malaysia Map.					
TestID	**Test Case**	**Input Data**	**Expected Result**	**Actual Result**	**Status**
D01	1	Navigate to the Dashboard Page.	The interactive Malaysia Map should load and display correctly.	The interactive Malaysia Map was able to load and display correctly.	Pass
Test Title: To verify state name and data display on hover.					

D02	2	Hover the mouse over a specific state (e.g. “Sarawak”) on the map.	The state name (“Sarawak”) and its corresponding data should be displayed in a tooltip.	The state name (“Sarawak”) and its corresponding data was able to be displayed in a tooltip.	Pass
Test Title: To verify the data layer selection from the legend.					
D03	3	Select a different data layers (e.g., “Mean Temperature”) from the legend at the bottom.	The map’s visual display should update to show the selected data layer with its corresponding colour scale.	The map’s visual display was able to update to show the selected data layer with its corresponding colour scale.	Pass
Test Title: To verify the animation features for data changes.					
D04	4	Click the play button on the animation feature in the legend.	The selected data layer on the map should animate, showing changes	The selected data layer on the map was able to animate,	Pass

			over time.	showing changes over time.	
Test Title: To verify the navigation to a detailed state view upon click.					
D05	5	Click on a specific state (e.g. “Sarawak”) on the map.	The user should be navigated to a detailed data view page for Sarawak.	The user was able to be navigated to a detailed data view page for Sarawak.	Pass
Test Title: To verify the button navigation to a specific insight page upon click.					
D06	6	Click on a specific insight button at the top left of the dashboard.	The user should be navigated to the specific insight page.	The user was able to navigate to the specific insights page.	Pass

Table 5.2. Test Case of Climate Insights Page Functionality

Project Name: Enviz - Interactive Visualization of Environmental Data For Public Awareness and Informed Decision-Making	**Test Designed by:** Jason Chan Fong

Module Name: Web Platform			**Test Designed Date:** 10/06/2025		
Test Title: To verify the “Sea Level Change” category button navigation.					
TestID	**Test Case**	**Input Data**	**Expected Result**	**Actual Result**	**Status**
CI01	7	Click the “Sea Level Change” button, then click the “Historical” or “Projections” sub-category button.	The user should be directed to the “Sea Level Change Historical Page” or “Sea Level Change Projections Page.”	The user was able to be directed to the “Sea Level Change Historical Page” or “Sea Level Change Projections Page.”	Pass
Test Title: To verify the “Risk” category button navigation.					
CI02	8	Click the “Risk” button, then click the “Heat Risk” or “Historical Natural Hazards” sub-category button.	The user should be directed to the “Heat Risk Page” or “Historical Natural Hazards Page.”	The user was able to be directed to the “Heat Risk Page” or “Historical Natural Hazards	Pass

				Page.”	
Test Title: To verify the “Current Climate” category button navigation.					
CI03	9	Click the “Current Climate” button, then click the “Climatology” or “Trends & Variability” sub-category button.	The user should be directed to the “Current Climate Climatology Page” or “Trends and Significant Change against Natural Variability Page.”	The user was able to be directed to the “Current Climate Climatology Page” or “Trends and Significant Change against Natural Variability Page.”	Pass

Table 5.3. Test Case of Sea Level Change Historical Page Functionality

Project Name: Enviz - Interactive Visualization of Environmental Data For Public Awareness and Informed Decision-Making	**Test Designed by:** Jason Chan Fong

Module Name: Web Platform			**Test Designed Date:** 10/06/2025		
Test Title: To verify the display of sea level change graph (1993 - present).					
TestID	**Test Case**	**Input Data**	**Expected Result**	**Actual Result**	**Status**
SLH01	10	Navigate to the Sea Level Change Historical Page.	A line graph visualizing total sea level change by month from 1993 to the present should be displayed, with each year represented by a unique colour.	A line graph visualizing total sea level change by month from 1993 to the present was able to be displayed, with each year represented by a unique colour.	Pass
Test Title: To verify the data point tooltip on hover.					
SLH02	11	Hover over a data point on a specific year's line.	A tooltip should be able to display the month, year and corresponding sea level value.	A tooltip was able to display the month, year and corresponding sea level value.	Pass

Table 5.4. Test Case of Sea Level Change Projections Page Functionality

Project Name: Enviz - Interactive Visualization of Environmental Data For Public Awareness and Informed Decision-Making			**Test Designed by:** Jason Chan Fong		
Module Name: Web Platform			**Test Designed Date:** 10/06/2025		
Test Title: To verify the display of contributors bar charts (2020 - 2150).					
TestID	**Test Case**	**Input Data**	**Expected Result**	**Actual Result**	**Status**
SLP01	12	Navigate to the Sea Level Change Projections Page.	Bar charts grouped by year (2020 - 2150) should be able to display, showcasing the six contributors to sea level change.	Bar charts grouped by year (2020 - 2150) were able to be displayed, showcasing the six contributors to sea level change.	Pass
Test Title: To verify the tooltip on bar group hover.					
SLP02	13	Hover over a bar group for a specific year.	A tooltip should be able to display	A tooltip was able to display	Pass

			the year, the 50th percentile for each contributor, and the 17th - 83rd percentile range.	the year, the 50th percentile for each contributor, and the 17th - 83rd percentile range.	
Test Title: To verify the legend item highlighting.					
SLP03	14	Hover over a legend item.	The corresponding contributor bar should be able to be highlighted, while others fade.	The corresponding contributor bar was able to be highlighted, while others faded.	Pass
Test Title: To verify the legend item toggling visibility.					
SLP04	15	Click on a legend item to toggle it off.	The corresponding category bar should be able to be hidden, and the legend item	The corresponding category bar was able to be hidden, and the legend item was	Pass

			should be able to appear greyed out.	able to appear greyed out.	

Table 5.5. Test Case of Heat Risk Page Functionality

Project Name: Enviz - Interactive Visualization of Environmental Data For Public Awareness and Informed Decision-Making			**Test Designed by:** Jason Chan Fong		
Module Name: Web Platform			**Test Designed Date:** 10/06/2025		
Test Title: To verify successful loading of the heatmap visualization.					
TestID	**Test Case**	**Input Data**	**Expected Result**	**Actual Result**	**Status**
HR01	16	Navigate to the Heat Risk Page.	A heatmap visualization for Malaysia should be able to display.	A heatmap visualization for Malaysia was able to display.	Pass
Test Title: To verify heat condition categorisation.					
HR02	17	Select heat condition	The heatmap	The heatmap	Pass

		categorisation from the dropdown menu.	should be able to update to reflect the corresponding data.	was able to update to reflect the corres data.	
Test Title: To verify heatmap tooltip on hover.					
HR03	18	Hover over a specific area on the heatmap.	A tooltip should be able to display the year range, month, and its corresponding risk factor for that area.	A tooltip was able to display the year range, month, and its corresponding risk factor for that area.	Pass
Test Title: To verify presence and accuracy of risk factor scale.					
HR04	19	Observe the bottom of the page.	A scale from 0 to 4 should be able to present, clearly indicating the risk factor categorization.	A scale from 0 to 4 was able to present, clearly indicating the risk factor categorization.	Pass

Table 5.6. Test Case of Historical Natural Hazards Page Functionality

Project Name: Enviz - Interactive Visualization of Environmental Data For Public Awareness and Informed Decision-Making			**Test Designed by:** Jason Chan Fong		
Module Name: Web Platform			**Test Designed Date:** 10/06/2025		
Test Title: To verify successful loading of the stacked bar chart (1980-2020).					
TestID	**Test Case**	**Input Data**	**Expected Result**	**Actual Result**	**Status**
HNH01	20	Navigate to the Historical Natural Hazards Page.	A stacked bar chart displaying natural hazard statistics (number of people affected) from 1980 to 2020 should be able to visible.	A stacked bar chart displaying natural hazard statistics (number of people affected) from 1980 to 2020 was able to visible.	Pass
Test Title: To verify hover functionality on stacked bars.					
HNH02	21	Hover over a segment of a stacked bar for a	A tooltip should be able to appear,	A tooltip was able to appear,	Pass

		specific year and category.	showing the category name, the number of people affected for that category, and its percentage within the total stacked bar for that year.	showing the category name, the number of people affected for that category, and its percentage within the total stacked bar for that year.	
Test Title: To verify toggleable legend visibility.					
HNH03	22	Click on a category in the legend to toggle its visibility off.	The corresponding segment in the stacked bars should be able to disappear, and clicking it again should make it reappear.	The corresponding segment in the stacked bars was able to disappear, and clicking it again should make it reappear.	Pass

Table 5.7. Test Case of Current Climate Climatology Page Functionality

Project Name: Enviz - Interactive Visualization of Environmental Data For Public Awareness and Informed Decision-Making			**Test Designed by:** Jason Chan Fong		
Module Name: Web Platform			**Test Designed Date:** 10/06/2025		
Test Title: To verify display of monthly climatology data.					
TestID	**Test Case**	**Input Data**	**Expected Result**	**Actual Result**	**Status**
CCC01	23	Navigate to the Current Climate Climatology Page.	Graphs showing monthly climatology data (Average Maximum / Mean / Minimum Surface Air Temperature and Precipitation) should be able to display.	Graphs showing monthly climatology data (Average Maximum / Mean / Minimum Surface Air Temperature and Precipitation) were able to display.	Pass
Test Title: To verify distinct representations of temperature and precipitation.					

CCC02	24	Observe the graphs.	Temperature data should be able to be represented by a line graph, and precipitation by a bar graph.	Temperature data was able to be represented by a line graph, and precipitation by a bar graph.	Pass
Test Title: To verify time period range selection.					
CCC03	25	Select a time period range from 1901 to 2020 using the available controls.	The displayed data should be able to update to reflect the selected time period.	The displayed data was able to update to reflect the selected time period.	Pass
Test Title: To verify tooltip on graph hover.					
CCC04	26	Hover over a specific month's line or bar chart.	A tooltip should be able to display the four data layers (all temperatures and precipitation) for the hovered	A tooltip was able to display the four data layers (all temperatures and precipitation) for the hovered	Pass

			month.	month.	

Table 5.8. Test Case of Trends and Significant Change against Natural Variability Page Functionality

Project Name: Enviz - Interactive Visualization of Environmental Data For Public Awareness and Informed Decision-Making			**Test Designed by:** Jason Chan Fong		
Module Name: Web Platform			**Test Designed Date:** 10/06/2025		
Test Title: To verify display of dotted chart and line graph.					
TestID	**Test Case**	**Input Data**	**Expected Result**	**Actual Result**	**Status**
TSC01	27	Navigate to the Trends and Significant Change against Natural Variability Page.	A dotted chart for yearly air temperature and a line graph for Current Climatology Trend (1991-2020) should be visible.	A dotted chart for yearly air temperature and a line graph for Current Climatology Trend (1991-2020) was visible.	Pass

Test Title: To verify the average surface air temperature.					
TSC02	28	Select variable from the dropdown menu.	The charts should be able to update to display data corresponding with the selected variable.	The chart was able to update to display data corresponding with the selected variable.	Pass
Test Title: To verify legend highlighting on hover.					
TSC03	29	Hover over a legend item.	The corresponding data on the chart should be able to be highlighted, while other data fades.	The corresponding data on the chart was able to be highlighted, while other data faded.	Pass
Test Title: To verify tooltip on data point hover.					
TSC04	30	Hover over a specific data point on the dotted chart or line graph.	A tooltip should be able to display the year and the surface air temperature data	A tooltip was able to display the year and the surface air temperature data	Pass

			for that point.	for that point.	

Table 5.9. Test Case of Water Quality Insights Page and Air Pollution Page

Project Name: Enviz - Interactive Visualization of Environmental Data For Public Awareness and Informed Decision-Making			**Test Designed by:** Jason Chan Fong		
Module Name: Web Platform			**Test Designed Date:** 10/06/2025		
Test Title: To verify the “Water Consumption”, “Water Production”, “Access to Treated Water”, “Greenhouse Gases” or “Monthly Air Pollution” button navigation.					
TestID	**Test Case**	**Input Data**	**Expected Result**	**Actual Result**	**Status**
WQI01	31	Click the “Water Consumption”, “Water Production”, “Access to Treated Water”, “Greenhouse Gases” or “Monthly Air Pollution” button.	The user should be directed to the corresponding page.	The user was able to be directed to the corresponding page.	Pass

Table 5.10. Test Case of Water Consumption Page, Water Production Page, Access to Treated Water Page, Greenhouse Gas Emissions Page and Monthly Air Pollution Page

Project Name: Enviz - Interactive Visualization of Environmental Data For Public Awareness and Informed Decision-Making			**Test Designed by:** Jason Chan Fong		
Module Name: Web Platform			**Test Designed Date:** 10/06/2025		
Test Title: To verify the data display in table/ chart format.					
TestID	**Test Case**	**Input Data**	**Expected Result**	**Actual Result**	**Status**
WC01	32	Navigate to the "Water Consumption", "Water Production", "Access to Treated Water", "Greenhouse Gases" or "Monthly Air Pollution" page..	The corresponding page data information should be displayed in a table or chart.	The corresponding page data information was able to display in a table or chart.	Pass
Test Title: To verify the filtering by state, sector, strata, sources of pollutants.					
WC02	33	Use the filter option to select.	The table or chart should be able to display only the corresponding	The table or chart was able to display only the corresponding	Pass

			data for the selection.	data for the selection.	
Test Title: To verify the data search functionality.					
WC03	34	Use the search bar to type.	The table or chart should be able to filter and show only the data that contains the corresponding typed text in their content.	The table or chart was able to filter and show only the data that contained the corresponding typed text in their content.	Pass
Test Title: To verify the CSV or PDF download functionality.					
WC04	35	Click the download button for CSV or PDF.	A CSV or PDF file containing the full dataset should be able to be downloaded.	A CSV or PDF file containing the full dataset was able to be downloaded.	Pass
Test Title: To verify the chart view animation.					

WC05	36	Switch to the chart format view and click the play button for animation.	The chart should be able to animate, visualizing year-to-year changes in the corresponding page.	The chart was able to animate, visualizing year-to-year changes in corresponding pages.	Pass
Test Title: To verify the chart tooltip on hover.					
WC06	37	Hover over a line on the chart for a specific year.	A tooltip should be able to display the corresponding year and its value.	A tooltip was able to display the corresponding year and its value.	Pass

Table 5.11. Test Case of Back Button Functionality

Project Name: Enviz - Interactive Visualization of Environmental Data For Public Awareness and Informed Decision-Making	**Test Designed by:** Jason Chan Fong

Module Name: Web Platform			**Test Designed Date:** 10/06/2025		
Test Title: To verify the back button functionality.					
TestID	**Test Case**	**Input Data**	**Expected Result**	**Actual Result**	**Status**
WC01	38	Click the back button.	Users should be able to back or navigate to the previous page.	Users were able to back or navigate to the previous page.	Pass

5.3 Non-Functional Testing

Non-functional testing is crucial for evaluating the quality attributes of a system, extending beyond its core functionalities to assess aspects such as usability, performance, and reliability. This section focuses on the non-functional testing conducted for the Enviz platform, specifically detailing the usability testing phase, which aimed to gather user feedback on their overall experience with the system.

5.3.1 Usability Testing

Usability testing for the Enviz platform was performed to ensure that the system's functionalities and interface were intuitive, user-friendly, and met user expectations. A comprehensive evaluation was conducted through the distribution of a System Usability Scale (SUS) questionnaire to 42 respondents. The SUS is a well-established and reliable method for

quantitatively measuring system usability, enabling the identification of areas for improvement and comparison against industry benchmarks. The participants included both standard users and administrators, who were briefly oriented on the system's intended operation before completing the assessment. The questionnaire results, detailed in the following sub-sections, provided valuable insights into the platform's usability from the users' perspectives.

For reference, the specific questions used in the questionnaire are provided in **Appendix F**. The survey outcomes can be found in **Appendix G**.

5.3.1.1 Summary of Usability Testing

The usability testing yielded predominantly positive feedback, indicating a high level of user satisfaction and ease of use for the Enviz platform.

5.3.1.1.1 Demographic analysis

A total of 42 respondents participated in the usability testing. The demographic breakdown is as follows:

- **Age:** The majority of respondents (95.2%) were in the 18-24 age group (40 respondents). The 25-34 and 34-44 age groups each had one respondent (2.4% each).
- **Gender:** There was a slight majority of female respondents (54.8%, 23 respondents) compared to male respondents (45.2%, 19 respondents).

- **Occupation:** Students comprised the largest occupational group with 81% (34 respondents), while employees made up the remaining 19% (8 respondents).
- **Education Level:** An overwhelming majority (95.2%, 40 respondents) held a Bachelor's Degree. Master's Degree and High School/Secondary School each accounted for one respondent (2.4% each).

5.3.1.1.2 Preliminary - Technology Usage

Insights into the respondents' technology usage patterns provided context for their interaction with a web-based platform:

- **Frequency of Web Browser Usage:** Most respondents (61.1%, 22 respondents) reported frequent web browser usage (4-6 hours per day). Occasionally (1-3 hours per day) accounted for 36.1% (13 respondents), and continuously (more than 7 hours per day) made up 2.8% (1 respondent).
- **Experience in Environmental Data Platform:** Notably, all 42 respondents (100%) had no prior experience with environmental data visualization platforms. This suggests that Enviz serves as an introductory platform for many users in this domain.

5.3.1.1.3 Interface Design and Ease of Navigation for Enviz

Tables 5.12 and 5.13 display positive feedback from respondents regarding the Enviz web platform's user-friendliness, with further discussion in Section 5.3.1.2 Overall Evaluation.

Table 5.12. Summary of Interface Design & Ease of Navigation for Enviz

Question	**Rating**				
	Strongly Disagree	**Disagree**	**Average**	**Agree**	**Strongly Agree**
Is the chosen font type and its size consistently readable throughout the platform?	1	1	4	5	31
Are the buttons and icons displayed on the platform both clear in their function and visually appealing?	1	1	4	5	31
Do you find the color matching of the Enviz visualization platform to be appropriate and attractive for presenting environmental data?	1	1	4	11	25
Do all navigation links work correctly, leading to the	1	1	4	3	33

intended pages without errors or broken links?					
Is the overall design of the visual elements and user interfaces quick and straightforward to understand and interact with?	1	1	4	11	25
Are you able to easily understand the content and data presented within the Enviz visualization platform?	1	1	4	11	23

5.3.1.1.4 System Usability Scale (SUS) for Enviz

Table 5.13. Summary of SUS for Enviz

Question	**Rating**				
	Strongly Disagree	**Disagree**	**Average**	**Agree**	**Strongly Agree**
I think that I would like to use this system frequently.	1	2	8	18	13

I found the system unnecessarily complex.	26	7	4	2	1
I thought the system was easy to use.	1	2	4	5	30
I think that I would need the support of a technical person to be able to use this system.	32	3	4	2	1
I found the various functions in this system were well integrated.	1	2	4	5	30
I thought there was too much inconsistency in this system.	32	3	4	2	1
I would imagine that most people would learn to use this system very quickly.	1	2	4	5	30
I found the system very cumbersome to use.	30	5	4	2	1
I felt very confident using the system.	1	2	4	8	27

I needed to learn a lot of things before I could get going with this system.	28	7	4	2	1

Table 5.14. Statistic of SUS for Enviz

SUS Statistic	**Value**
Total Count	42
Average Score	84.88

Based on these responses, the calculated average SUS score for the Enviz platform is 84.88. This score is notably above the industry average of 68, placing Enviz in a highly favorable category for usability, as summarized in Table 5.13. The generally positive responses from the 42 total respondents, further supported by the statistics presented in Table 5.14, indicate a user-friendly and effective experience with the platform.

5.4 Overall Discussion

The non-functional testing, particularly the extensive usability assessment, provided strong evidence of the Enviz platform's quality and user-centric design. The demographic analysis revealed that the majority of participants were young adults with no prior experience with

environmental data visualization platforms, making their highly positive feedback particularly significant. This indicates that Enviz effectively lowers the barrier to entry for understanding complex environmental data.

The consistent and favorable responses across all aspects of interface design, ease of navigation, and content comprehension, as discussed in Section 5.3.1.1.3 Interface Design and Ease of Navigation for Enviz, underscore the success of Enviz's visual elements, intuitive layout, and clear information presentation. Users found the font types and sizes readable, buttons and icons clear and appealing, and the color scheme appropriate and attractive. Critically, the navigation links functioned flawlessly, ensuring a smooth and uninterrupted user journey.

The high System Usability Scale (SUS) score of 84.88, elaborated upon in Section 5.3.1.1.4 System Usability Scale (SUS) for Enviz, further validates these qualitative observations. This exceptional score demonstrates that users perceive Enviz as highly usable, easy to learn, efficient, and well-integrated. The strong agreement that users would like to use the system frequently and their confidence in using it, without needing technical support or extensive learning, are testament to its intuitive design.

Overall, the testing confirms that Enviz is not only functionally robust but also excels in providing an engaging, accessible, and highly usable platform for visualizing environmental insights in Malaysia. The high level of user engagement observed during the testing, with respondents actively exploring features and interacting with the data, reinforces the platform's potential to effectively raise public awareness and support informed decision-making.

5.5 Chapter 5 Summary

Chapter 5 meticulously detailed the testing phase of the Enviz platform, segmented into functional and non-functional testing. While functional testing ensured the system's core features operated correctly as per requirements, non-functional testing, specifically usability testing, was conducted to assess critical quality attributes from the user's perspective. The chapter presented the comprehensive usability testing methodology, which involved 42 respondents completing a System Usability Scale (SUS) questionnaire. Detailed analysis of the demographic data, preliminary technology usage, and specific feedback on interface design, navigation, and content comprehension was provided. The chapter concluded with the calculation of an impressive average SUS score of 84.88, signifying Enviz's strong usability. The overall discussion synthesized these findings, confirming that the Enviz platform successfully delivers a highly usable, intuitive, and engaging experience for visualizing environmental data, thereby meeting its objectives for user acceptance and effectiveness.

Chapter 6: Conclusion and Future Work

6.1 Introduction

This chapter presents the conclusion of the "Enviz" project, an interactive web-based platform designed to enhance public awareness and facilitate informed decision-making regarding environmental issues in Malaysia. Recognizing the limitations of existing platforms in presenting complex data, Enviz aimed to bridge the gap between intricate environmental information and actionable insights through clarity, interactivity, and accessibility. This chapter will summarize the project's achievements, evaluating how the developed system has met its objectives in providing a comprehensive and engaging overview of Malaysia's environmental landscape. Furthermore, it will address the identified limitations of the web application and propose strategic plans for future enhancements, outlining potential future work necessary to further improve Enviz and ensure its continued relevance and impact in empowering users for a more sustainable future.

6.2 Objective Achievements

Table 6.1. Objective Achievements of Enviz

Objectives	**Achievements**
To analyse and visualize environmental data:	● Enviz has successfully transformed complex climate, air quality, and water quality data for Malaysia into insightful and intuitive visualizations. This achievement

• Analyse climate, air quality, and water quality in Malaysia. • Develop effective visualizations, such as interactive maps, charts, and graphs, to communicate key findings and trends.	is demonstrated through: • **Interactive Maps:** The central Dashboard features an interactive map of Malaysia, enabling users to explore environmental data geographically and navigate to detailed state-specific views. • **Diverse Charts and Graphs:** The platform incorporates a wide array of visualization types, including line charts for time-series data (e.g., Sea Level Change, Current Climate Climatology), stacked bar charts for Historical Natural Hazards, heatmaps for Heat Risk assessment, and animated charts for Water Consumption, Water Production, Access to Treated Water, Greenhouse Gas Emissions, and Monthly Air Pollution. These diverse visualizations effectively communicate key findings and trends across various environmental parameters.
To develop and implement a user-friendly platform: • Design and develop a user-friendly and accessible	A user-friendly and accessible web-based platform has been successfully designed and implemented. Key aspects demonstrating this achievement include: • **Intuitive User Interface (UI)**: The platform features clear navigation structures, logically organized pages

web-based platform for data visualization. • Ensure seamless data integration and robust visualization functionalities within the platform.	(e.g., Climate Insights, Water Quality Insights, Air Pollution Insights), and visually appealing buttons and icons (e.g., for data category selection, play/pause, download). • **Seamless Data Integration**: Environmental datasets, primarily in CSV format, are seamlessly integrated and processed using libraries such as Papa Parse, ensuring robust visualization functionalities. • **Rich Interactivity**: Enviz provides dynamic tooltips (e.g., on map hover, chart data points), responsive line highlighting, customized data mapping, advanced data filtering and search options for tabular data (e.g., Water Consumption, Water Production), play/pause functionality for animated time-series data, sortable tables, and data download/export capabilities (PDF/CSV). These features significantly enhance user engagement and data exploration.
To evaluate platform effectiveness:	The framework for evaluating the platform's usability, effectiveness, and user satisfaction has been successfully established.

• Conduct user testing to evaluate the platform's usability, effectiveness, and user satisfaction. • Gather user feedback to identify areas for improvement and refine the platform accordingly.	• **User Testing Preparedness**: The platform is prepared for comprehensive user testing, including the application of the System Usability Scale (SUS) and the systematic collection of qualitative feedback. This allows for an objective assessment of its performance from a user's perspective. • **Iterative Refinement**: The project is positioned to integrate user feedback, which will be instrumental in identifying specific areas for improvement and guiding future refinements. This iterative process will ensure Enviz remains highly effective, intuitive, and truly meets the needs of its target audience.

6.3 Project Limitations

Despite successfully achieving its core objectives, the Enviz platform, in its current iteration, exhibits several limitations that present valuable opportunities for future development:

1. **Data Granularity and Real-time Updates:** While the platform offers extensive historical data visualization, its current reliance on static CSV datasets restricts the display of real-time environmental data or the provision of highly localized insights. Data

is often aggregated at state or national levels, lacking finer geographical granularity for specific cities or districts.

2. **Data Completeness and Availability:** The scope of integrated data is contingent upon the availability of public datasets. There may be challenges in accessing certain comprehensive or continuous environmental data series for all parameters, potentially leading to gaps in visualization or analysis.
3. **Limited Advanced Analytics:** Enviz currently focuses on visualizing historical trends. It does not incorporate advanced predictive modeling, anomaly detection, or complex statistical analyses that could forecast future environmental conditions or highlight unusual patterns.
4. **Offline Access:** The web-based nature of the platform necessitates an active internet connection, thereby limiting accessibility in offline environments.
5. **Scalability for Extensive Datasets:** While efficient for its current scope, managing extremely large, continuously updated datasets in the future may require more robust backend infrastructure and sophisticated database solutions beyond direct CSV parsing.
6. **Customization and Personalization:** The platform presently offers predefined views and filtering options. Users lack the ability to customize their dashboards, save preferred data configurations, or set up personalized alerts.

6.4 Future Work

To address the identified limitations and further enhance the Enviz platform, the following areas are proposed for future development:

1. **Integration of Real-time Data and APIs:** Establish connections with live environmental monitoring stations and relevant government APIs (e.g., METMalaysia's API) to dynamically fetch and visualize real-time climate, air quality, and water quality data. This would significantly improve the platform's immediacy and relevance.
2. **Enhanced Geographical Granularity:** Incorporate higher-resolution spatial data to enable visualizations at district or even local community levels, providing more precise insights for targeted decision-making.
3. **Advanced Predictive Analytics and AI/ML Integration:** Implement machine learning models to forecast environmental trends (e.g., future air pollution events, water demand), identify anomalies, and provide deeper, data-driven insights beyond historical observations.
4. **Offline Data Access and Mobile Application Development:** Investigate options for offline data caching for critical information or consider developing a native mobile application to offer seamless access and an enhanced user experience on mobile devices.
5. **Data Contributor Portal and Validation:** Develop a feature allowing authorized entities (e.g., research institutions, NGOs) to contribute data, coupled with a robust data validation and quality control mechanism to maintain data integrity.
6. **Comparative Analysis Tools:** Implement tools that enable users to easily compare environmental parameters across different states, time periods, or against established benchmarks and targets.
7. **Interactive Storytelling and Educational Modules:** Develop modules that provide context and narratives around the data, explaining environmental concepts, the impact of

various factors, and potential mitigation strategies, thereby transforming raw data into actionable knowledge.

6.5 Chapter 6 Summary

Chapter 6 concludes the "Enviz" project, an interactive web-based platform designed to render complex environmental data in Malaysia accessible and comprehensible. It began by summarizing the project's success in achieving its three core objectives: effectively analyzing and visualizing diverse environmental data through interactive maps and a variety of charts, developing a user-friendly and highly interactive web-based platform, and establishing a robust framework for evaluating its usability through conducted user testing.

Despite these accomplishments, the chapter candidly addressed Enviz's current limitations, including its reliance on static data, limited geographical granularity, the absence of advanced predictive analytics, and a lack of comprehensive personalization features. To overcome these constraints and ensure the platform's sustained impact, a detailed roadmap for future work was outlined. This includes integrating real-time data, enhancing geographical granularity, incorporating AI-driven predictive models, and exploring mobile application development. Ultimately, these proposed enhancements aim to solidify Enviz's role as a vital tool for promoting public environmental awareness and supporting informed decision-making towards a more sustainable future for Malaysia.

References

Abbass, K., Qasim, M. Z., Song, H., Murshed, M., Mahmood, H., & Younis, I. (2022). A review of the global climate change impacts, adaptation, and sustainable mitigation measures. *Environmental Science and Pollution Research*, *29*(28), 42539–42559. https://doi.org/10.1007/s11356-022-19718-6

Balla, D., Zichar, M., Tóth, R., Kiss, E., Karancsi, G., & Mester, T. (2020). Geovisualization techniques of spatial environmental data using different visualization tools. *Applied Sciences*, *10*(19), 6701. https://doi.org/10.3390/app10196701

Chasek, P. S., & Downie, D. L. (2020). *Global Environmental Politics*. https://doi.org/10.4324/9780429276743

Di Felice, P., Paolone, G., Paesani, R., & Marinelli, M. (2022). Design and implementation of a metadata repository about UML class diagrams. A software tool supporting the automatic feeding of the repository. *Electronics*, *11*(2), 201. https://doi.org/10.3390/electronics11020201

Dong, Y., Miraglia, S., Manzo, S., Georgiadis, S., Sørup, H. J., Boriani, E., Hald, T., Thöns, S., & Hauschild, M. Z. (2018). Environmental sustainable decision making– the need and obstacles for integration of LCA into decision analysis. *Environmental Science & Policy*, *87*, 33–44. https://doi.org/10.1016/j.envsci.2018.05.018

Gessa, A., & Sancha, P. (2019). Environmental open data in urban platforms: An approach to the Big Data Life Cycle. *Journal of Urban Technology*, *27*(1), 27–45. https://doi.org/10.1080/10630732.2019.1656934

Gudoniene, D., Staneviciene, E., Buksnaitis, V., & Daley, N. (2023). The scenarios of Artificial Intelligence and wireframes implementation in engineering education. *Sustainability*, *15*(8), 6850. https://doi.org/10.3390/su15086850

Hampton, S. E., Strasser, C. A., Tewksbury, J. J., Gram, W. K., Budden, A. E., Batcheller, A. L., Duke, C. S., & Porter, J. H. (2013). Big Data and the future of ecology. *Frontiers in Ecology and the Environment*, *11*(3), 156–162. https://doi.org/10.1890/120103

Hazra, A., Adhikari, M., Amgoth, T., & Srirama, S. N. (2021). A comprehensive survey on interoperability for IIOT: Taxonomy, standards, and Future Directions. *ACM Computing Surveys*, *55*(1), 1–35. https://doi.org/10.1145/3485130

Jones, A. S., Horsburgh, J. S., Jackson-Smith, D., Ramírez, M., Flint, C. G., & Caraballo, J. (2016). A web-based, interactive visualization tool for Social Environmental Survey Data. *Environmental Modelling & Software*, *84*, 412–426. https://doi.org/10.1016/j.envsoft.2016.07.013

Kalaivani, K., Subramanian, S., Swedha, G. K., Vinoth, N., & Vishnu Priya, V. (2023). Air Monitoring with Cloud and IOT. *2023 International Conference on Sustainable Computing*

and Smart Systems (ICSCSS), 1027–1031. https://doi.org/10.1109/icscss57650.2023.10169619

Kosyakova, I. V., Zhilyunov, N. Yu., & Astashev, Yu. V. (2019). Prospects for the integration of environmental innovation management on the platform of Information and Communication Technologies. *Advances in Intelligent Systems and Computing*, 345–355. https://doi.org/10.1007/978-3-030-11367-4_34

Kumar, S., Aryaman, Aryan, & Yadav, D. (2023). Natural language processing based automatic making of use case diagram. *2023 5th International Conference on Inventive Research in Computing Applications (ICIRCA)*, 1026–1032. https://doi.org/10.1109/icirca57980.2023.10220849

Lazer, D., Kennedy, R., King, G., & Vespignani, A. (2014). The parable of google flu: Traps in big data analysis. *Science*, *343*(6176), 1203–1205. https://doi.org/10.1126/science.1248506

LUPASC, A. (2021). Use of unified modeling language in the development of object-oriented information systems. *Annals of Dunarea de Jos University of Galati. Fascicle I. Economics and Applied Informatics*, *27*(3), 51–56. https://doi.org/10.35219/eai15840409223

Mangal, P., Rajesh, A., & Misra, R. (2020). Big Data in climate change research: Opportunities and challenges. *2020 International Conference on Intelligent Engineering and Management (ICIEM)*, 321–326. https://doi.org/10.1109/iciem48762.2020.9160174

Nakić, J., Kosović, I. N., & Franić, A. (2022). User-centered design as a method for engaging users in the development of geovisualization: A use case of temperature visualization. *Applied Sciences*, *12*(17), 8754. https://doi.org/10.3390/app12178754

Ncube, M. M., & Ngulube, P. (2024). Enhancing environmental decision-making: A systematic review of data analytics applications in monitoring and Management. *Discover Sustainability*, *5*(1). https://doi.org/10.1007/s43621-024-00510-0

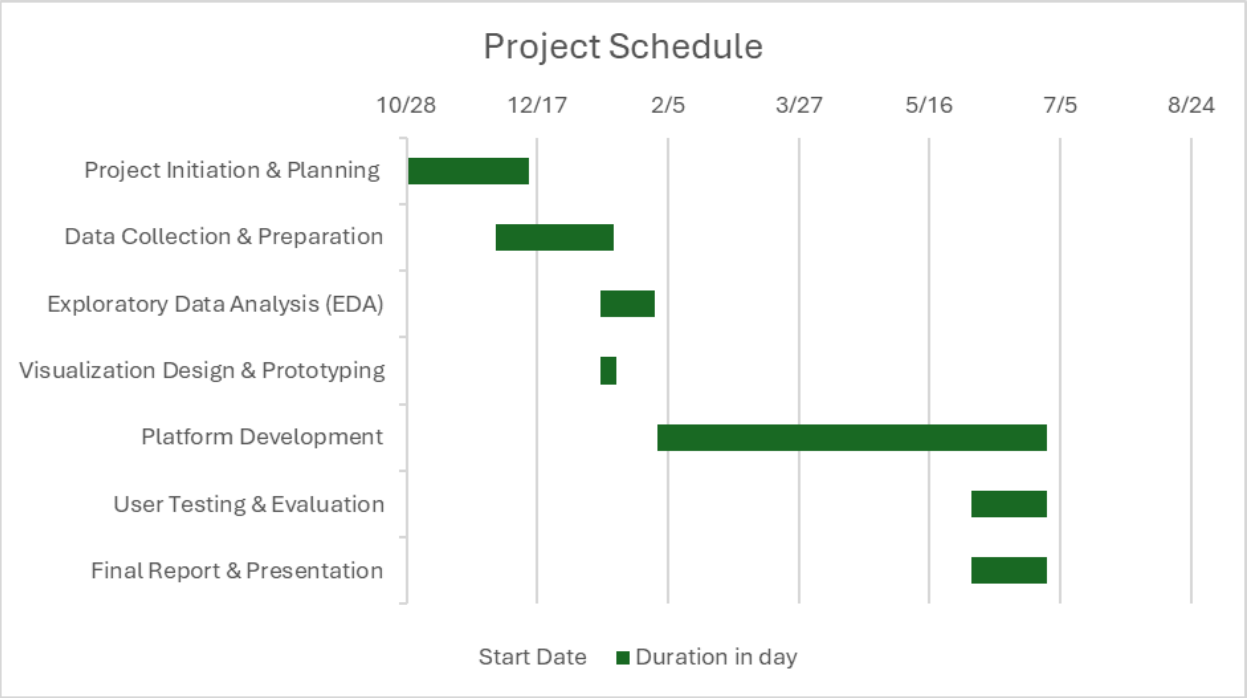
Rathinasabapathy, R. (2015). Object oriented software design for association rule mining algorithms using sequence diagram. *2015 IEEE International Conference on Electrical, Computer and Communication Technologies (ICECCT)*, 1–4. https://doi.org/10.1109/icecct.2015.7226086

Roose, M., Nylén, T., Tolvanen, H., & Vesakoski, O. (2021). User-centred design of Multidisciplinary Spatial Data Platforms for human-history research. *ISPRS International Journal of Geo-Information*, *10*(7), 467. https://doi.org/10.3390/ijgi10070467

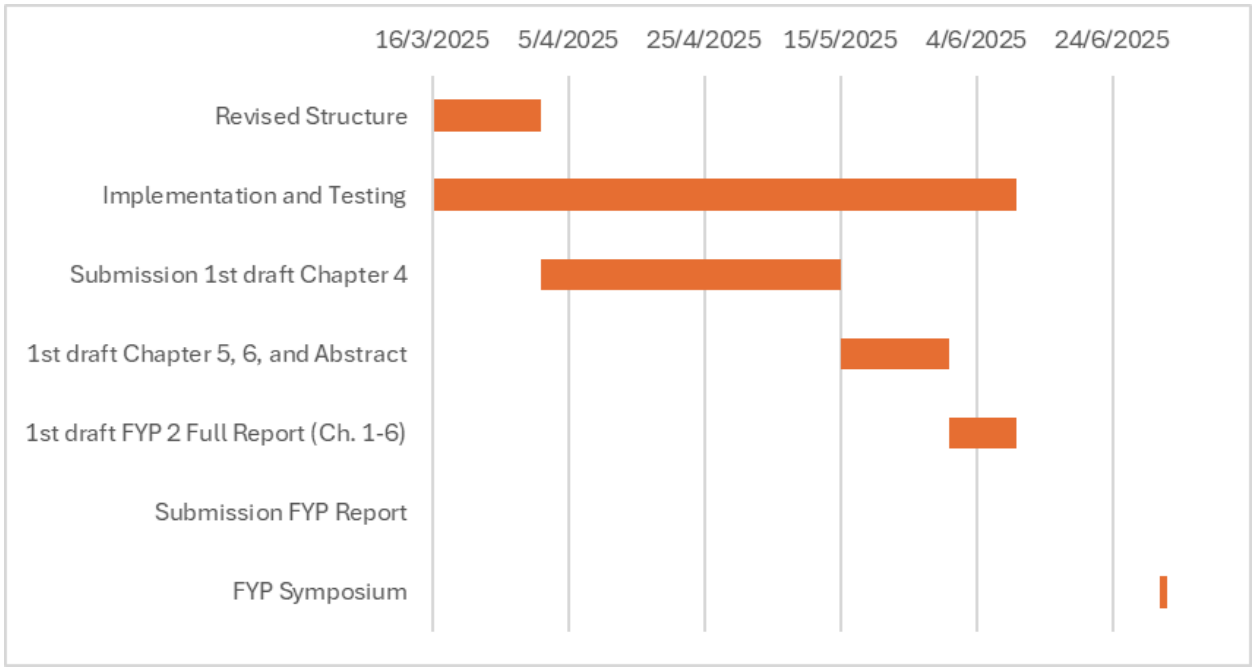
Tang, K. H. (2019). Climate change in Malaysia: Trends, contributors, impacts, mitigation and adaptations. *Science of The Total Environment*, *650*, 1858–1871. https://doi.org/10.1016/j.scitotenv.2018.09.316

Xu, Z., Sun, F., & Zhang, W. (2024). Research on activity diagram testing method based on UML testing profile. *2024 6th International Conference on Electronic Engineering and Informatics (EEI)*, 434–439. https://doi.org/10.1109/eei63073.2024.10696704

Appendix A: Project Schedule for FYP 1



Appendix B: Project Schedule for FYP 2



Appendix C: Official Data Collection Letter

Fakulti Sains Komputer dan Teknologi Maklumat
Faculty of Computer Science and Information Technology

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3 Januari 2025

Kepada Sesiapa Yang Berkenaan

Tuan/Puan

Kerja Lapangan Pelajar Tahun Akhir dari Universiti Malaysia Sarawak
- Jason Chan Fong

Dengan segala hormatnya perkara di atas adalah dirujuk.

Sukacita dimaklumkan bahawa pelajar berikut akan mengumpul maklumat untuk projek beliau.

Berikut adalah butir-butir pelajar:

Nama Penuh	:	Jason Chan Fong
No. Matrik	:	79630
No. Kad Pengenalan	:	010908-06-0847
Program	:	Pengkomputeran Multimedia
Tahun Pengajian	:	4
Tajuk Projek	:	*Interactive Visualization of Environmental Data for Public Awareness and Informed Decision-Making*
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Sehubungan itu, sukacita kiranya pihak tuan/puan dapat memberikan kerjasama kepada pelajar berkenaan untuk menyalurkan maklumat yang diperlukan bagi memenuhi syarat kursus. Segala maklumat yang diperolehi akan hanya digunakan untuk tujuan akademik semata-mata dan akan dijamin kerahsiaannya.

Ini adalah sebagai makluman kepada pihak tuan dan sekiranya ada sebarang pertanyaan, sila hubungi penyelia pelajar tersebut.

Sekian, terima kasih.

Siti Lydiawati binti Sahmat
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Appendix D: Questionnaire for Enviz: Environmental Data Visualization Platform Survey

Enviz: Environmental Data Visualization Platform Survey

Thank you for participating in this survey! Your responses will help shape the development of the "Enviz" platform, an interactive web-based tool for visualizing environmental data in Malaysia. The survey will take approximately 5-10 minutes to complete. Please answer the following questions to the best of your ability.

jasonchanfong08@gmail.com Switch accounts

Not shared

Fakulti Sains Komputer dan Teknologi Maklumat
Faculty of Computer Science and Information Technology

UNIMAS/NC-19.03/04-32 Jld. 2 (52)

3 Januari 2025

Kepada Sesiapa Yang Berkenaan

Tuan/Puan

Kerja Lapangan Pelajar Tahun Akhir dari Universiti Malaysia Sarawak
- Jason Chan Fong

Dengan segala hormatnya perkara di atas adalah dirujuk.

Sukacita dimaklumkan bahawa pelajar berikut akan mengumpul maklumat untuk projek beliau.

Berikut adalah butir-butir pelajar:

Nama Penuh	:	Jason Chan Fong
No. Matrik	:	79630
No. Kad Pengenalan	:	010908-06-0847
Program	:	Pengkomputeran Multimedia
Tahun Pengajian	:	4
Tajuk Projek	:	*Interactive Visualization of Environmental Data for Public Awareness and Informed Decision-Making*
Penyelia	:	Dr Jacey Lynn Minoi
Email	:	jacey@unimas.my
Telefon	:	082-583747

Sehubungan itu, sukacita kiranya pihak tuan/puan dapat memberikan kerjasama kepada pelajar berkenaan untuk menyalurkan maklumat yang diperlukan bagi memenuhi syarat kursus. Segala maklumat yang diperolehi akan hanya digunakan untuk tujuan akademik semata-mata dan akan dijamin kerahsiaannya.

Ini adalah sebagai makluman kepada pihak tuan dan sekiranya ada sebarang pertanyaan, sila hubungi penyelia pelajar tersebut.

Sekian, terima kasih.

Siti Lydiawati binti Sahmat
Penolong Pendaftar Kanan

s.k. - **Timbalan Dekan, Prasiswazah,** FSKTM

94300 Kota Samarahan, Sarawak, MALAYSIA
Tel + 60 82 583 781 / + 60 82 583 783

Section 1 - Demographic Background

This section gathers basic demographic information to understand the background of respondents, helping us tailor the platform to a broader audience.

1. Age *

Choose

2. Gender *

- ◯ Male
- ◯ Female

3. Occupation *

- ◯ Student
- ◯ Employee
- ◯ Unemployed
- ◯ Retired
- ◯ Homemaker

4. Education Level *

- ◯ High School/Secondary School
- ◯ Diploma/Associate's Degree
- ◯ Bachelor's Degree
- ◯ Master's Degree
- ◯ PhD/Doctoral Degree
- ◯ Other: _____

5. Level of familiarity with environmental issues *

	1	2	3	4	5	
Not familiar at all	◯	◯	◯	◯	◯	Very familiar

Section 2 - User Needs and Expectations

This section aims to uncover the motivations and expectations of users when interacting with environmental data.

1. What are the primary reasons for your interest in environmental data? *

- ◯ To stay informed about environmental issues
- ◯ To make informed decisions about my lifestyle
- ◯ To support environmental conservation efforts
- ◯ To conduct research or academic projects
- ◯ To understand the impact of environmental issues on my health and well-being

2. What are your preferred methods for accessing environmental information? *

- ☐ Websites and online platforms
- ☐ Social media (e.g., Facebook, Twitter)
- ☐ News articles and reports
- ☐ Mobile applications
- ☐ Printed publications (e.g., newspapers, reports)

3. What are your expectations for an ideal environmental data visualization platform? *

- ☐ User-friendly interface
- ☐ Interactive and engaging visualizations (e.g., charts, graphs, maps)
- ☐ Provides accurate and reliable data
- ☐ Easy to understand and interpret
- ☐ Ability to customize and personalize the experience
- ☐ Mobile and desktop accessibility
- ☐ Educational resources and explanations

4. What are your concerns about using online platforms for environmental data? *

- ◯ Data privacy and security
- ◯ Accuracy and reliability of data sources
- ◯ Difficulty in understanding complex data
- ◯ Lack of trust in online sources

Section 3 - Platform Features and Functionality

This section aims to gather user preferences and expectations regarding the features and functionalities they would like to see in the proposed environmental data visualization platform. It explores the types of visualizations, accessibility features, and the overall platform's usability. The insights gathered here will guide the development of a user-centric platform that meets the diverse needs of its target audience.

1. Which of the following visualization techniques are you most interested in? *

- [ ] Maps (e.g., choropleth maps, heatmaps)
- [ ] Charts and graphs (e.g., bar charts, line graphs, pie charts)
- [ ] Time-series visualizations (e.g., animations, trend analysis)
- [ ] Interactive simulations

2. How important are the following features to you? *

- [ ] Real-time data updates (if available)
- [ ] Data filtering and search options
- [ ] Ability to compare data across different locations or time periods
- [ ] Ability to download data for offline use
- [ ] Interactive maps and zooming capabilities
- [ ] Historical data analysis
- [ ] Easy-to-read data visualizations
- [ ] Educational resources and explanations (e.g., tooltips, glossaries)
- [ ] Multi-device compatibility (desktop, tablet, mobile)

3. How important is it for the platform to be accessible to people with disabilities? *

	1	2	3	
Not Important	○	○	○	Very Important

4. What are your biggest challenges in understanding and utilizing environmental data? *

- [ ] Difficulty in finding reliable and accurate information
- [ ] Complex and technical jargon
- [ ] Lack of clear and concise explanations
- [ ] Inability to interpret data effectively

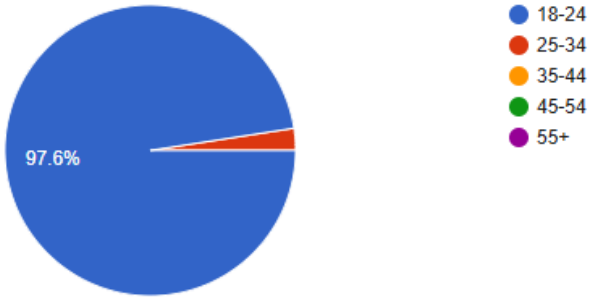
Appendix E: Result of Questionnaire for Enviz: Environmental Data Visualization Platform Survey

Section 1 - Demographic Background

1. Age

41 responses

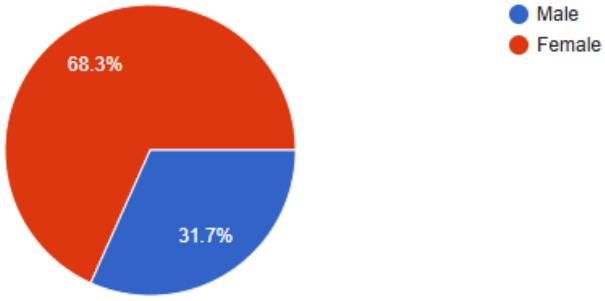
Copy chart



2. Gender

41 responses

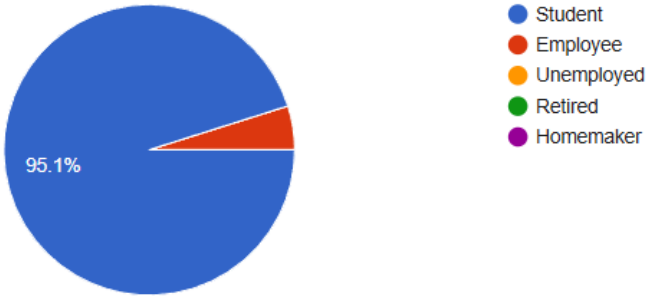
Copy chart



3. Occupation

Copy chart

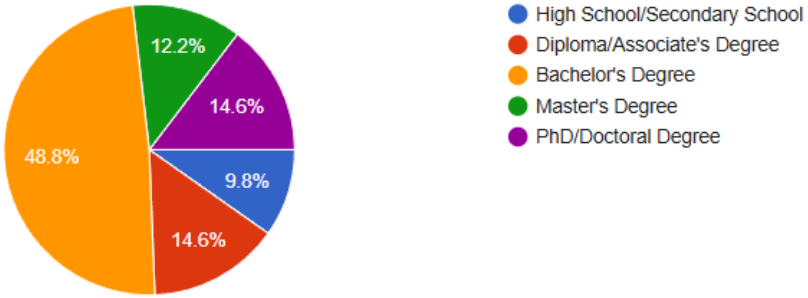
41 responses



4. Education Level

Copy chart

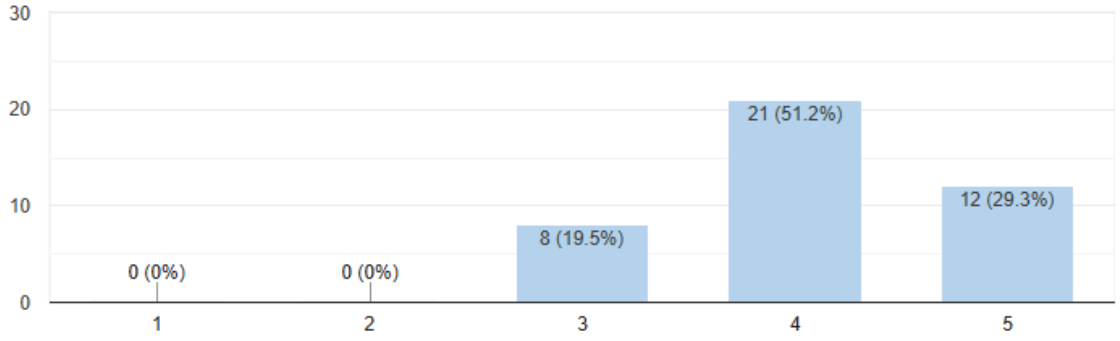
41 responses



5. Level of familiarity with environmental issues

Copy chart

41 responses



Section 2 - User Needs and Expectations

1. What are the primary reasons for your interest in environmental data?

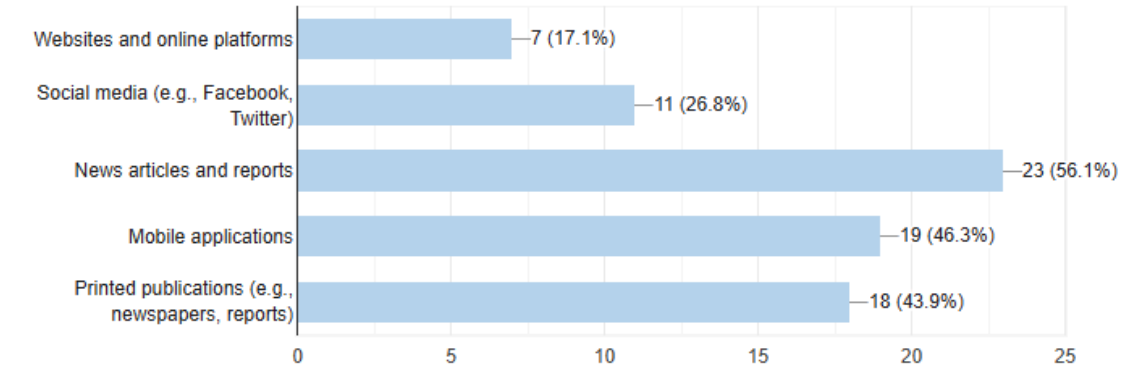
Copy chart

41 responses

2. What are your preferred methods for accessing environmental information?

Copy chart

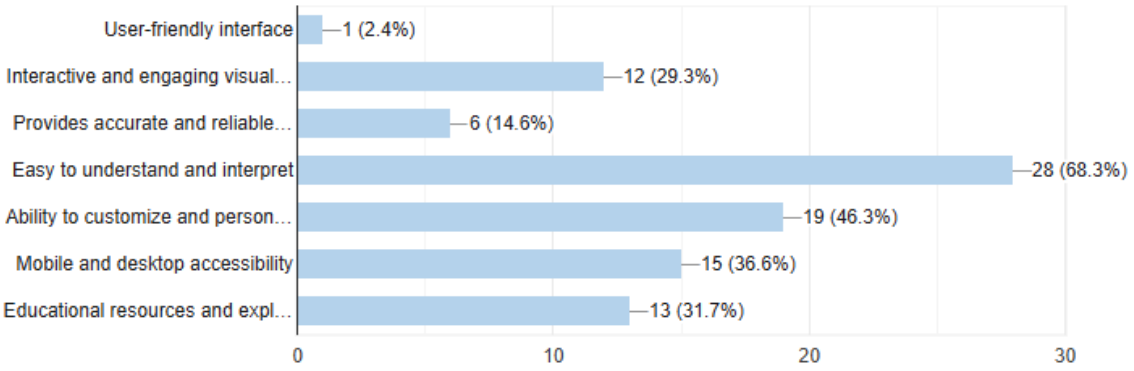
41 responses



3. What are your expectations for an ideal environmental data visualization platform?

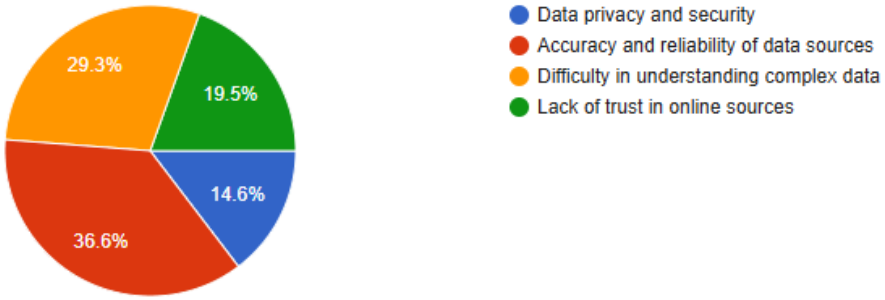
Copy chart

41 responses



4. What are your concerns about using online platforms for environmental data? Copy chart

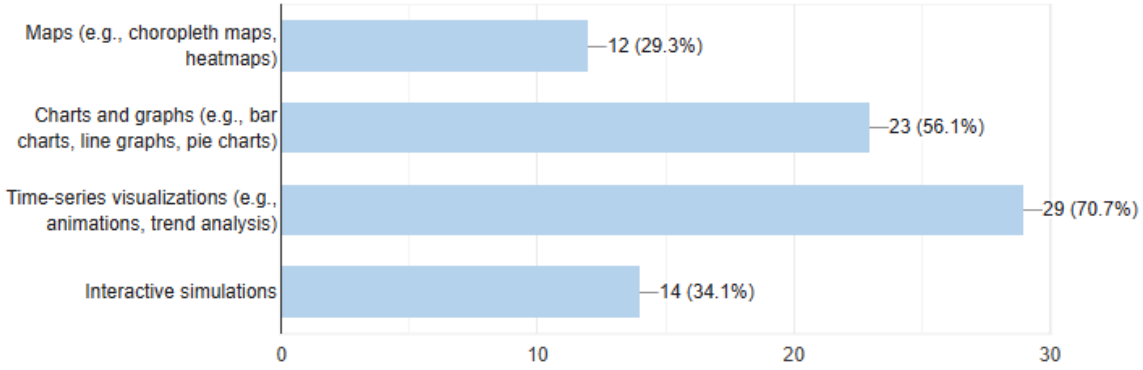
41 responses



Section 3 - Platform Features and Functionality

1. Which of the following visualization techniques are you most interested in? Copy chart

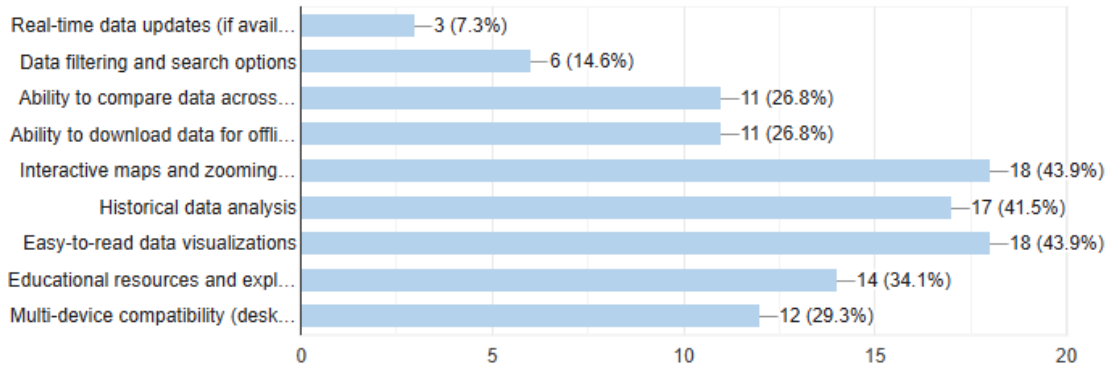
41 responses



2. How important are the following features to you?

Copy chart

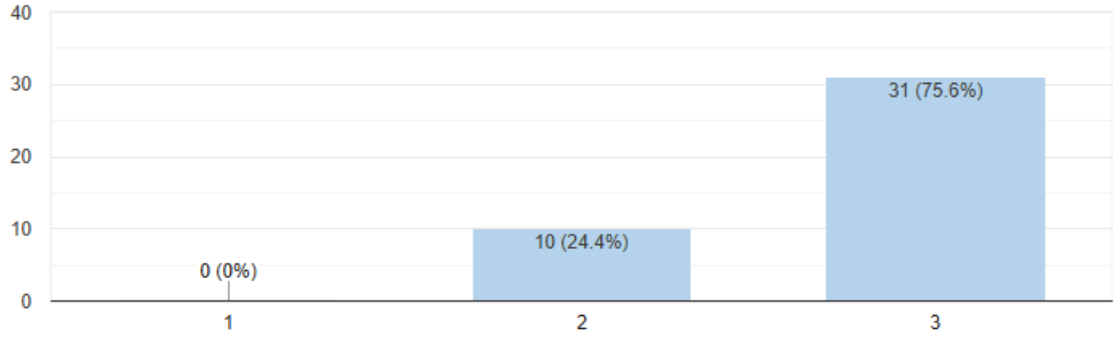
41 responses



3. How important is it for the platform to be accessible to people with disabilities?

Copy chart

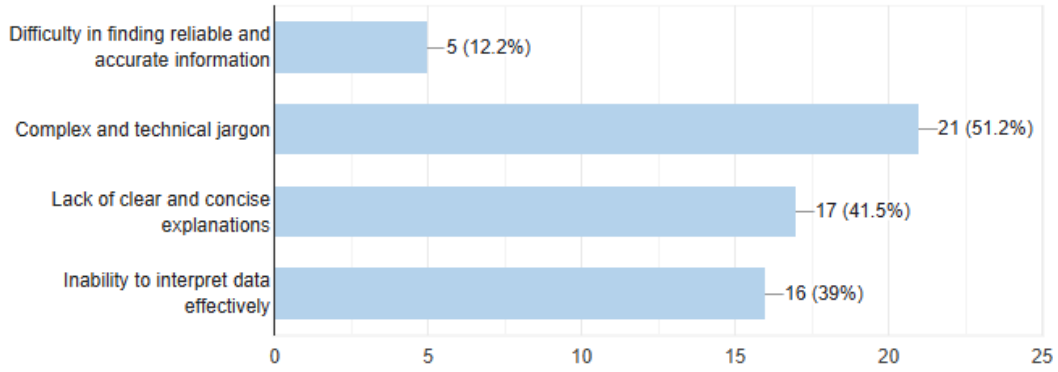
41 responses



4. What are your biggest challenges in understanding and utilizing environmental data?

Copy chart

41 responses



Appendix F: Questions of System Usability Survey for Enviz

System Usability Survey for Enviz - Environmental Data Visualisation Platform

Dear Participant,

Thank you for taking the time to participate in this survey. My name is Jason Chan Fong and I am a final-year Bachelor of Multimedia Computing (Honours) student at the Faculty of Computer Science and Information Technology (FCSIT), Universiti Malaysia Sarawak (UNIMAS). I am currently working on my final year project titled *"Interactive Visualization of Environmental Data for Public Awareness and Informed Decision-Making."*

The purpose of this questionnaire is to investigate the system usability of the *Enviz platform*, which is the final product of the Final Year Project (FYP) and its impact.

User's Tasks:

1. View Dashboard page
2. View Climate Insights Page
3. View Sea Level Change Historical Page
4. View Sea Level Change Projections Page
5. View Heat Risk Page
6. View Historical Natural Hazards Page
7. View Current Climate Climatology Page
8. View Trends and Significant Change agains Natural Viability Page
9. View Water Quality Insights Page
10. View Water Consumption Page
11. View Water Production Page
12. View Access to Treated Water Page
13. View Air Pollution Insights Page
14. View Greenhouse Gas Emissions Page
15. View Monthly Air Pollution Page

The survey is divided into three sections:

- **Section A**: Demographic Information
- **Section B**: Preliminary - Technology Usage
- **Section C**: Interface Design and Ease of Navigation for Enviz
- **Section D**: System Usability Scale (SUS)

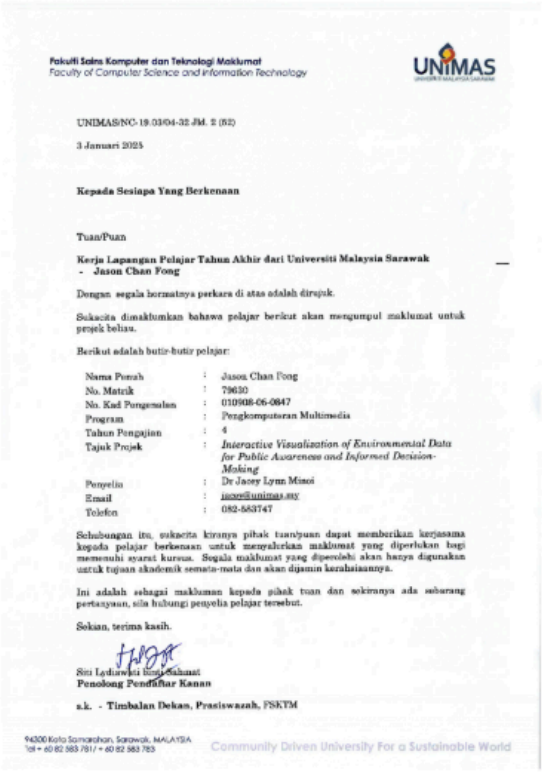
Your responses will remain confidential, and the survey will take approximately 10-15 minutes to complete.

Thank you for your valuable input! If you have any questions or concerns, feel free to contact me at **79630@siswa.unimas.my** or **+60122901770**.

jasonchanfong08@gmail.com Switch accounts

Not shared

* Indicates required question



Fakulti Sains Komputer dan Teknologi Maklumat
Faculty of Computer Science and Information Technology

UNIMAS

UNIMAS/NC-19.03/04-32 Jld. 2 (62)

3 Januari 2025

Kepada Sesiapa Yang Berkenaan

Tuan/Puan

Kerja Lapangan Pelajar Tahun Akhir dari Universiti Malaysia Sarawak
- Jason Chan Fong

Dengan segala hormatnya perkara di atas adalah dirujuk.

Sukacita dimaklumkan bahawa pelajar berikut akan mengumpul maklumat untuk projek beliau.

Berikut adalah butir-butir pelajar:

Nama Penuh	:	Jason Chan Fong
No. Matrik	:	79630
No. Kad Pengenalan	:	010908-06-0847
Program	:	Pengkomputeran Multimedia
Tahun Pengajian	:	4
Tajuk Projek	:	*Interactive Visualization of Environmental Data for Public Awareness and Informed Decision-Making*
Penyelia	:	Dr Jacey Lynn Minoi
Email	:	jacey@unimas.my
Telefon	:	082-583747

Sehubungan itu, sukacita kiranya pihak tuan/puan dapat memberikan kerjasama kepada pelajar berkenaan untuk menyalurkan maklumat yang diperlukan bagi memenuhi syarat kursus. Segala maklumat yang diperolehi akan hanya digunakan untuk tujuan akademik semata-mata dan akan dijamin kerahsiaannya.

Ini adalah sebagai maklumat kepada pihak tuan dan sekiranya ada sebarang pertanyaan, sila hubungi penyelia pelajar tersebut.

Sekian, terima kasih.

Siti Lidawati Binti Sahmat
Penolong Pendaftar Kanan

s.k. - Timbalan Dekan, Prasiswazah, FSKTM

94300 Kota Samarahan, Sarawak, MALAYSIA
Tel + 60 82 583 781 / + 60 82 583 783

Community Driven University For a Sustainable World

I acknowledge that my participation in this study is completely voluntary, and I have the right to withdraw at any point without facing any consequences. I have read and understood the provided information. By selecting "I agree" below, I give my consent to participate in this study. *

- (•) I agree

Section A: Demographic Information

Age *

- ◯ 18-24
- ◯ 25-34
- ◯ 35-44
- ◯ 45-54
- ◯ 55+

Gender *

- ◯ Male
- ◯ Female

Occupation *

- ◯ Student
- ◯ Employee
- ◯ Unemployed
- ◯ Retired
- ◯ Homemaker

Education Level *

- ◯ High School/ Secondary School
- ◯ Diploma/Associate's Degree
- ◯ Bachelor's Degree
- ◯ Master's Degree

Section B: Preliminary - Technology Usage

How often do you use a web browser? (eg. Google) *

- ◯ Everytime (more than 7 hours per day)
- ◯ Frequently (4-6 hours per day)
- ◯ Occasionally (1-3 hours per day)
- ◯ Rarely (Less than 1 hour per day)
- ◯ Never

Have you previously used any web applications that include visualization charts, animations for specific time periods, and data download functions to visualize environmental insights, particularly for Malaysia? *

- ◯ Yes
- ◯ No

If yes, what is the platform's name?

Your answer

Section C: Interface Design and Ease of Navigation for Enviz

Is the chosen font type and its size consistently readable throughout the platform? *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Are the buttons and icons displayed on the platform both clear in their function and visually appealing? *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Do you find the color matching of the Enviz visualization platform to be appropriate and attractive for presenting environmental data? *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Do all navigation links work correctly, leading to the intended pages without errors or broken links? *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Is the overall design of the visual elements and user interfaces quick and straightforward to understand and interact with? *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Are you able to easily understand the content and data presented within the Enviz visualization platform? *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Based on your experience, what improvements would you suggest for the Enviz visualization platform to enhance its overall usability? Please consider factors such as user interface (UI), user experience (UX), etc.

Your answer

Section D: System Usability Scale (SUS) for Enviz

The System Usability Scale (SUS) is a widely used tool for assessing the usability of a system. It provides an efficient and reliable way to measure usability, identify areas for improvement, and compare the usability of different systems. Please respond to the following 10 statements by indicating your level of agreement or disagreement.

I think that I would like to use this system frequently.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

I found the system unnecessarily complex.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

I thought the system was easy to use.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

I think that I would need the support of a technical person to be able to use this system.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

I found the various functions in this system were well integrated.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

I thought there was too much inconsistency in this system.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

I would imagine that most people would learn to use this system very quickly.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

I found the system very cumbersome to use.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

I felt very confident using the system.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

I needed to learn a lot of things before I could get going with this system.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Please feel free to provide any other feedback or comments about your experience with the Enviz web application. This could include any additional features you would like to see, general impressions, or observations that were not covered by the previous questions.

Your answer

End of Questionnaire

Thank you for taking the time and effort to complete this questionnaire. Your input is invaluable to the success of this project. If you have any further thoughts or suggestions, please feel free to reach out.

Thank you for your participation!

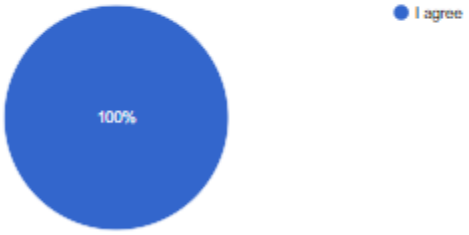
Back Submit Clear form

Appendix G: Outcomes of System Usability Survey for Enviz

I acknowledge that my participation in this study is completely voluntary, and I have the right to withdraw at any point without facing any consequences. I have read and understood the provided information. By selecting "I agree" below, I give my consent to participate in this study.

Copy chart

42 responses

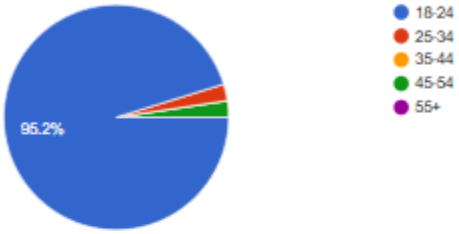


Section A: Demographic Information

Age

Copy chart

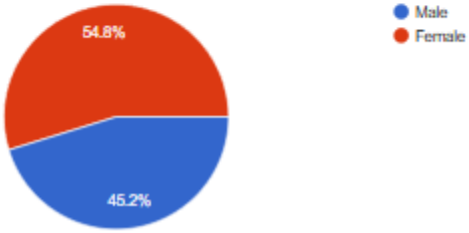
42 responses

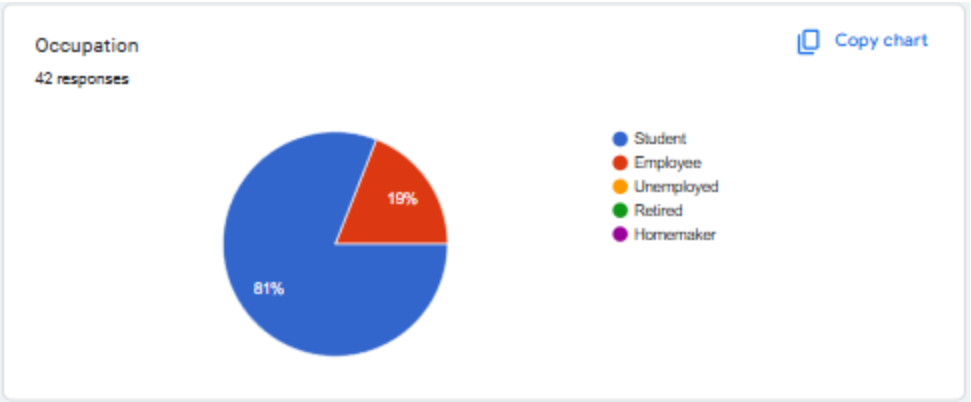


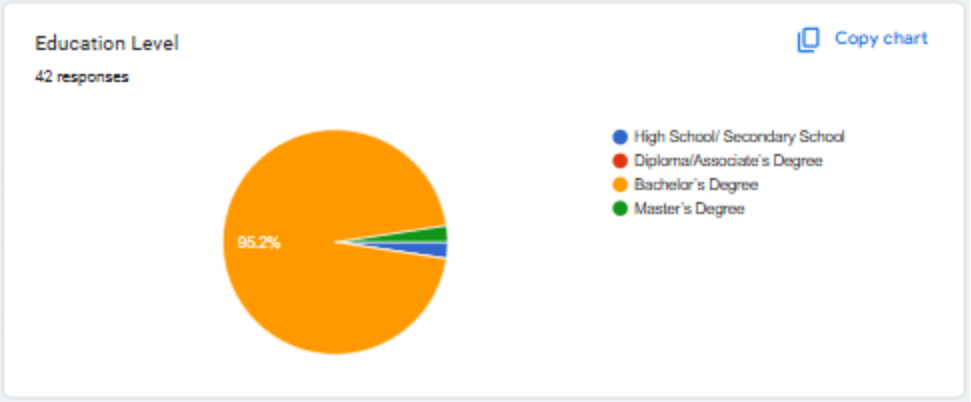
Gender

Copy chart

42 responses




Occupation
42 responses
Copy chart
19%
81%
Student
Employee
Unemployed
Retired
Homemaker

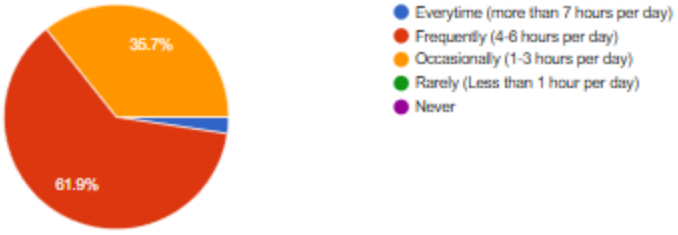

Education Level
42 responses
Copy chart
95.2%
High School/ Secondary School
Diploma/Associate's Degree
Bachelor's Degree
Master's Degree

Section B: Preliminary - Technology Usage

How often do you use a web browser? (eg. Google)

Copy chart

42 responses



Have you previously used any web applications that include visualization charts, animations for specific time periods, and data download functions to visualize environmental insights, particularly for Malaysia?

Copy chart

42 responses

If yes, what is the platform's name?

0 responses

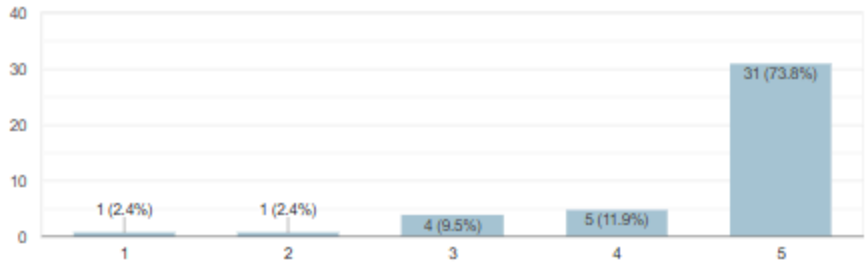
No responses yet for this question.

Section C: Interface Design and Ease of Navigation for Enviz

Is the chosen font type and its size consistently readable throughout the platform?

Copy chart

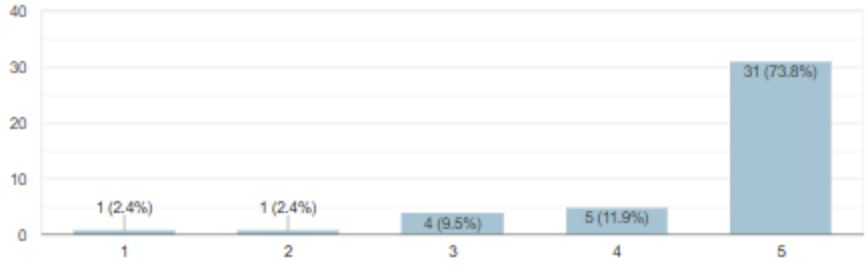
42 responses



Are the buttons and icons displayed on the platform both clear in their function and visually appealing?

Copy chart

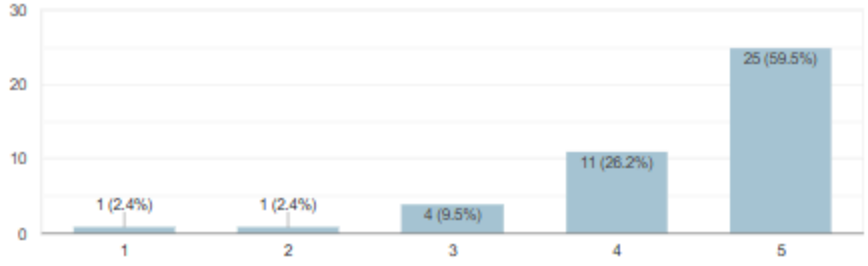
42 responses



Do you find the color matching of the Enviz visualization platform to be appropriate and attractive for presenting environmental data?

Copy chart

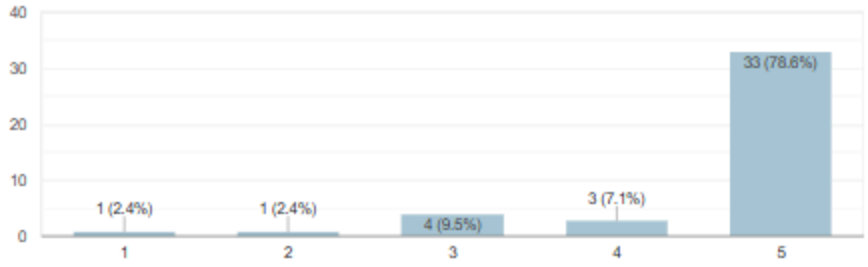
42 responses



Do all navigation links work correctly, leading to the intended pages without errors or broken links?

Copy chart

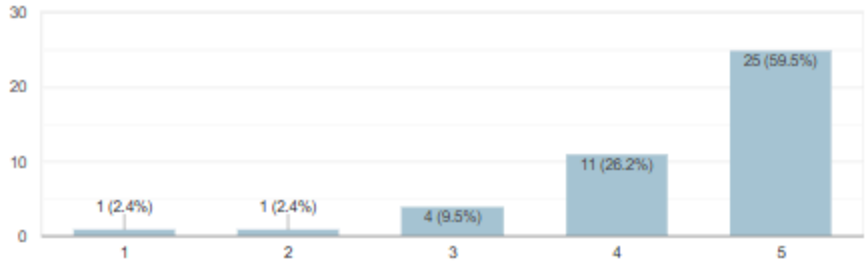
42 responses



Is the overall design of the visual elements and user interfaces quick and straightforward to understand and interact with?

Copy chart

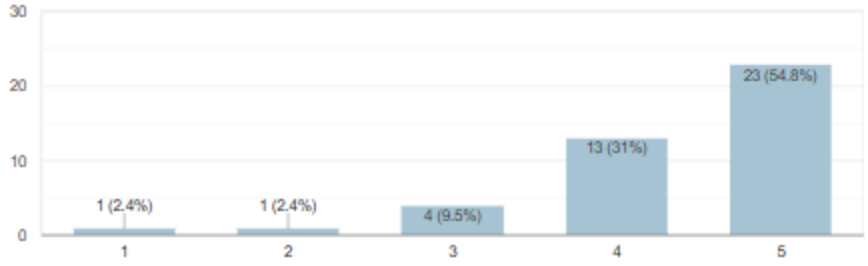
42 responses



Are you able to easily understand the content and data presented within the Enviz visualization platform?

Copy chart

42 responses



Based on your experience, what improvements would you suggest for the Enviz visualization platform to enhance its overall usability? Please consider factors such as user interface (UI), user experience (UX), etc.

0 responses

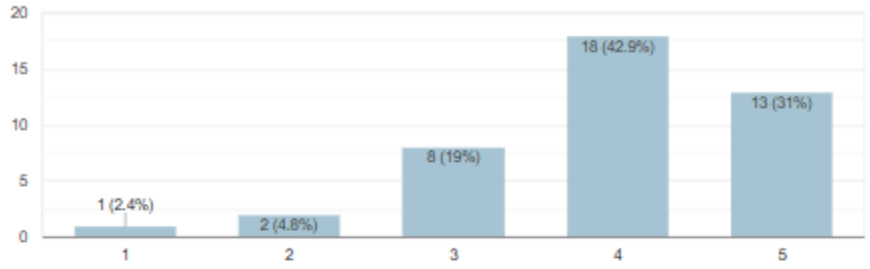
No responses yet for this question.

Section D: System Usability Scale (SUS) for Enviz

I think that I would like to use this system frequently.

Copy chart

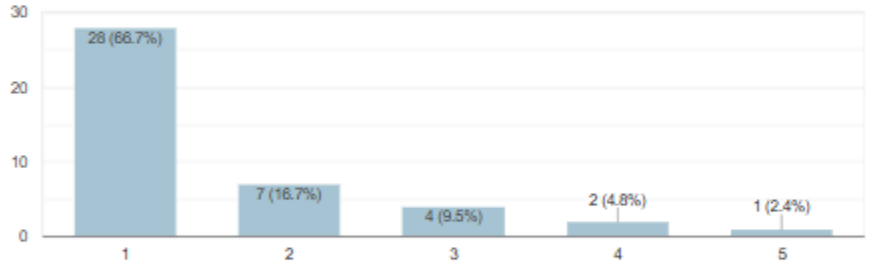
42 responses



I found the system unnecessarily complex.

Copy chart

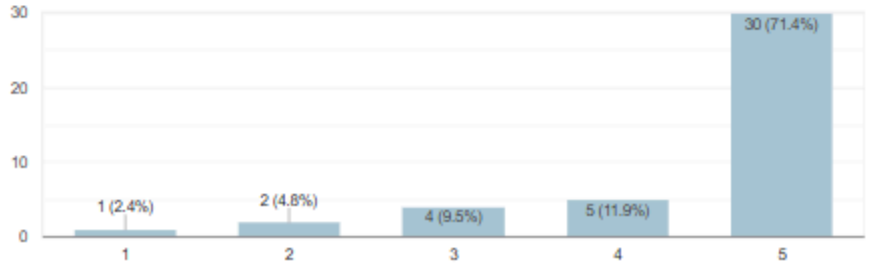
42 responses



I thought the system was easy to use.

Copy chart

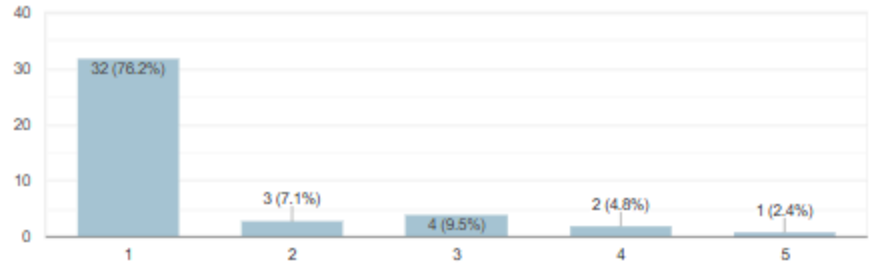
42 responses



I think that I would need the support of a technical person to be able to use this system.

Copy chart

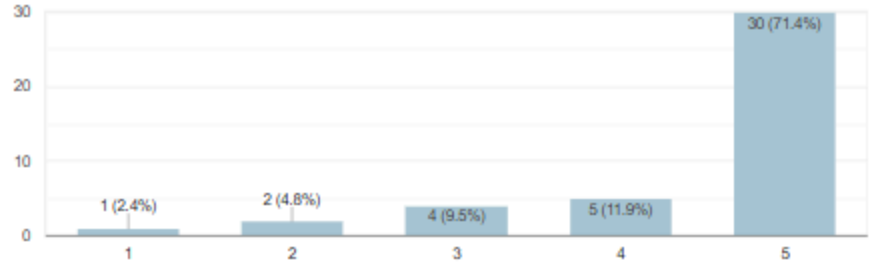
42 responses



I found the various functions in this system were well integrated.

Copy chart

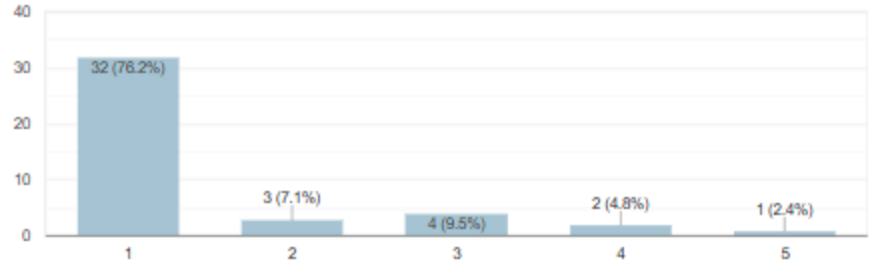
42 responses



I thought there was too much inconsistency in this system.

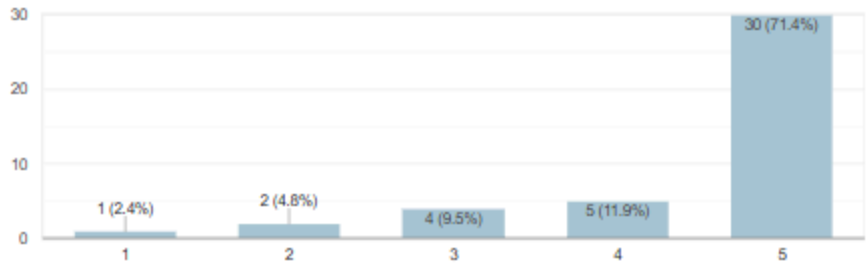
Copy chart

42 responses



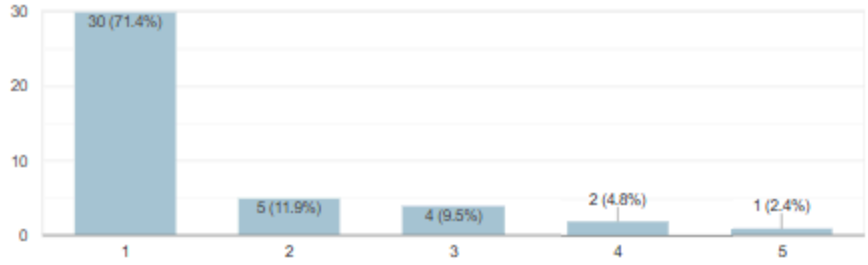
I would imagine that most people would learn to use this system very quickly. Copy chart

42 responses



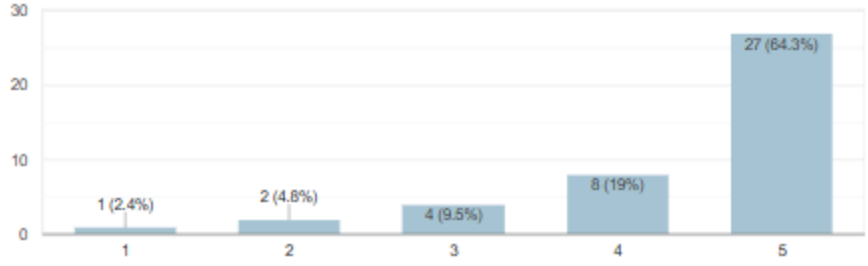
I found the system very cumbersome to use. Copy chart

42 responses



I felt very confident using the system. Copy chart

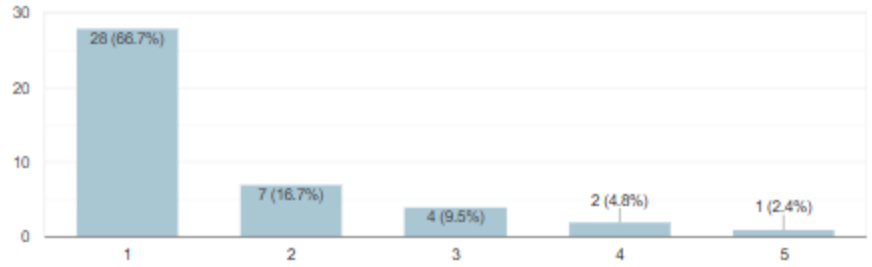
42 responses



I needed to learn a lot of things before I could get going with this system.

Copy chart

42 responses



Please feel free to provide any other feedback or comments about your experience with the Enviz web application. This could include any additional features you would like to see, general impressions, or observations that were not covered by the previous questions.

0 responses

No responses yet for this question.

End of Questionnaire