|  |
| --- |
|  |
| GreenPath |
| Tracking Your Carbon Footprint and Beyond |

|  |
| --- |
| CSIS-4495-001  Subasinghe Mudiyanselage Indika Gayashan Upasena - 300362878  12-2-2024 |

Table of Contents

[1 Introduction 3](#_Toc184081547)

[1.1 The Need for Personalized Sustainability Tools 3](#_Toc184081548)

[1.2 Literature Review and Knowledge Gaps 3](#_Toc184081549)

[1.3 Assumptions, Hypotheses, and Benefits of the Research 4](#_Toc184081550)

[1.3.1 Assumptions 4](#_Toc184081551)

[1.3.2 Hypotheses 4](#_Toc184081552)

[1.3.3 Potential Benefits of the Research 5](#_Toc184081553)

[2 Proposed Research Project 5](#_Toc184081554)

[2.1 Research Design and Objectives 5](#_Toc184081555)

[2.1.1 Objectives 5](#_Toc184081556)

[2.2 Methodology and Justification 6](#_Toc184081557)

[2.2.1 Data Collection 6](#_Toc184081558)

[2.2.2 Personalized Recommendations 6](#_Toc184081559)

[2.2.3 Data Visualization 6](#_Toc184081560)

[2.3 Data Collection and Analytics 6](#_Toc184081561)

[2.3.1 Data Collection 6](#_Toc184081562)

[2.3.2 Analytics and Recommendation Generation 7](#_Toc184081563)

[2.3.3 Data Visualization 7](#_Toc184081564)

[2.4 Technologies 7](#_Toc184081565)

[2.5 Expected Results 7](#_Toc184081566)

[3 Project Planning and Timeline 8](#_Toc184081567)

[3.1 Phase 1: Requirement Analysis (10-09-2024 to 16-09-2024) 8](#_Toc184081568)

[3.2 Phase 2: Design & Development (17-09-2024 to 20-10-2024) 8](#_Toc184081569)

[3.3 Phase 3: Integration (21-10-2024 to 04-11-2024) 9](#_Toc184081570)

[3.4 Phase 4: Testing & Refinement (05-11-2024 to 18-11-2024) 9](#_Toc184081571)

[3.5 Phase 5: Final Delivery (19-11-2024 to 30-11-2024) 9](#_Toc184081572)

[4 Implemented Features 10](#_Toc184081573)

[4.1 Dashboard 10](#_Toc184081574)

[4.2 Impact Entry 13](#_Toc184081575)

[4.3 Community & Gamification 17](#_Toc184081576)

[4.4 Recommendations 19](#_Toc184081577)

[4.5 Android Mobile App – Companion App 20](#_Toc184081578)

[5 Reflections 22](#_Toc184081579)

[6 Concluding Remarks 23](#_Toc184081580)

[7 References 24](#_Toc184081581)

[8 Appendix 24](#_Toc184081582)

[8.1 Appendix A: Installation Guide 24](#_Toc184081583)

[8.2 Appendix B: User Guide 25](#_Toc184081584)

[8.3 Appendix C: Hardware, Software, Cloud, Architecture 26](#_Toc184081585)

# Introduction

Sustainability has become a pressing global concern in recent decades, largely due to the impacts of climate change, resource depletion, and environmental damage. It highlights the importance of balancing economic growth, environmental protection, and social well-being to secure a sustainable future. Human activities, especially in areas like energy use, transportation, waste production, and food systems, play a significant role in environmental challenges such as carbon emissions, water scarcity, and pollution.

The GreenPath app focuses on environmental sustainability, providing users with tools to monitor, assess, and minimize their environmental footprint. By offering tailored suggestions based on individual habits, GreenPath helps users adopt more eco-friendly practices, contributing to the collective fight against climate change

## The Need for Personalized Sustainability Tools

Despite widespread awareness of environmental issues, many individuals struggle to understand the direct impact of their daily activities on the environment and how to reduce that impact effectively. Key questions arise:

* How can individuals track their carbon footprint, water usage, and waste production?
* What personalized, actionable steps can people take to make meaningful changes in their daily behaviours toward a more sustainable lifestyle?
* How can technology be leveraged to automate sustainability tracking and provide data-driven insights?

These questions are important because individual actions collectively have a significant influence on global environmental health. However, without clear, data-driven tools to measure personal impact and suggest actionable improvements, many people feel disconnected from the environmental consequences of their choices. By addressing this gap, the GreenPath app seeks to bridge the disconnect between awareness and action, providing users with the necessary information and guidance to make more sustainable decisions.

## Literature Review and Knowledge Gaps

Research on sustainability has been extensive, covering topics from carbon emissions tracking to waste reduction, renewable energy adoption, and individual behavioural changes toward sustainable living. Multiple studies have shown that tracking and awareness can significantly impact consumer behaviour. For example:

* **Carbon footprint calculators** like CoolClimate have been developed to estimate emissions based on various factors such as transportation and diet (Jones & Kammen, 2011).
* Studies on **behavioural nudges** have demonstrated that personalized feedback and goal-setting can lead to more sustainable consumer behaviour (Allcott & Rogers, 2014).
* **Gamification** and social features, as explored by Hamari et al. (2014), have proven effective in driving engagement and motivation toward eco-friendly practices.

However, existing research often highlights certain limitations and knowledge gaps:

* **Personalized insights**: Most carbon footprint calculators and sustainability tools provide static, generalized feedback, but lack the ability to offer dynamic, personalized recommendations based on user data.
* **Difficulty in maintaining user engagement**: Many sustainability apps and platforms struggle to retain users over the long term, largely because of limited interactivity and a lack of personalized goal setting.
* **Integration challenges**: Existing tools tend to address single dimensions of sustainability (e.g., energy consumption or waste) without offering a comprehensive approach that considers various aspects of environmental impact.

By building on these findings, GreenPath aims to address these gaps by providing a holistic platform that integrates multiple environmental factors, such as carbon emissions, water usage, and waste production tailored suggestions to users.

## Assumptions, Hypotheses, and Benefits of the Research

### Assumptions

* Individuals are more likely to adopt sustainable behaviours if they can easily track their environmental impact and receive personalized, actionable recommendations.
* Gamification and community engagement features will motivate users to actively pursue sustainability goals.

### Hypotheses

* Users who actively track their environmental impact through GreenPath and receive personalized recommendations will demonstrate a measurable reduction in their carbon footprint, water usage, and waste production over time.
* The introduction of gamified elements (e.g., challenges, badges) and social features (e.g., leaderboards, group activities) will lead to higher user engagement and a sustained commitment to eco-friendly practices.
* GreenPath users will show greater awareness and understanding of how their daily activities contribute to environmental issues, compared to users who do not use similar tracking tools.

### Potential Benefits of the Research

The findings from this project could provide valuable insights into the role of personalized feedback and gamification in driving sustainable behavior. By helping individuals make more informed choices, the GreenPath app has the potential to:

* Reduce individual carbon footprints: Users will be more aware of how to lower their emissions through specific lifestyle changes (e.g., dietary adjustments, energy-saving practices).
* Promote water conservation: With detailed tracking and goal-setting features, users will be able to reduce unnecessary water usage in daily activities.
* Reduce waste production: By encouraging recycling, composting, and conscious consumption, users will produce less waste, contributing to waste reduction initiatives.

At a larger scale, GreenPath could serve as a model for future sustainability tools that integrate comprehensive and personalized recommendations to help society move toward a more sustainable future.

# Proposed Research Project

## Research Design and Objectives

The proposed research project involves the development and evaluation of the GreenPath app, a web-based platform and android mobile app (a companion app supports the main web-based application with a focus on adding data) that helps users track and reduce their environmental impact. The app will focus on key sustainability areas, such as carbon emissions (via transportation and energy usage), water consumption, and waste production. By providing users personalized recommendations and progress tracking, GreenPath aims to empower individuals to adopt more sustainable behaviours.

### Objectives

* Develop a platform that allows users to input data related to their carbon footprint, water consumption, and waste production.
* Offer personalized, actionable recommendations based on user data to help them reduce their environmental impact.
* Provide intuitive visualizations of environmental data to help users understand their sustainability progress.
* Evaluate the effectiveness of the app in promoting sustainable behaviour by analyzing user engagement and environmental impact over time.

## Methodology and Justification

The research methodology combines data collection, analysis, and user engagement through the following components:

### Data Collection

Users will manually input data for tracking of energy use, transportation, and waste habits. This allows the app to calculate environmental metrics.

**Justification**: Research (e.g., Allcott & Rogers, 2014) shows that personalized feedback can drive sustainable changes, which GreenPath builds upon by offering multi-domain tracking.

### Personalized Recommendations

GreenPath will provide rule-based recommendations tailored to users’ specific habits. For example, if energy consumption is high, the app may suggest using energy-efficient appliances or lowering thermostat settings.

**Justification**: Studies like Abrahamse et al. (2005) support the use of tailored feedback for behaviour change, which GreenPath applies across carbon, water, and waste domains.

### Data Visualization

The app will use charts and graphs to display trends in users' sustainability metrics, such as carbon emissions or water consumption, with goal indicators to motivate improvement.

**Justification**: Visual feedback and gamification are proven to engage users (Hamari et al., 2014), which can foster long-term behaviour change.

## Data Collection and Analytics

### Data Collection

Data for the project will be collected through user inputs via web app and mobile app. Users will be able to input data about their daily habits (e.g., energy usage, transportation methods, water consumption, waste production).

To start the project, I will:

* Build the data input forms and API integration modules.
* Set up a backend system to store user data
* Ensure data privacy by securing sensitive user data.

### Analytics and Recommendation Generation

Once data is collected, the app will:

* **Analyze Usage Patterns**: For each user, the app will track their daily activities and compare them to sustainable benchmarks (e.g., average carbon emissions for transportation).
* **Generate Personalized Recommendations**: Using rule-based algorithms, the app will generate recommendations like reducing energy consumption or adopting more sustainable food choices. These recommendations will be tailored to specific behaviours that deviate from sustainability goals.

### Data Visualization

* The app will present user data visually through interactive charts and graphs. For instance, the user’s carbon footprint over time will be shown through line graphs, while water usage trends will be displayed in bar charts.
* Color-coded indicators will signal whether users are meeting their sustainability goals (e.g., green for improvement, red for exceeding limits).

## Technologies

**Platform**: Web based application which runs on browser and android mobile application

**Programming language**: JavaScript, Java

**Database**: MongoDb

**Front-end and backend:** ReactJs / VueJs and NodeJs

## Expected Results

The expected outcomes include:

* Reduced Carbon Footprint: Users will lower emissions by following personalized recommendations, such as adopting greener transport or reducing energy use.
* Water and Waste Reduction: Users will conserve water and manage waste more effectively through actionable advice on daily habits.
* Increased Engagement: Visual feedback and gamified elements will drive long-term engagement, fostering sustained behavioral change.

Practical Contributions:

* For Individuals: The GreenPath app will provide users with a tool to better understand and manage their environmental impact, empowering them to make data-driven choices that contribute to sustainability.
* For the Environment: On a larger scale, collective use of the GreenPath app could lead to meaningful reductions in carbon emissions, water usage, and waste production, contributing to broader environmental goals like mitigating climate change and preserving natural resources.

# Project Planning and Timeline

**Project Duration**:

* **Start Date**: 10-09-2024
* **End Date**: 30-11-2024
* **Total Duration**: 12 weeks

The project is divided into 5 key phases: Requirement Analysis, Design & Development, Data Collection & Integration, Testing & Refinement, and Final Delivery.

## Phase 1: Requirement Analysis (10-09-2024 to 16-09-2024)

**Duration**: 1 week  
**Key Milestones & Deliverables**:

* **Milestone 1**: Finalize functional and non-functional requirements.
  + Deliverable: Requirements document, outlining core features such as carbon tracking, water usage, waste tracking.
* **Milestone 2**: Technology stack selection.

## Phase 2: Design & Development (17-09-2024 to 20-10-2024)

**Duration**: 5 weeks  
**Key Milestones & Deliverables**:

* **Milestone 3**: User interface (UI) and user experience (UX) design.
  + Deliverable: Wireframes and mockups for the GreenPath app
* **Milestone 4**: Front-end development.
  + Deliverable: Functional UI for the app (dashboard, user input forms).
* **Milestone 5**: Android mobile app development.
  + Deliverable: Functional mobile UI.
* **Milestone 6**: Back-end development.
  + Deliverable: Back-end infrastructure with API integrations and database setup for storing user data.

## Phase 3: Integration (21-10-2024 to 04-11-2024)

**Duration**: 2 weeks  
**Key Milestones & Deliverables**:

* **Milestone 7**: API integration for carbon, water, and waste tracking with web and mobile applications.
  + Deliverable: Integrated web app and mobile app with API connections for transportation, energy, and water usage data.

## Phase 4: Testing & Refinement (05-11-2024 to 18-11-2024)

**Duration**: 2 weeks  
**Key Milestones & Deliverables**:

* **Milestone 8**: Unit testing and integration testing.
  + Deliverable: Test cases and reports ensuring the core functionalities (data input, API integration, recommendations) are working as expected.
* **Milestone 10**: Refinement and bug fixing.
  + Deliverable: Updated, refined version of the GreenPath app

## Phase 5: Final Delivery (19-11-2024 to 30-11-2024)

**Duration**: 2 weeks  
**Key Milestones & Deliverables**:

* **Milestone 11**: Final version of GreenPath app.
  + Deliverable: Fully functioning web app and mobile app with carbon, water, and waste tracking features, data visualization, and personalized recommendations.
* **Milestone 12**: Documentation and project report.
  + Deliverable: Final project report, including technical documentation, user guide

A graph with numbers and a bar

Description automatically generated with medium confidence

# Implemented Features

## Dashboard

**Summary Cards:**  
The dashboard includes summary cards displaying total carbon emissions, transport emissions, energy emissions, and waste emissions. Each card pulls data from corresponding backend APIs, which perform data aggregation for a quick, at-a-glance summary of user impact metrics. Most of the data on this page is filterable by date, enabling users to analyze specific timeframes.

A screenshot of a computer

Description automatically generated

Figure : Dashboard Emission Summary

**Charts:**  
The dashboard features three primary charts, providing users with a graphical overview of their impact metrics:

* **Carbon Footprint (Donut Chart)**: Visualizes the breakdown of carbon sources.
* **Waste Management (Pie Chart)**: Displays waste distribution by type.
* **Daily Water Consumption (Bar Chart)**: Shows daily water usage trends.

All charts are dynamic, updating as data entries are logged by the user. Backend aggregation APIs fetch and process data based on the user’s profile, enabling real-time data visualization.

A close up of a pie chart

Description automatically generated

Figure :Dashboard Charts 1

A graph of blue rectangular bars

Description automatically generated with medium confidence

Figure : Dashboard Charts 2

A computer screen shot of a program code

Description automatically generated

Figure : Backend Chart Api Code for Daily Water Usage

**Recommendation Widget:**  
The recommendation widget offers a list of the latest, dynamically generated recommendations tailored to the user's sustainability habits. This feature will further enhance the app’s value by actively engaging users in sustainable practices.

**A screenshot of a computer

Description automatically generated**

Figure : Recommendation Widget

## Impact Entry

Each impact category (carbon footprint, water usage, and waste management) has a dedicated entry form with corresponding API integrations, allowing users to log and update their daily metrics efficiently. The forms are designed in tab views for seamless navigation:

**Carbon Footprint Entry**:

Users can enter daily transport data, including distance travelled and mode of transport. The system supports multiple entries per day, accommodating different travel types (e.g., car, train). The backend API aggregates data, calculating carbon emissions using predefined emission factors. A summary view displays the daily emissions total after submission.

A screenshot of a computer

Description automatically generated

Figure : Impact Entry - Carbon Footprint 1

A screenshot of a computer

Description automatically generated

Figure : Impact Entry - Carbon Footprint 2

**Water Usage Entry**:

The water usage form allows users to log their daily water consumption, with options to enter data in different units. The backend API computes the related emissions based on water usage, displaying results in the summary view.

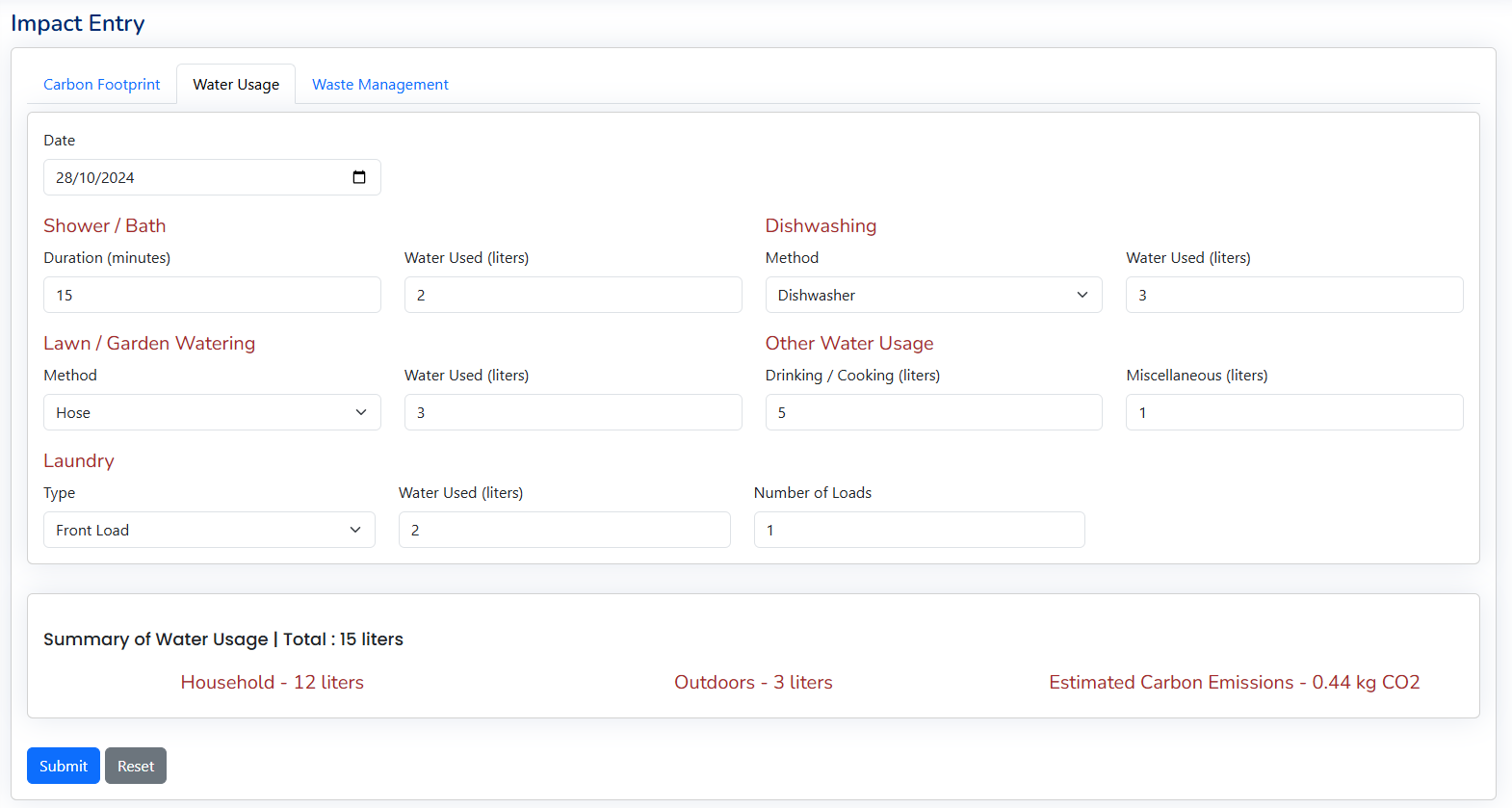


Figure : Impact Entry - Water Usage

**Waste Management Entry**:

Users can record daily waste contributions, specifying waste type and quantity. The backend API supports multiple entries per day, calculating total emissions for the recorded waste. The waste summary view allows users to monitor their impact easily.

A screenshot of a computer

Description automatically generated

Figure : Impact Entry - Waste Management

A screenshot of a computer program

Description automatically generated

Figure : Emission Factors

A screen shot of a computer code

Description automatically generated

Figure : Emission Calculation Formulas

## Community & Gamification

The Community page fosters collaboration, competition, and collective action towards sustainability goals.

**Echo Points System**: Users earn points for eco-friendly actions, placing them in zones (Bronze, Silver, Gold, Platinum), with a dedicated widget displaying their points.

A yellow and black bar

Description automatically generated

Figure : Echo Points

**Latest Activity Feed**: Updates on user achievements (e.g., reduced waste generation) can be liked and shared within the community, driving motivation through peer recognition.

A screenshot of a computer

Description automatically generated

Figure : Latest Activity Feeds

**Challenges/Events**: Users can join or leave active challenges/events to earn points and further their impact.

A screenshot of a computer

Description automatically generated

Figure : Challenges / Events

**Gamification Leaderboard**: Weekly rankings highlight top performers in categories like Carbon Champion, Water Saver, and Waste Minimizer, fostering healthy competition.

A screenshot of a social media post

Description automatically generated

Figure : Gamification Leaderboard

## Recommendations

The Recommendations feature provides actionable, data-driven guidance for improving sustainability habits.

* **Categorized Tabs**: Recommendations are grouped into four categories:
  + **Benchmarks-Based**: Comparing user data to predefined standards.
  + **Historic Patterns**: Derived from user data trends.
  + **Comparative Feedback**: Based on peer group performance.
  + **Context-Aware Suggestions**: Tailored to seasonal or regional events.
* **Dynamic Updates**: Generated by a background scheduler (weekly by default) and stored in MongoDB for efficiency and persistence.
* **User Interaction**: Displayed as color-coded tiles (green for positive actions, red for improvement areas), which users can delete if not relevant or after action taken.

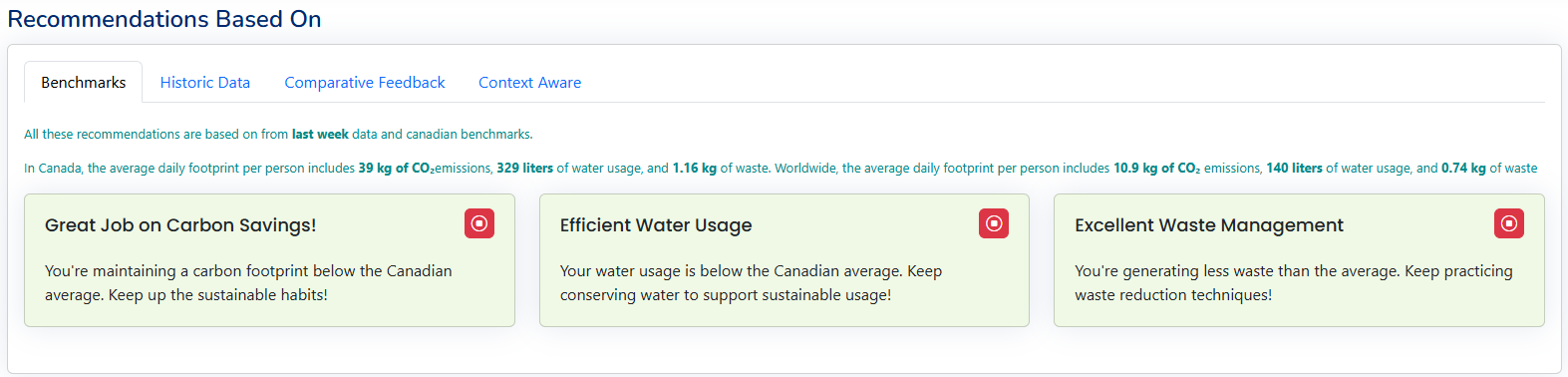


Figure : Recommendations

**Challenges Faced in Creating Recommendations**

One of the primary challenges in generating accurate and relevant recommendations was the variability in benchmark values, which are influenced by factors such as geography, culture, and regional practices. Benchmarks for sustainability, such as carbon emissions or water usage, can vary significantly between countries and even within regions. This disparity posed difficulties in ensuring the recommendations were both precise and actionable for all users.

To address this challenge, I introduced a dual-benchmark system tailored to user demographics. The system currently supports two sets of benchmark values: **North American benchmarks** and **Worldwide benchmarks**. Based on the user's location data, the system compares their sustainability metrics against the appropriate benchmark set to provide more regionally relevant recommendations.

As an initial implementation, the system prioritizes **North American benchmarks** for users in this region. This approach ensures better alignment with user expectations and allows room for expansion to other region-specific benchmarks in the future, enhancing the global scalability of the recommendation engine.

This strategy has improved the accuracy and contextual relevance of the generated recommendations, but the process of continuously refining benchmarks remains an ongoing challenge.

## Android Mobile App – Companion App

As part of the GreenPath project, a companion Android mobile application was developed to facilitate seamless daily impact entry. The mobile app focuses on simplicity and functionality, making it easy for users to track their sustainability efforts on the go.

**Key Features**

1. **Login System**
   * The app includes a **login page** where users authenticate themselves using their credentials.
   * Once logged in, users are directed to the dashboard.
2. **Dashboard with Limited Data**
   * The dashboard provides a concise overview of the user’s sustainability metrics, including:
     + **Total Carbon Footprint**: Displays the aggregate carbon emissions.
     + **Breakdown of Emissions**: Categorized into transport emissions, energy emissions, and waste emissions.
     + **Today’s Total Water Usage**: Highlights daily water consumption trends.
   * All data on the dashboard can be **filtered by date**, enabling users to analyze specific timeframes.
3. **Impact Entry Features**
   * The app includes dedicated forms for entering daily sustainability data:
     + **Carbon Footprint Entry**: Users can log emissions related to transport and energy usage.
     + **Water Usage Entry**: Facilitates recording of daily water consumption.
     + **Waste Management Entry**: Tracks waste disposal and categorization.
   * Each input form is designed for ease of use and integrates with the backend to update the user’s profile seamlessly.

The Android mobile app complements the main web application by offering a streamlined way to enter and review impact data, ensuring user engagement and consistent tracking of sustainability metrics.

A screenshot of a smartphone

Description automatically generated

Figure : Android Mobile App

# Reflections

Reflecting on the process of proposing and implementing the GreenPath project, several key takeaways and insights stand out:

**What I Learned**

1. **Importance of Clear Requirements**:  
   Developing the GreenPath app emphasized the value of having well-defined functional and non-functional requirements. This clarity early on helped streamline the design and development phases.
2. **The Role of Adaptability**:  
   Challenges such as creating region-specific recommendations required adaptive problem-solving, teaching me the importance of flexibility in addressing unforeseen obstacles.
3. **User-Centric Design**:  
   Focusing on user experience during the design phase helped me realize how crucial intuitive interfaces and meaningful visualizations are to engagement and usability.
4. **System Scalability**:  
   Implementing a dual-benchmark system provided insights into designing scalable features that can accommodate future regional expansions without disrupting current functionality.

**What I Would Do Differently**

1. **Enhanced Benchmark Diversity**:  
   If given the opportunity to implement this project again, I would prioritize a broader range of benchmarks for more geographic regions from the outset, reducing dependency on 2 benchmarks set.
2. **Early User Testing**:  
   Incorporating user testing earlier in the development cycle would provide valuable feedback on feature relevance and usability, improving the product before release.
3. **Backend Optimization**:  
   While the recommendation engine performed as expected, optimizing it for real-time or on-demand generation could improve the system’s responsiveness and user experience.

**Final Reflections**

The GreenPath project was both a challenging and rewarding experience. It highlighted the complexities of building a sustainability-focused app and underscored the importance of thoughtful design, scalability, and user engagement. This journey has enhanced my technical and project management skills, better preparing me for future endeavors. If given another chance, I would aim for a more collaborative approach with subject matter experts and prioritize user feedback to ensure the app’s ongoing success and relevance.

# Concluding Remarks

In completing the GreenPath project, I am grateful for the insights and guidance provided by Professor Bambang A.B. Sarif, whose expertise has been invaluable in navigating both technical and conceptual aspects of the project. The direction offered during our discussions helped clarify complex challenges and encouraged me to explore sustainable development practices in greater depth.

I also extend my thanks to my peers, whose feedback and collaborative spirit enriched the project experience. The GreenPath has been a rewarding journey, and I look forward to continuing to build upon this foundation as I work towards delivering a comprehensive and impactful app that contributes to eco-conscious living.

# References

1. **Allcott, H., & Rogers, T.** (2014). *The Short-Run and Long-Run Effects of Behavioural Interventions: Experimental Evidence from Energy Conservation*. American Economic Review, 104(10), 3003-3037.
2. **Abrahamse, W., Steg, L., Vlek, C., & Rothengatter, T.** (2005). *A review of intervention studies aimed at household energy conservation*. Journal of Environmental Psychology, 25(3), 273-291.
3. **Hamari, J., Koivisto, J., & Sarsa, H.** (2014). *Does Gamification Work? A Literature Review of Empirical Studies on Gamification*. 2014 47th Hawaii International Conference on System Sciences, 3025-3034.
4. **Bootstrap**. "Bootstrap." Accessed from <https://getbootstrap.com/>. Bootstrap is a widely-used open-source front-end toolkit for building responsive web applications, providing CSS and JavaScript components.
5. **ApexCharts**. "ApexCharts." Accessed from <https://apexcharts.com/>. ApexCharts is a library for creating interactive charts and visualizations, which helps to enhance data representation in web applications.
6. **Wint AI**. “Carbon Impact of Water Consumption.” White paper. Accessed from <https://wint.ai/wp-content/uploads/2022/02/White-paper-Carbon-Impact-of-Water-Consumption-Final.pdf>. This paper examines the environmental impact of water usage on carbon emissions, providing essential data for sustainability analysis.
7. **U.S. Environmental Protection Agency (EPA)**. "Greenhouse Gas Equivalencies Calculator." Accessed from <https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator>. This calculator offers conversions for common activities into equivalent CO₂ emissions, useful for evaluating and reducing carbon footprints.
8. **ENERGY STAR**. "Building Emissions Calculator: Technical Reference." Accessed from <https://www.energystar.gov/buildings/tools-and-resources/building-emissions-calculator-technical-reference>. This document provides methodology and data tables to estimate emissions for various building activities, adaptable for personal or household-level emission estimates.
9. **Britannica**. "Carbon Footprint." Accessed from <https://www.britannica.com/science/carbon-footprint>. This entry provides an overview of carbon footprints, their measurement, and factors influencing individual and organizational carbon emissions.
10. **Climate Watch Data**  
    Provides detailed information about global greenhouse gas emissions by sector and region.  
    <https://www.climatewatchdata.org/ghg-emissions>
11. **The Nature Conservancy: Carbon Footprint Calculator**  
    An interactive tool for calculating individual carbon footprints based on activities like transportation, energy usage, and waste management.  
    <https://www.nature.org/en-us/get-involved/how-to-help/carbon-footprint-calculator/>
12. **World Bank: Solid Waste Management**  
    Insights into global waste management practices, trends, and challenges, with data on waste generation by countries.  
    <https://www.worldbank.org/en/topic/urbandevelopment/brief/solid-waste-management>
13. **Eurostat: Waste Statistics**  
    Statistical analysis of waste generation, treatment, and recycling across European Union countries.  
    <https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Waste_statistics>
14. **Statista: Municipal Solid Waste Generation by Country**  
    Presents per capita data on municipal solid waste (MSW) generation across different countries.  
    <https://www.statista.com/statistics/689809/per-capital-msw-generation-by-country-worldwide/>
15. **Renogy Blog: Average Household Energy Use**  
    Explains energy consumption patterns for the average household in kWh, useful for understanding and reducing energy-related carbon emissions.  
    <https://ca.renogy.com/blog/how-many-kwh-does-the-average-home-use/>

# Appendix

## Appendix A: Installation Guide

Project Repo Path: <https://github.com/gayashanacd/CSIS_4495_Project_ISu878.git>

**How to run frontend VueJs app**

* Copy project file to a location and open terminal / command prompt in inside root folder.
* Run “**npm install**” to install all modules needed
* Execute “**npm run serve**” to run the application.
* Open web browser and navigate to <http://localhost:8080/> to view.

**How to run backend NodeJs app**

* Copy project file to a location and open terminal / command prompt in inside root folder.
* Run “**npm install**” to install all modules needed
* Execute “**node server**” to run the application.
* Open web browser and navigate to <http://localhost:5000/api/getusers> to see all users from mongo DB cloud

**How to run android mobile app**

* Install android studio in local machine ( <https://androidstudio.googleblog.com/2024/08/android-studio-koala-202411-patch-2-now.html> ). App was developed with Android Studio Koala | 2024.1.1 Patch 2.
* Open android app with android studio.
* Create a new virtual device. App was tested with Pixel 8.
* Run the application and use provided accounts to login.

**Cloud Deployed Urls**

**Frontend:** [**https://greenpath-lyart.vercel.app/**](https://greenpath-lyart.vercel.app/)

**Backend:** [**https://greenpath-backend.vercel.app/api/getusers**](https://greenpath-backend.vercel.app/api/getusers)

**Test User Accounts**

|  |  |
| --- | --- |
| Username | Password |
| julia | julia123 |
| indi | indi123 |
| peter | peter123 |

## Appendix B: User Guide Web Application

The GreenPath web app provides an intuitive platform for tracking and improving sustainability efforts. Below is a step-by-step guide for using the app’s main features, available at [GreenPath Web App](https://greenpath-lyart.vercel.app/).

**1. Login and New User Registration**

* **Login**:  
  Enter your username and password on the login page. Use the credentials provided (e.g., username: **julia**, password: **julia123**) to access the app.

A screenshot of a login form

Description automatically generated

Figure : User Guide - Login

* **New User Registration**:  
  For new users, click the "Get Started" button to create an account. Complete the profile creation process by providing necessary details, such as location and eco-friendly preferences.

A screenshot of a computer

Description automatically generated

Figure : User Guide – Register

**2. Dashboard**

* The dashboard offers a consolidated view of your sustainability data:
  + **Summary Cards**: Displays total carbon emissions, transport emissions, energy emissions, waste emissions, and daily water usage.
  + **Charts**:
    - Carbon Footprint (Donut Chart)
    - Waste Management (Pie Chart)
    - Daily Water Consumption (Bar Chart)
  + **Recommendations Widget**: Lists personalized suggestions for improvement.
* Use the date filter to view data for specific timeframes.

A screenshot of a computer

Description automatically generated

Figure : User Guide - Dashboard

**3. Impact Entry**

* Input daily data for the following categories:
  + **Carbon Footprint**: Transport and energy usage.

A screenshot of a computer

Description automatically generated

Figure : User Guide - Impact Entry Carbon Footprint

* + **Water Usage**: Track daily water consumption.

A screenshot of a computer

Description automatically generated

Figure : User Guide - Impact Entry Water Usage

* + **Waste Management**: Log recyclable and non-recyclable waste.

A screenshot of a computer

Description automatically generated

Figure : User Guide - Impact Entry Waste Management

* After submitting, the summary of carbon emissions is displayed at the bottom of the page.

**4. Community**

* Engage with other users through the **Community Dashboard**:
  + **Echo Points Widget**: Displays your total points (Bronze, Silver, Gold, Platinum zones)
  + **Activity Feed**: View updates from other users, like their posts, and celebrate their achievements.
  + **Challenges & Events**: Join or leave challenges/events and earn Echo Points.
  + **Gamification Leaderboard**: Weekly leaderboards showcasing Carbon Champion, Water Saver, and Waste Minimizer.

A screenshot of a computer

Description automatically generated

Figure : User Guide - Community

**5. Recommendations**

* Navigate to the recommendations section to view categorized advice:
  + **Benchmarks-Based**
  + **Historic Data & Patterns**
  + **Comparative Feedback**
  + **Context-Aware Suggestions**
* Recommendations are color-coded: green for positive and red for areas needing improvement.

A screenshot of a computer

Description automatically generated

Figure : User Guide - Recommendations Based on Benchmarks

A screenshot of a computer

Description automatically generated

Figure : User Guide - Recommendations Based on Historic Data

A screenshot of a computer

Description automatically generated

Figure : User Guide - Recommendations Based on Comparative Feedbacks

A screenshot of a computer

Description automatically generated

Figure : User Guide - Recommendations Based on Context Aware

**6. User Profile**

* Update personal details and preferences via the profile page.
* View metrics and adjust your data to align with personal goals.

A screenshot of a computer screen

Description automatically generated

Figure : User Guide – Profile

**7. Logout**

* Click the "Sign Out" button on the top-right corner to securely end your session.

A screenshot of a computer

Description automatically generated

Figure : User Guide - Signout

## Appendix C: User Guide Android Mobile App

The GreenPath Android mobile app is a streamlined companion tool designed to facilitate quick and convenient daily impact tracking. Below is a step-by-step guide to using the app.

**1. Login**

* Launch the app, and you will be directed to the **Login Page**.
* Enter your credentials (username and password) to access the app.

A screenshot of a login screen

Description automatically generatedA screenshot of a phone

Description automatically generated

Figure : Mobile User Guide - Start Page / Login

**2. Dashboard**

* Once logged in, the **Dashboard** provides a concise overview of your environmental impact:
  + **Total Carbon Footprint**: Displays your overall carbon emissions.
  + **Breakdown of Emissions**: Categorized into:
    - **Transport Emissions**
    - **Energy Emissions**
    - **Waste Emissions**
  + **Today's Water Usage**: Displays the total water consumed for the day.
* **Filter by Date**: Use the date filter to view data for a specific day or period.

A screen shot of a phone

Description automatically generated

Figure : Mobile User Guide – Dashboard

**3. Impact Entry**

The app allows users to log daily sustainability data under three categories:

1. **Carbon Footprint Entry**
   * Add emissions data for **transport** and **energy usage**.
   * Input fields include metrics like distance traveled (e.g., km/miles) or energy consumed (e.g., kWh).
2. **Water Usage Entry**
   * Record your daily water consumption in liters or gallons.
3. **Waste Management Entry**
   * Log waste data by type: recyclable or non-recyclable waste.

A screenshot of a phone

Description automatically generated

Figure : Mobile User Guide - Impact Entry

**4. Logout**

* Click the Settings to navigate and Logout from the application.

A black rectangular frame with a white background

Description automatically generated

Figure : Mobile User Guide - Logout

## Appendix D: Hardware, Software, Cloud, Architecture

**Hardware**

* **Computers**: The GreenPath application development is carried out on **Microsoft Surface 4 Pro** laptop and **Acer Aspire Z 24** – All in one PC, which provide adequate processing power, portability, and compatibility with the necessary development tools for a seamless development experience.

**Software**

* **Code Editor**: **Visual Studio Code** is used as the primary development environment, chosen for its extensive library of extensions, flexibility, and support for JavaScript and Vue.js.
* **Version Control & Repository Management**: **Git** is used for version control, while **GitHub** serves as the cloud-based repository management system, allowing collaboration, version tracking, and backup.
* **Mobile Development Tool**: Android Studio was used for developing the Android mobile app. It offers an integrated development environment (IDE) with powerful tools for designing, coding, and debugging Android applications, ensuring seamless app performance across devices.

**Application Architecture and Technology Stack**

* **Platform**: GreenPath is a **web-based application**, designed to run on major browsers to provide users with easy access across devices without requiring an app installation.
* **Programming Language**: **JavaScript** is the core programming language, allowing for an integrated codebase across both the front-end and back-end, streamlining development and maintenance.
* **Front-End Framework**: The front end is built using **Vue.js**, selected for its flexibility, lightweight footprint, and reactive capabilities, which enable efficient user interface rendering and enhanced interactivity.
* **Back-End Framework**: **Node.js** powers the back-end, providing a non-blocking, event-driven framework that suits real-time applications and pairs well with MongoDB for high-performance data handling.
* **Database**: GreenPath utilizes **MongoDB (Atlas Cloud MongoDB)** for data storage. MongoDB’s NoSQL structure offers scalability and flexibility, which are essential for managing complex sustainability data, like carbon footprint, water usage, and waste tracking.
* **Deployment**: The web application and backend services are deployed on **Vercel**. Vercel is chosen for its performance optimization, ease of deployment, and support for modern web frameworks like Vue.js.
* **Continuous Integration and Deployment (CI/CD)**: Project repositories are integrated with **GitHub**, enabling automated CI/CD pipelines to ensure consistent deployment and updates.

**Cloud and Data Storage**

* **Database Cloud**: **MongoDB Atlas** provides a managed, secure cloud database environment. This cloud-hosted MongoDB deployment ensures data accessibility, security, and backup capabilities, optimizing performance and reducing operational burdens.