

## **DESIGN OF A MOBILE APPLICATION FOR CARBON EXPENDITURE RECORDING AND CARBON TAX ESTIMATION CALCULATION AS AN EFFORT TO SUPPORT CARBON EMISSION REDUCTION IN INDONESIA**

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### **ABSTRACT**

This research aims to develop a mobile application prototype to help people record carbon activities, calculate estimation of annual carbon tax, and increase public awareness and participation in order to support the implementation of carbon tax in Indonesia. The method used for research is a mixed method, integrating literature study (qualitative) and questionnaire survey (quantitative). Development process utilized the Agile Scrum Software Development Life Cycle (SDLC) model. The results of the research are in the form of the KarbonKU application, complemented by evaluations from users that show satisfaction in the aspects of interface design and functionality. In conclusion, KarbonKU is effective in helping users record carbon activities, calculate carbon tax estimates, and increase public awareness and participation in reducing carbon emissions in Indonesia.

**Keywords:** Mobile Application, Carbon Tax, Public Awareness, Carbon Emissions.

### **1. INTRODUCTION**

Climate change, driven by long-term shifts in temperature and weather patterns, is one of the most pressing global challenges. While such changes can occur naturally due to factors such as solar activity or volcanic eruptions, the overwhelming consensus within the scientific community is that human activities—particularly the burning of fossil fuels—have been the primary driver of climate change since the onset of industrialization. These activities have led to a global temperature rise of approximately 1.1°C over the past two centuries, and projections suggest that, without substantial reductions in emissions, global temperatures could increase by as much as 4.4°C by the end of the 21st century (IPCC, 2023). The consequences of such temperature increases are widespread and severe, including rising sea levels, extreme weather events, biodiversity loss, and disruptions to food and water security. Coastal cities, such as Jakarta, face existential threats, including the risk of sinking by 2050 due to rising sea levels. These impacts emphasize the urgent need for coordinated global action to mitigate climate change.

In response to these challenges, the United Nations Framework Convention on Climate Change (UNFCCC, 2015) was established to promote international cooperation in reducing greenhouse gas (GHG) emissions. A key milestone in these efforts is the Paris Agreement (IPCC, 2023), which aims to limit global warming to well below 2°C, with an aspiration to limit the increase to 1.5°C (UNFCCC, 2015). To achieve this, nations have adopted various mitigation strategies, including carbon pricing mechanisms such as carbon taxation. Countries like Canada and Japan have demonstrated the effectiveness of carbon taxes in reducing emissions, particularly from the transportation and industrial sectors (Pretis, 2022).

Indonesia, the world's 9th largest emitter of CO<sub>2</sub>, contributes approximately 619 megatons of CO<sub>2</sub> annually, or about 1.7% of global emissions (Friedlingstein et al., 2022). In line with its commitment to the Paris Agreement, Indonesia has pledged to reduce its GHG emissions by 29% by 2030 (Kementerian Energi dan Sumber Daya Mineral, 2020). This commitment is supported by key legislative measures, including Law No. 7 of 2021 (Undang-Undang Nomor 7, 2021) and Presidential Regulation No. 98 of 2021 (Presiden Republik Indonesia, 2021), which enable the implementation of carbon pricing mechanisms such as carbon taxes. However, despite the legal framework, the rollout of Indonesia's carbon tax has been delayed—initially scheduled for 2022, it has now been postponed until 2025. The delay has been attributed to concerns about the readiness of the domestic carbon market, potential economic impacts on industries, particularly in the energy and transportation sectors, and the need for alignment with international regulations such as the European Union's Carbon Border Adjustment Mechanism (Indraini, 2022).

A fundamental challenge in ensuring the effective implementation of Indonesia's carbon tax policy lies in raising public awareness, fostering acceptance, and engaging the broader population in emission reduction efforts. Key barriers to successful implementation include:

1. **Limited Public Awareness and Education:** A significant proportion of the population lacks a clear understanding of the environmental impacts of carbon emissions and the role of carbon taxes. This knowledge gap hampers public support for the policy and impedes its successful adoption.

2. **Inadequate Tools for Carbon Activity Monitoring:** Many individuals have limited access to tools that allow them to monitor and accurately track their carbon-related activities, particularly in terms of emissions from transportation and household energy use. This lack of data makes it difficult for citizens to understand their carbon footprint and take proactive measures to reduce it.
3. **Absence of User-Friendly Carbon Tax Estimation Tools:** The complexity of carbon tax policies and their economic implications is often opaque to the general public. Without easy-to-use tools that estimate carbon tax obligations based on individual activities, it is difficult for citizens to understand their financial responsibilities under the new policies.
4. **Lack of Accessible Emission Testing Information:** Many citizens are unaware of the locations and requirements for vehicle emissions testing, a crucial component of regulatory compliance. This gap limits engagement with the emission reduction goals set by the government.
5. **Demand for a Comprehensive Digital Solution:** There is a clear need for an integrated digital platform that consolidates educational content, carbon tracking, tax estimation, and emissions testing information. Such a tool would empower individuals to take control of their carbon footprint, facilitate informed decision-making, and enhance participation in national carbon reduction initiatives.

To address these critical challenges, this study proposes the development of KarbonKU, a mobile application prototype designed to empower individuals in managing their carbon emissions. KarbonKU will enable users to record and track their carbon-related activities, estimate their carbon tax obligations, access educational content on climate change, and locate emission testing centers. By promoting transparency, increasing awareness, and fostering individual accountability, KarbonKU aims to enhance public engagement, drive behavioral change, and contribute to Indonesia's carbon reduction goals.

## 2. METHOD

This research aims to develop and evaluate a mobile application prototype, KarbonKU, designed to record carbon-related activities, calculate carbon tax estimates, and raise public awareness regarding carbon emissions. To achieve this, a mixed-methods approach was utilized, integrating both qualitative and quantitative research methods. The development process followed an iterative Agile Scrum Software Development Life Cycle (SDLC) model, ensuring flexibility in meeting user needs and incorporating continuous feedback during the design and implementation phases.

### Literature Review

The importance of developing mobile applications for carbon emissions management and education has been widely discussed in recent literature. According to Petersen et al., (2020), a mobile app to increase citizens awareness about their own carbon footprint, by integrating energy and transport-related data. Similarly with Cellina et al., (2019), argue that Smartphone apps persuading users to engage in more sustainable behaviour.

In terms of carbon taxation, Carbon taxes are widely seen as a key instrument of climate policy. Although many countries and regions have already implemented them in some form, they still face resistance. How people's prior knowledge about carbon taxation affects policy acceptability (Maestre-Andrés et al., 2021). The carbon-tax is often regarded as a profitable tool to mitigate emissions rate. The effectiveness of the carbon-tax was studied by many authors and the results differ according to the impact and objectives (Ghazouani et al., 2020).

### Research Methodology

The development of KarbonKU was carried out using the Agile Scrum approach, a flexible and iterative model commonly employed in software development. According to Al-Saqqa et al., (2020) Al-Saqqa, S. et al. (2020), Agile software development is a lightweight approach that was proposed to overcome the convolutional development methods' limitations and to reduce the overhead and the cost while providing flexibility to adopt the changes in requirements at any stage, this is done by managing the tasks and their coordination through a certain set of values and principles. The development process consisted of the following stages (*Roger Pressman*, n.d.) :

#### a. Product Backlog Maintenance

This stage is the process of rearranging and updating the list of system requirements (product backlog). This activity includes adding details, removing irrelevant items, and resetting development priorities. The goal is to ensure that the backlog is always up to date and ready to use in the next sprint.

#### b. Sprint Planning

Held at the beginning of each sprint, this meeting aims to plan work during the sprint period. The development team selects items from the product backlog to be included in the sprint backlog, which will then be worked on for one sprint cycle.

c. Sprint Execution

At this stage, all items in the sprint backlog are implemented by the development team within the specified sprint period. The main focus is to complete the priority features or modules.

d. Weekly Scrum

Regular weekly meetings are held every time to provide updates on progress, identify obstacles, and develop a work plan for the following week. This process helps maintain efficient communication over time.

e. Sprint Review

After the sprint is complete, a review of the sprint's work results is conducted. The team discusses the products or features that have been developed with stakeholders to get direct feedback. This feedback is used as a basis for improvements in the next sprint.

f. Sprint Retrospective

This internal evaluation stage is conducted to reflect on the sprint process that has been running. The focus is on increasing the effectiveness of the team's work process and improving managerial and technical obstacles so that they are not repeated in the next sprint.

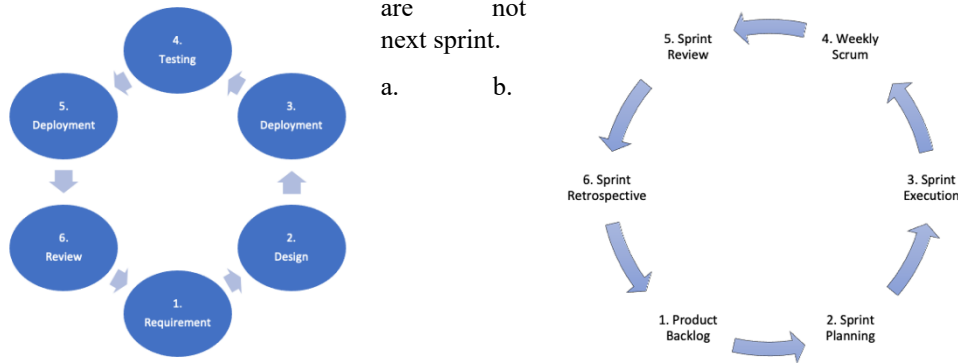


Figure 1. (a) Agile SDLC, (b) Agile Stages

## User Requirements Survey

To ensure the development of a user-centered application, a survey was conducted in March 2024, gathering data from 128 participants. The survey aimed to assess user needs, environmental awareness, and attitudes toward carbon tax monitoring applications. User requirement surveys are essential for understanding the demographic and behavioral patterns of potential app users, ensuring that the final product aligns with user expectations.

The following are the prioritized features along with the percentage of respondents who supported each one:

Table 1. Key Application Features Based on User Needs

| Feature                                                  | Result |
|----------------------------------------------------------|--------|
| 1. Educational Content on Carbon and Carbon Tax Policies | 77.3%  |
| 2. Accurate Carbon Usage Tracking                        | 72.7%  |
| 3. Carbon Tax Simulation Tool                            | 68.8%  |
| 4. Nearest Emission Testing Facility Locator             | 65.6%  |
| 5. Multi-Vehicle Registration per Account                | 60.2%  |
| 6. Carbon Usage Report Generation                        | 60.2%  |



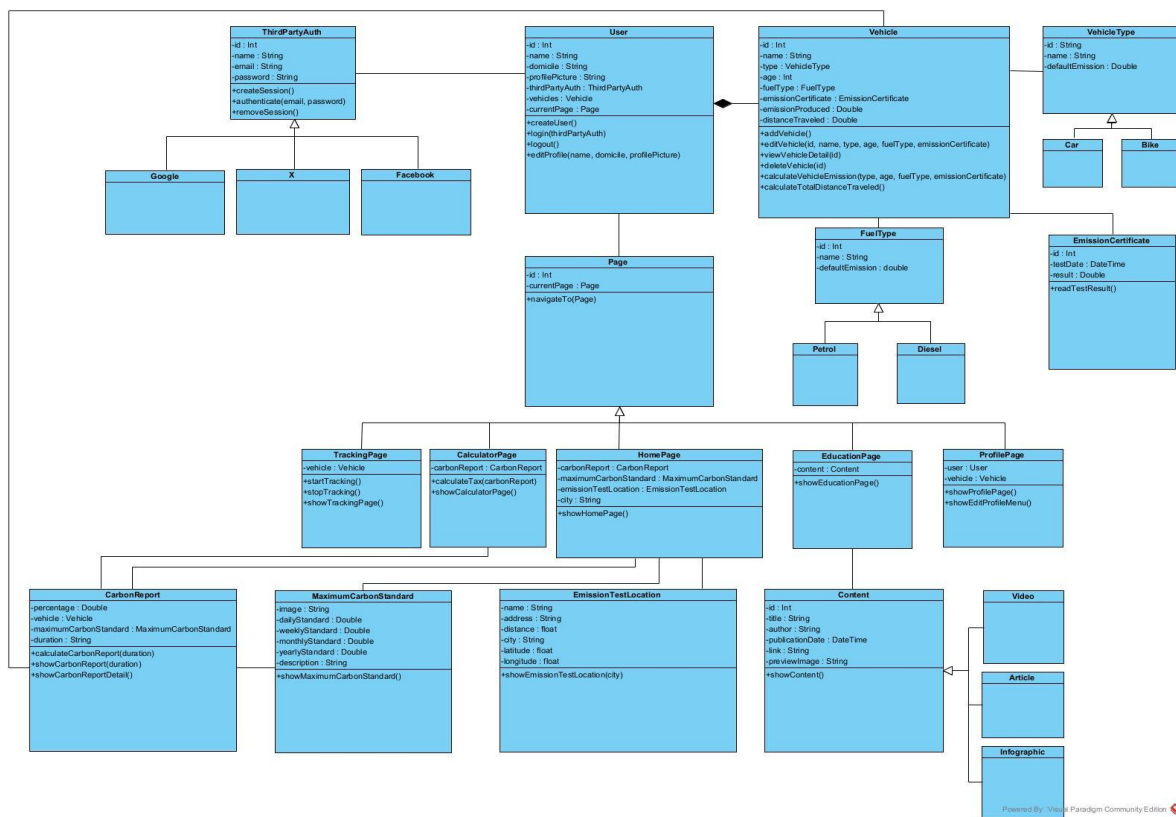


Figure 3. Class diagram KarbonKU Application

## User Interface

The following page serves as an introduction, presenting an overview of the KarbonKU application to new users. It provides a brief explanation of the functionalities and features available in the application. Users will see this page the first time they download and open KarbonKU, and can navigate through the sequence using the "Next" button provided or they can tap the "Skip" button to go directly to the login page.

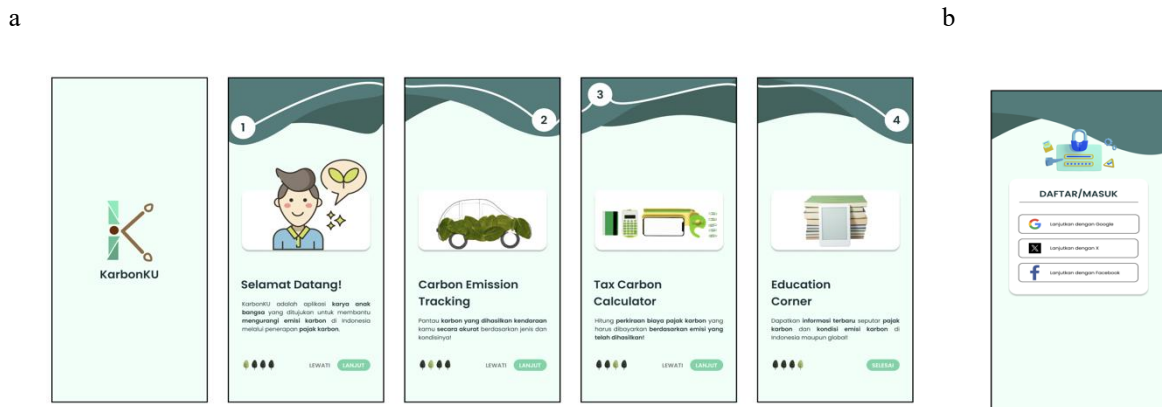


Figure 4. (a) Welcoe Page, (b) Login Page

After successfully registering, users access the Home Page of KarbonKU, which includes several key widgets:

- Carbon Report** – Shows a summary of carbon emissions and travel distance as a percentage of the maximum carbon standard. Users can view reports daily, weekly, monthly, or yearly.
- Report Detail** – Displays detailed daily emission records, including vehicle used, distance, and emission levels. Clicking expands it to show more details.
- Maximum Carbon Standard** – Provides users with emission limit guidelines (daily to yearly) based on a 2020 National Conservancy study (2 tons/year standard).

- d. Nearest Emission Test Locations – Lists nearby emission testing centers based on selected city, showing name, address, operating hours, and distance. Users can view locations on a map.

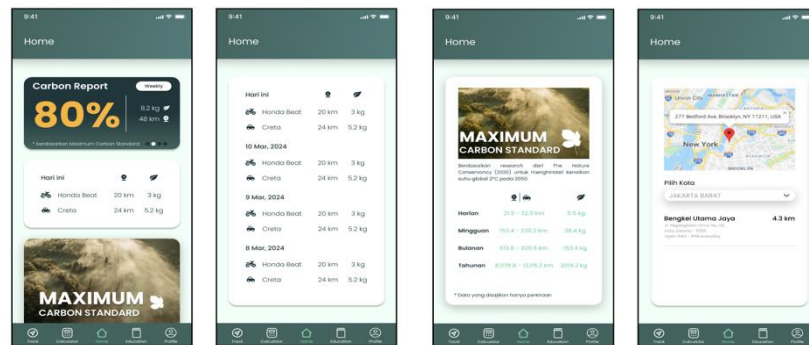
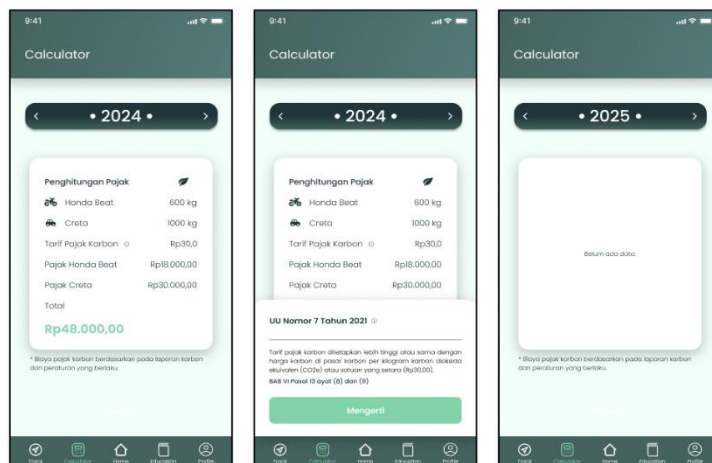


Figure 5. Home Page

a



b

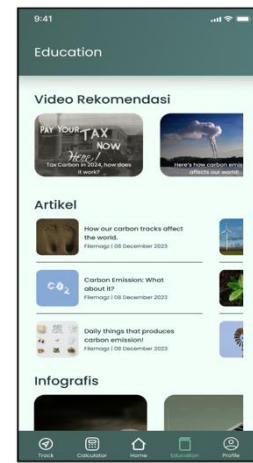


Figure 6. (a) Calculator Page, (b) Education Page

## Evaluation

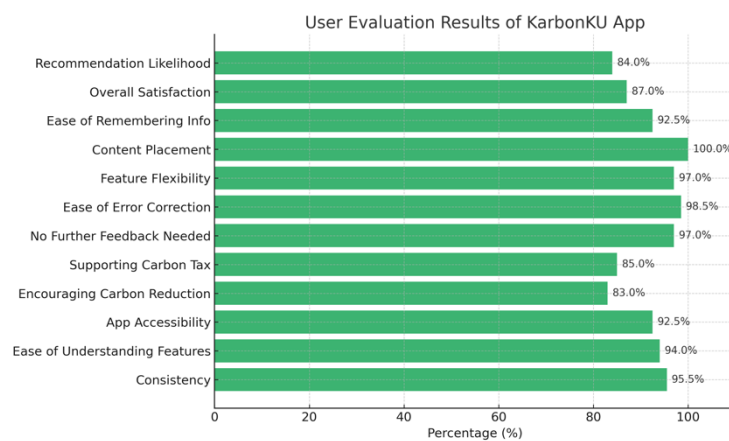


Figure 7. User Evaluation Result

To evaluate users' perspectives on the KarbonKU application's UI, a survey titled "Kuesioner Evaluasi User Interface Aplikasi KarbonKU" was conducted online. The questionnaire was distributed in December 2024 and was structured based on the 8 Golden Rules of Interface Design and the 5 Measurable Human Factors. The evaluation was based on an analysis of the average responses from 67 participants, as shown in the graph above.

User Acceptance Testing (UAT) was conducted to evaluate user feedback on the functionality of the KarbonKU application. The goal of this evaluation was to ensure that the application performs as expected in real-world scenarios, through analysis of feedback across all use cases of the KarbonKU application.

Table 2. User Acceptance Testing

| No | Use Case                    | Result | Feedback                                                                                           |
|----|-----------------------------|--------|----------------------------------------------------------------------------------------------------|
| 1  | Login                       | ✓      | Difficulty switching Google accounts due to automatic re-login.                                    |
| 2  | Third Party Auth            | ✓      | Suggests adding login via username/password or phone number.                                       |
| 3  | View Report                 | ✓      | Page indicator should be more visible; scrolling preferred within widgets.                         |
| 4  | View Report Detail          | ✓      | Data should be shown from most recent; add time filter.                                            |
| 5  | View Emission Test Location | ✓      | Default location should match user's domicile; allow manual city selection.                        |
| 6  | Track Carbon Emission       | ✓      | Display only a stop button during tracking; add auto-stop feature.                                 |
| 7  | Calculate Tax               | ✓      | Enable manual tracking entry in case of user forgetfulness.                                        |
| 8  | Browse Education            | ✓      | Improve background and text color contrast for readability.                                        |
| 9  | View Education Item         | ✓      | Add confirmation before accessing content; display it in-app.                                      |
| 10 | View Profile                | ✓      | Allow enlarging profile photos when tapped.                                                        |
| 11 | Edit Profile                | ✓      | Use dropdowns to ensure accurate domicile data input.                                              |
| 12 | Add Vehicles                | ✓      | Add preview, remove diesel for bikes, add octane, restrict age to <20 yrs, fix vehicle icon color. |
| 13 | View Vehicles               | ✓      | Feature is already functioning well.                                                               |
| 14 | View Vehicle Detail         | ✓      | Enable zoom-in on certificate photo.                                                               |
| 15 | Edit Vehicle                | ✓      | Suggests same improvements again (photo preview, options, restrictions).                           |
| 16 | Delete Vehicle              | ✓      | Feature is already functioning well.                                                               |
| 17 | Logout                      | ✓      | Add confirmation on logout; improve logout button design.                                          |

## 4. CONCLUSION

Based on the analysis of the results and discussion, it can be concluded that the KarbonKU application provides several useful features that support users in tracking and managing their carbon emissions. The results of this research show that the carbon tracking feature helps users record their daily carbon-related activities, the tax calculator assists in estimating carbon tax calculations, and the educational content enhances public awareness of the environmental impacts of carbon emissions. Overall, the KarbonKU application plays a significant role in encouraging public participation in reducing carbon emissions in Indonesia and supports the implementation of carbon taxes in the transportation sector.

The system can be further improved by expanding its functionality to include features such as language selection, manual data input for the tax calculator, and time filters in the carbon report section. To improve the accuracy of carbon tracking, it is recommended to incorporate additional parameters like fuel quality, engine condition, and OCR technology for reading emission test certificates. Enhancements to the user interface can also be made by ensuring consistency in language, improving system feedback, and presenting additional information more effectively. Future development may also consider building versions of the application for various mobile operating systems to reach a broader range of users.

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