# Web-based dashboard of data integration for green highway performance management

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## ABSTRACT

Highway concessionaires in Malaysia spend considerable assets for managing different forms of data during highway projects' life cycles. In this context, and based on the use of modern technologies, an enormous volume of highway data is generated daily. These data can be utilized to extract and evaluate indicators to analyze highway green performance. Feedback from indicators allows to grasp the sustainable practices and implement corrective actions. Dashboards have become popular in recent years as uniquely powerful tools for communicating important information. This research adopted the approach of a centralized data provider to develop a web-based visualization dashboard, as a technique to reinforce decisions in the highway sector. The dashboard will be employed to gain information about highway green performance to enhance decisions. In this dashboard, data integration of Malaysia Green Highway Index and Carbon Footprint Calculator has been used in illustrating the visualization. The development utilized a web-based multi-programming language. The quantitative and qualitative measures were used to validate the dashboard. Findings demonstrated an increase in accuracy of data monitoring and quicker decision-making using the Dashboard. The outcome of this research will add value to the green highway development and map the highway towards a better and sustainable quality of life nationally and internationally. Furthermore, this research will pave the way for future researchers to integrate other efficient tools and parameters that contribute towards sustainable development.

**Keywords:** Big Data; Carbon Footprint; Data Visualization; Dashboard, Green Highway Rating System.

## INTRODUCTION

Today global data generation is huge and daunting (Perra, Rossi, Samay, & Vespignani, 2020). We depend on a large variety of instruments and sources of knowledge, and massive volumes of data can be analyzed on numerous social and environmental phenomena. This circumstance brought a new and demanding requirement: to obtain meaningful information from such data to be able to explore beyond it (Berengueres & Ferran, 2020). So, the mutual scare element is the capacity to recognize that data and reproduce value from it (Vila, Estevez, & Fillottrani, 2018). Different principles were created to tackle the quality and usage of data in organizations. Determining data efficiency and the integration of multiple sources of data to get useful information, monitoring the performance, and taking the right decision (Hafifi Che Wahid et al., 2019).

Malaysia Highways are among the country's most crucial infrastructures, and they play a critical function in a country's social and economic growth. Malaysia highway authority is committed to contributing to the government's target for greenhouse gas (GHG) emissions reductions. The introduction of the "Malaysia Green Highway Index (MyGHI)" in 2014 was introduced which concerns in-depth sustainable practices. However, highway authority, concessionaire, and University Technology Malaysia (UTM) extend their study in 2018 to a holistic assessment of the impact of Malaysian highways on the environment. They establish the Carbon Footprint Calculator (CFC) to calculate the greenhouse gases emissions and to assess the impact on the national environment. In Malaysia highway management, the green assessment data are converted into usable information (Ramlia et al., 2019). This information is used to help relevant decisions at various stages and processes during the life cycle of a highway project (Yousif et al., 2018).

Once the number of highway projects increased over time, a large amount of data had to be managed. The data from MyGHI and CFC are varied and big and need to be integrated,

managed, and visualized. A web-based dashboard for Malaysia's green highway data integration framework is established to represent the overall evaluation process of the green project's assessment. This data integration would include insight on GHG pollution levels that can be used to build a stronger pollution management strategy. This data integration is useful for highway assessment and visualizing the green performance.

This research built a bridge between the MyGHI, the CFC of the highway projects, and the important decision support system. The decisions that will be aided are wide-ranging from implementing green initiatives to help reduce the GHG emissions from highways lifecycle, and strategies to increase their green scores for all MyGHI criteria. The developed dashboard uses the dynamic website system, which is known as a form of web software, and applies the approach of systematic and solid application creation to ensure product quality and standard (Yahaya, Ibrahim, & Deraman, 2017). To offer a user-friendly experience for integrating MyGHI and CFC data, a graphical user interface (GUI) was developed by using multi-programming languages. This Web-based GUI Called Malaysia Green Highway Dashboard. There are several practical applications of the dashboard (Gowthami & Kumar, 2017). This research dashboard can be used to identify the high levels of GHG emissions during the project's lifecycle and can note the changes in the green performance according to MyGHI criteria.

## METHODOLOGY

At present, both MyGHI and CFC data in different structural forms are stored in different various spreadsheets and reports. The data from highway concessionaires regarding the CO2 emissions from each element of CFC plus the scoring obtained for each category of MyGHI, all these data are individual and to reach this data is not easy and simple, as a result, both projects are independent of each other and works as a separate entity meanwhile they should work as one entity. Therefore, data integration and visualization are needed to enhance the evaluation of data efficiency. So, the gap here is the two projects complement each other for the highway projects sustainability. Therefore, to fill this gap, there is a need for a comprehensive approach

for integrating MyGHI with CFC and to visualize and displays this comprehensive integration into one interface that unites the two projects together and represents a quick decision-making system that can be developed by the web-based dashboard. To solve such a problem the initial steps were carried out at the beginning of the research from identifying the problem, determining the research area, aim, objectives, and scope of the research study followed by significance and novelty of the research to achieve the aim. Figure 1 presents the structural functionality of the research. However, the experimental framework for dashboard development can be seen in figure 2.

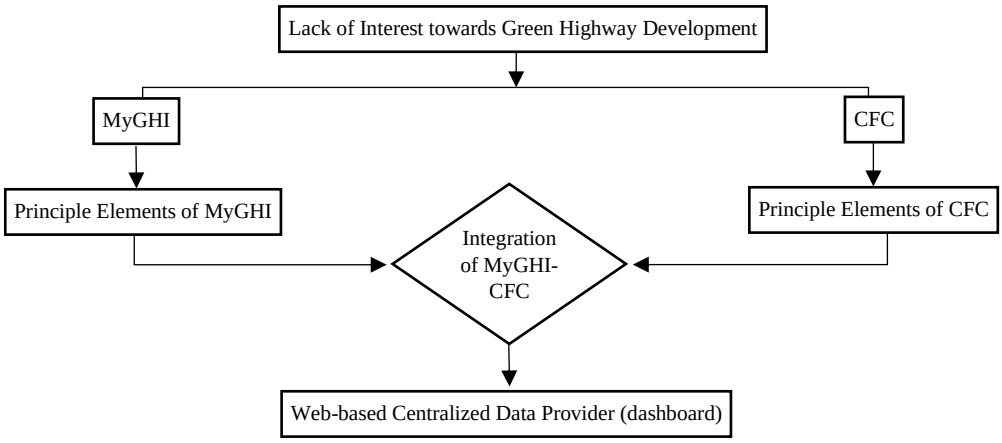


**Figure 1.** Structural functionality of the research

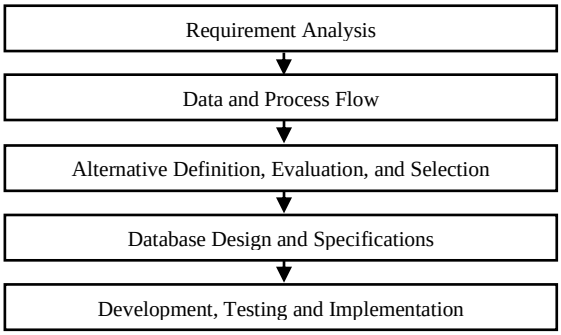


**Figure 2.** An experimental framework for dashboard development

## ARCHITECTURAL SYSTEM DESIGN AND MODELLING OF DASHBOARD

An applied Centralized Data Provider (CDP) for the Decision Support System (DSS) for integrating MyGHI data with CFC must comprise three master capabilities: collecting the data and saving it in the database, creating the concessioner's profile, and displaying the analyzed data. Through the dashboard development stage, these abilities were considered. The DSS can be utilized to guide the top management in the process of highway assessment and enhancing new green-certified projects. The web-based integration dashboard architectural system is shown in Figure 3. This shows that upon entering the website, the user can choose which evaluation presents.

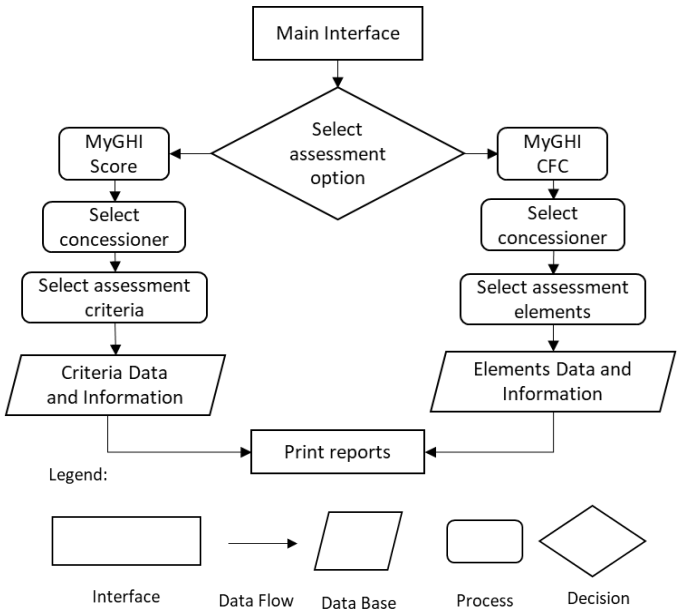


**Figure 3.** Web-based integration dashboard architectural system

Many studies that adopted and developed monitoring systems in the construction industry. The core principle of monitoring systems is to transform data into information, to make it useful, Table 1 is a summary of some of these studies. In the table, the previous studies were analyzed and sort them into categories according to the context of the research, clearly can notice that monitoring systems were developed for most aspects of the construction industry, furthermore, the core of the researches study was briefly addressed with the most important keywords were mentioned.

**Table 1.** Summary studies of some integrating monitoring tools in the construction industry.

| Research context | Important keywords | The core of the research area | Authors |
|---|---|---|---|
| Health & safety | Risk, hazards, privacy, compliance | Develop a construction risk map, a structural health monitoring system, and a framework for storing and analyzing real-time data | "(Antwi-Afari et al., 2018; O'Shea & Murphy, 2020; Oswald, Sherratt, & Smith, 2018)" |
| Stage monitoring | Feedback control, stage analysis | Develop a system for information integration | "(Gao, Zhou, Liang, Weng, & Zhu, 2020; Li, Xue, Li, Hong, & Shen, 2018; Liu et al., 2020)" |
| Energy monitoring | Saving, consumption, efficiency | Develop multi-technologies integration tool for energy management | "(Ali, Coté, Heidarinejad, & Stephens, 2019; Degha, Laallam, & Said, 2019; Jradi et al., 2018)" |
| Smart monitoring | IoT, BIM, sensors, smart buildings | Develop multi-technologies integration tools for building monitoring | "(Edirisinghe & Woo, 2020; Ferreira, Resende, & Martinho, 2018; Shi et al., 2020)" |
| Water management | Water quality, microcontroller, sensors | Develop an intelligent water management system using multi-technologies | "(Mirauda, Capece, & Erra, 2020; Sirombo, Filippi, Catalano, & Sica, 2017; Yasin et al., 2021)" |
| Facility management | Sensors, data processing, building life cycle | Develop a predictive integrated analysis tool for the facility management system | "(Arslan, Riaz, & Munawar, 2017; Gouda Mohamed, Abdallah, & Marzouk, 2020; Quinn et al., 2020)" |
| Data management and visualization | Information modeling, heterogeneous data, real-time monitoring | Develop a big data management system by integrating multi-technologies | "(Gara, Zakaria, Aminudin, Adzar, & Yousif, 2021; Lv, Li, Lv, & Xiu, 2020; Yousif et al., 2021)" |
| Disaster and emergency response | Unmanned aerial vehicles, wireless sensor, evacuation/rescue route optimization | Develop an emergency response system | "(Chen, Liu, & Wu, 2018; Kamilaris & Prenafeta-Boldú, 2018; Park et al., 2018)" |
| Waste management | Solid waste, Environmental impact, Conservation of resources | Develop a construction waste management system | "(Espuny et al., 2021; Suomi, Serkkola, & Korhonen, 2017; Yusof, Jidin, & Rahim, 2017)" |
| Predictive maintenance | Decision support system, detection, forecasting | Develop a real-time information system for prediction | "(Cheng, Chen, Chen, & Wang, 2020; Massaro, Galiano, Meuli, & Massari, 2018; Tsai et al., 2019)" |

## DASHBOARD INTERFACE DEVELOPMENT

A dashboard (GUI) that be similar to somewhat the dashboard of a vehicle's, arranges and displays the information in a manner that is easy to understand. This dashboard project aims to integrate and present information from multiple components which as MyGHI and CFC into one integrated display, it is referred to as MyGHI-DASHBOARD. This interface is designed as a web application. It includes a command where users can simply click and the application responds to that command, also the users can interact with the application using images, boxes,

hyperlinks, and graphs rather than text. The user interface (UI) is what the user sees, the user cannot access the source code of the interface.

The homepage of the dashboard is often crucial, it will give clients the first indication when they enter the website, so it should be integrated and appealing to magnetize clients to come back over. Anyone who looks into the main site will see the first interface that appeared in the MyGHI Dashboard website as shown in Figure 4. The home page is the web site's primary or major Web page. The home page is being utilized to make access to other pages of the dashboard by including links to prioritize pages and information regarding the dashboard features. Meanwhile, the website uses the home page to magnetize clients to register to access the dashboard.

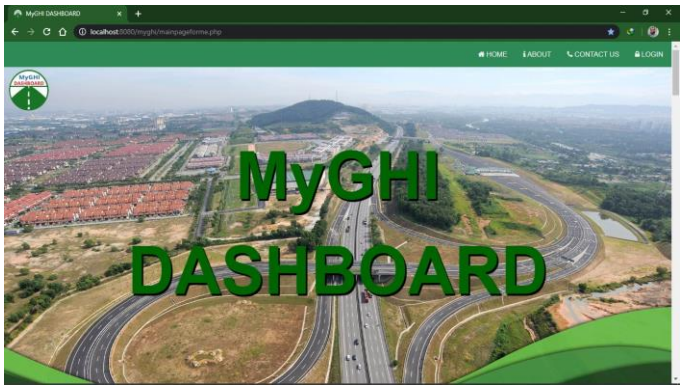


**Figure 4.** Dashboard website home page

Homepage and all other dashboard pages are divided into several parts according to positions: header, footer, right and left bars. User's personal information such as their username and profile picture will be shown in the header navigation bar of the dashboard. On the left sidebar of the dashboard, there are widgets, the widget is a common term for the UI component which helps the user to communicate with the software. Widgets show information and promote the user to respond in a variety of different ways. Its features include switches, dropdown menus, pop-up tabs, search boxes, and tabs, it is called the sidebar menu as shown in Figure 5. In essence, through the sidebar, we can browse and monitor the two projects that were integrated into this dashboard, as will be discussed in detail in the following sections.


**Figure 5.** MyGHI user dashboard interface

**Myghi assessment**

The MyGHI comes with categories and levels. Under the MyGHI Score section at the sidebar, users can find “MyGHI Categories”, “MyGHI Levels” and specific information related to each concessioner such as PLUS, BESRAYA, KESAS, and all the rest of the concessioner list. The user needs to simply click on what he is looking for to display according to the workflow as shown in Figure 6. The workflow mapping in Figure 6 shows the whole sub-sections available under the MyGHI Score section.

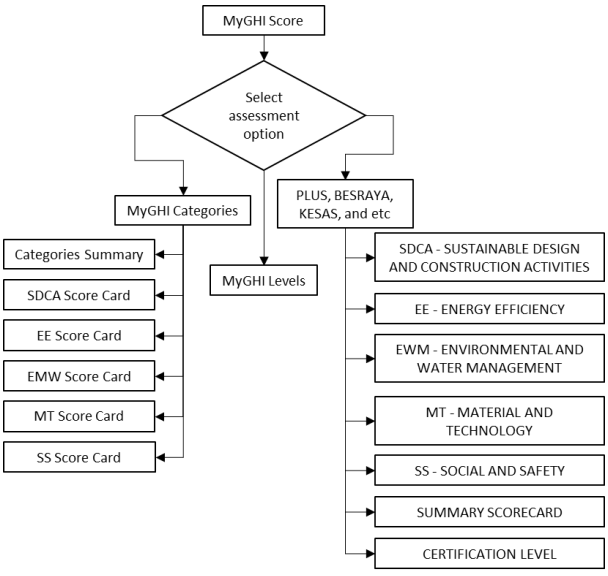


**Figure 6.** Workflow mapping for MyGHI assessment menu

For every concessioner, registered users are only allowed to view and monitor the performance of the main criteria scorecard, total scores, and certification level. In addition, users can generate a report by clicking on the print button. The report will be generated in pdf format. This report will be printed for evidence and record purposes as shown in Figure 7.


**Figure 7.** Concessioner (X) MyGHI-SDCA scorecard

**CFC assessment**

The CFC comes with categories and elements. Under the CFC Assessment section, users can find Emission factors and specific information related to each concessioner such as PLUS, BESRAYA, KESAS, and all the rest of the concessioner list. The user needs to simply click on what he is looking for to display according to the workflow as shown in Figure 8. The workflow mapping in Figure 8 shows the whole sub-sections available under the CFC section.

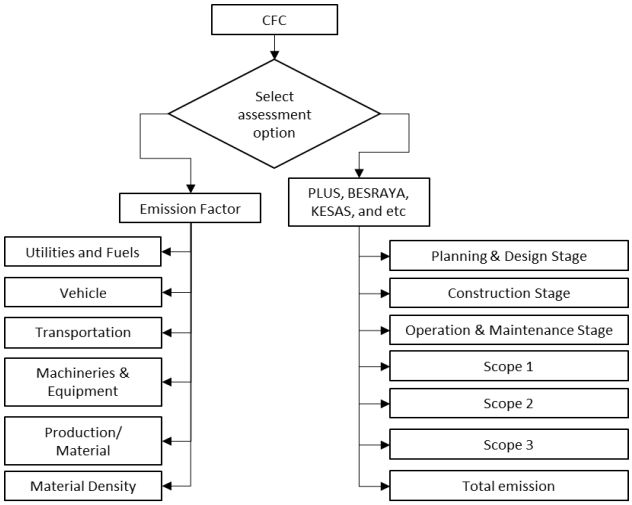


**Figure 8.** Workflow mapping for CFC Assessment menu

For every concessioner, users are only allowed to view and monitor the performance of elements and total emissions. In addition, users can generate a report by clicking on the print button. The report will be generated in pdf format. This report will be printed for evidence and record purposes as shown in Figure 9.

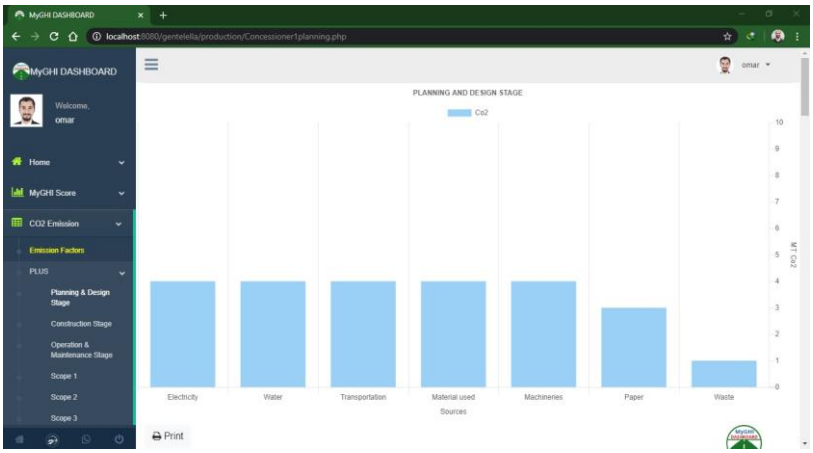


**Figure 9.** Concessioner (X) planning and design stage carbon emissions

## VALIDATION OF THE INTEGRATION DASHBOARD

During the development, several test methods were used to validate the performance of the system. System testing offers manual and automatic means to run and check the application functionality, evaluate if it satisfies defined criteria or intended outcomes. To deliver high standards, the system places a priority on reliability and integrity. Also, for software testing, the Black Box testing method is used as an approach to examining the functionality of the application without peering into its internal structures. This method is used to let users who are not experienced with the internal structures of the system, providing inputs and verify the outputs against the expected outcome (Xu, 2017). The following are several different detailed function tests.

**1)** User Registration Test: User registration is an important process to access the dashboard, it's required to assure system functionality. Testing the registration form is not as simple as testing a static page because it requires connecting to the database and writing (insert) user information into the database, user information needs to be unique, otherwise, the database will return an error message. A test case has been performed and all succeed as shown in Table 2. While testing we try to find any errors in the system and database connections. The test has verified the entries comply with the terms and conditions that have been set up in the system and correctly entered into the database.

**Table 2.** User Registration Test

| **Test case** | **Test result** |
|---|---|
| Username, Email, password, organization, position, upload profile picture all are empty fields | Success |
| The password is in masked form when entered | Success |
| The password cannot be “copied” or “pasted” | Success |
| Test email format is illegal (example@example.xxx) | Success |
| The login button labeled "login in" runs and will be routed to the login page by clicking on it | Success |
| In case the user left fields blank, the notification message will be shown. | Success |
| (Scenario case to validate the data inserted correctly to the database) Username: omar; Email: omar.ameen93@gmail.com; Password: 0000; Organization: UTM; Position: Researcher; Upload Profile picture: omar.jpg | Success |

**2)** User Login Test: Testing of the user login is very important for any application in terms of the security aspect. When registered users log in by filling in the login form using their login information, thereafter send it to the webserver, follow it directly the system will check if the username is existing in the database and the password entered for this username is the same as the password in the database, via this process, the server picks the right login credentials, sets a session cookie in the user browser and the dashboard UI is accessed. The session cookie is used for all further communications with the webserver, authenticating the user as a logged-in user. If the user entered a wrong username or password or even entered a non-existent username a warning message will show up and the user will remain on the same page. Therefore, need to write a test for the user login, the test is performed to assure the application’s functionality, all test cases have been performed and all are succeeded. The following are the results of the user login test details as shown in Table 3.

**Table 3.** User Login Test

| **Test case** | **Test result** |
|---|---|
| By clicking the "Tab" key on the keyboard the user will maneuver or access the different controls. | Success |
| The password is in masked form when wrote | Success |
| The password cannot be “copied” or “pasted” | Success |
| Through entering valid information and clicking on the "Login" button or pressing "Enter key" the user will log in | Success |
| The user is not capable of log in with an invalid username and password and a warning message is displayed. | Success |
| In case the user left fields blank, the notification message will be shown. | Success |

| | |
|---|---|
| The reset password button labeled “lost your password?” runs and will be routed to the “Contact Us” section by clicking on it | Success |
| The create account button labeled “create account” runs and will be routed to the “registration page” by clicking on it | Success |

**3)** Graphical User Interface Test: Within this section the method of evaluating the application's graphical user interface, to ensure it meets the specifications. This is normally done through the use of a variety of test cases, this testing technique is used to identify the presence of defects in the software. GUI examination is an evaluation of the graphical components to ensure that the application works best perfectly. GUI validation includes inspecting the displays with controls and testing the functionality of the website to users on varying configurations of browser operation systems and machines. Tested on Microsoft Edge, Firefox, Google Chrome, and Apple Safari, all test case results are succeeded as shown in Table 4.

**Table 4.** GUI Test

| **Test case** | **Test result** |
|---|---|
| All icons and controls are available on the UI, including textbox, controls, and connections, which are correctly arranged | Success |
| The font style and width of the labels are visible and easy to understand | Success |
| The scale and coloring of the various UI components shall be as per the requirements | Success |
| The interface is flexible and can conform to various screen and system configurations | Success |
| When logging in, the user will not log out by pressing the Back button. | Success |
| All navigations and events like keypress/mouse click | Success |
| Verify data integrity | Success |
| The date field and numeric field formats | Success |
| Graphs/charts appear according to the standards and the data are correct | Success |
| The images have good clarity and are properly aligned | Success |
| The error message shall be delivered in RED color where relevant | Success |

## CONCLUSION

This research develops a new framework to build a bridge between the MyGHI, the CFC of the highway projects, and the important decision support system. This study transformed the integration into the web-based dashboard. This dashboard will develop a new creative program for the construction industry and especially for the highway sector. This integrated application ensures an effective, simple, fast, and smarter program to monitor green highway performance, monitor carbon emissions, and smarter important decisions making. The proposed system

would greatly revolutionize the way data are gathered, processed, and handled by fulfilling the needs of customers and the priorities of organizations in improving the decision-making systems of concessionaires.

This innovation is making the assessment process more user-friendly and efficient, reducing data complexity, easy data collaboration, and data integrity. The developed web-based dashboard will display data and results of the evaluations for all of the criteria of MyGHI and elements of CFC for each concessionaire. The dashboard has been successfully validated using various functional and non-functional tests, the tests are to identify the agreement level of the users on the functionality, reliability, usability, efficiency, and portability of the dashboard. This project can be utilized by governmental authorities and be incorporated into their existing tools for more and better green-certified highway development locally and globally. This integration can be developed to include financial aspects as well, and further developed an integrated system to include all types of highway and country's roadways.

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