

Web-Based Dashboard of Data Integration for Green Highway Performance Management

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Submitted : 09-09-2021

Revised : 16-03-2022

Accepted : 17-03-2022

ABSTRACT

Highway concessionaires in Malaysia spend considerable assets for managing different forms of data during highway projects life cycle. 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 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 with the goal of enhancing decisions. In this dashboard, data integration of MyGHI and CFC has been used in illustrating the visualization. The development utilized a web-based system, using HTML and CSS to build up basic static UI; use JavaScript to archive the processing data dynamically; use PHP to control models' logical function and MySQL database. 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.

Keywords: Big Data; Carbon Footprint; Centralized Data Provider; Dashboard; Data Integration; Data Visualization; Decision-making; 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 and collected on numerous social and environmental phenomena (Beneventano, Bergamaschi, Gagliardelli, & Po, 2015; Colmenar, Muslim, & Dara, 2014; Petychakis, Vasileiou, Georgis, Mouzakitis, & Psarras, 2014). This circumstance brought a new and demanding requirement: to obtain meaningful information from such data in order to be able to explore beyond it (Berengueres & Ferran, 2020). The capacity to capture data in order to grasp it, to analyze it, to generate interest from it, to envision it, to interact it will be a tremendously essential skill in the coming years, because now we really do have basically open and scattered data. So, the mutual scare element is the capacity to recognize that data and reproduce value from it (Varian, 2009; 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 from multiple sources of data to get useful information, real-time data analysis, monitoring the performance and taking the right decision (Wahid et al., 2019). In Malaysia highway management, the green assessment data are converted into a usable information (Ramli et al., 2019). This information is used in order to help relevant decisions at various stages and processes during the life cycle of a highway project (Yousif et al., 2018). A web-based dashboard for Malaysia green highway data integration framework is established to represent the overall evaluation process of the green project's assessment. This data integration would include an insight on GHG pollution levels that can be used to build a stronger pollution management strategy. The data integration for Malaysia Green Highway Index (MyGHI), is useful for highway assessment and visualizing the performance. It has the power to manage highway data efficiently and has the potential to further reduce the energy and carbon emission. As well as help to monitor the amount of carbon emission before and after the reduction action is implemented.

This research built a bridge between The Malaysia Green Highway Index, the carbon footprint of the highway projects and the important decision support system. The developed dashboard uses the dynamic website system, that 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 Malaysia Green Highway Index (MyGHI) and Carbon Footprint Calculator (CFC) data, a graphical user interface (GUI) was developed by using 4 Programming languages, Hypertext Pre-processor (PHP), Hypertext Mark-up Language (HTML), Cascading Style Sheets (CSS) and JavaScript (JS). 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 lifecycle of the projects, can note the changes in the green performance according to MyGHI criteria, and the project manager can allocate his resources accordingly. The framework is also capable of generating performance indicators (KPIs) for various activities or a company's investments. This is significant, since green managers mostly have to coordinate several concurrent projects for highway construction firms. Usage of the dashboard allows them to distribute their time and money wisely.

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 save it in the database, creating the concessioner's profile, and display 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 the highway assessment and enhancing of new green certified projects.

This web-based application gives users a comfortable place to monitor, manage and comparison between concessionaire's green performance. The system is divided into two division specified according to the authorizations, first is the client-side and on the other side is the administration. There is the registration, login, dashboard display, concessioners detail information and compression of green performance in the client-side; there is a user control, GUI modifications, data control, and display control for the administration to control and preserve the system functionality.

The web-based integration dashboard architectural system as shown in Figure 1. Shows that upon entering the website, the user can choose which evaluation he presents. The integration engine will request the data for each concessioner from the database of both MyGHI scoring and CFC, the data will be imported then visualized. Once the data is entered in the databases, the dashboard loads the data from the databases to the integration engine and subsequently plots the graphs to easily understand the analyzed data.

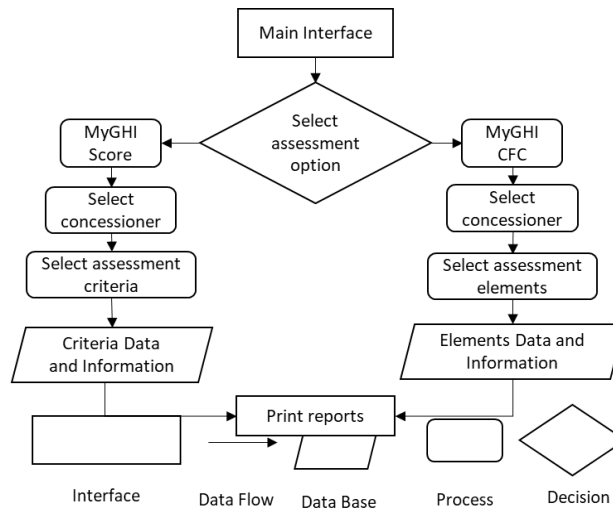


Figure 1. Web-based integration dashboard architectural system

The system includes build up customized web pages, such as the dashboard home page. These reuses static elements of web pages while defining dynamic elements based on parameters of web requests. Web services support static content, including the basic framework and shape (Himschoot, 2019). The web framework consists of: a template processor, the system's primary processing element; information resource, any of the various types of input data sources, such as from a SQL database, CSV files, and other forms of personal or network data; template resource, software models defined in a template language (Yadav, Rajpoot, & Dhakad, 2019).

For this system, any visitor can browse the home interface but only registered user can browse the dashboard, so when user want to select a concessioner and want to display their performance results, they should login first. If the visitor has right login credentials, they will simply login; if not, they require to register before, thereafter login. If they successfully enter, they are able to tour, check, monitor and take the right decision to improve their green performance.

The dynamic website is one in which a certain content of the response is dynamically created, whenever required. HTML documents are developed on the dynamic website by importing data from a database into template in HTML frameworks; this is an effective way to store large quantities of information than using static websites. Also, the dynamic website can return back different information for a URL based on user information or interests stored and may execute other operations as part of delivering a response (e.g. delivering notifications) (Kondal, Shah, & Slutsker, 2020).

Dashboard Interface Development

A dashboard Graphical User Interface (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 is Malaysia Green Highway Index and Carbon Footprint Calculator into one integrated display, it is referred to as MyGHI-DASHBOARD. This interface is designed as a web application. It includes 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.

he homepage of the dashboard is often crucial, it will give clients first indication when they enter the website, so it should be integrated and appealing to magnetize clients to come back over. Anyone who look into the main site will see the first interface that appeared in MyGHI Dashboard website as shown in Figure 5. The home page is the website'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 2. Dashboard website home page

Homepage and all other dashboard pages are divided into several parts according 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 called the sidebar menu as shown in Figure 6. In essence, through the sidebar, we can browse and monitor the two projects that were integrated into this dashboard, as it will be discussed in detail in the following sections.

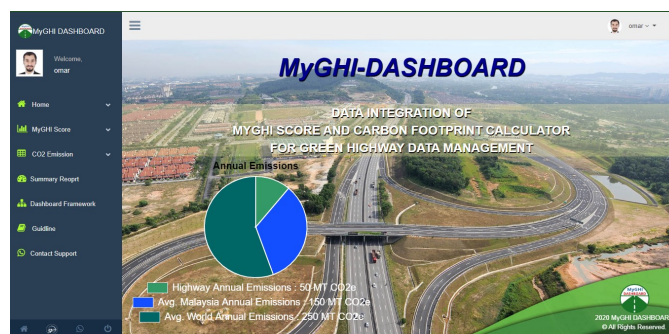


Figure 3. MyGHI user dashboard interface

MyGHI Assessment

The Malaysia Green Highway Index 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 concessioner list. User needs to simple click on what he is looking for to display according to the workflow as shown in Figure 7. In the workflow mapping in Figure 7 show the whole sub-sections available under MyGHI Score section.

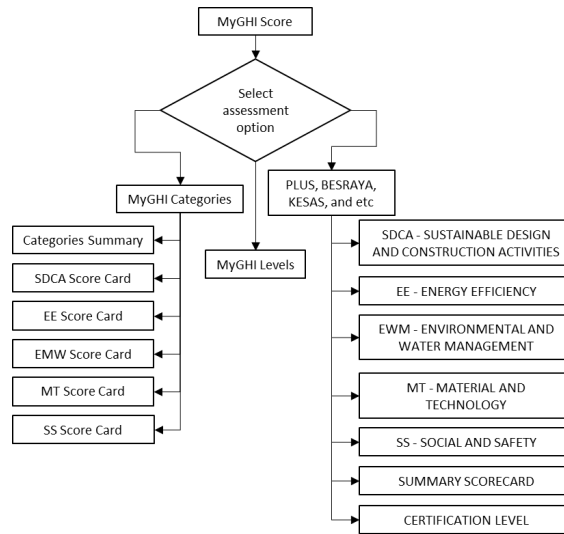


Figure 4. Workflow mapping for MyGHI assessment menu

For every concessioner, registered users are only allowed to view and monitor the performance of main criteria scorecard, total scores and certification level. In addition, users can generate report by clicking on print button. Report will be generated in pdf format. This report will be printed for evidence and record purposes as shown in Figure 8.

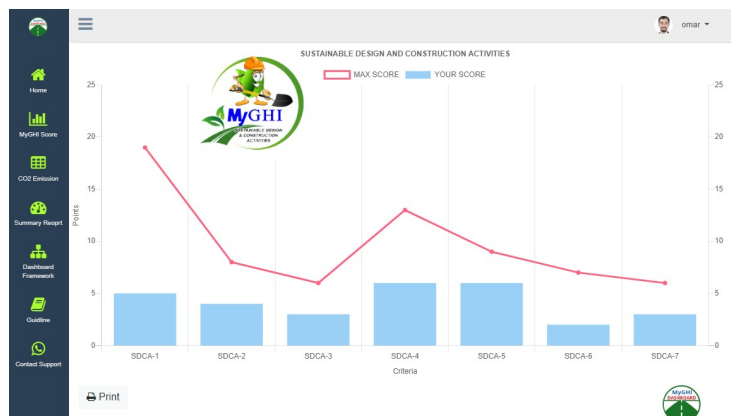


Figure 5. Concessioner (X) MyGHI-SDCA scorecard

CFC Assessment

The Carbon Footprint Calculator 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 concessioner list. User needs to simple click on what he is looking for to display according to the workflow as shown in Figure 9. In the workflow mapping in Figure 9 show the whole sub-sections available under CFC section.

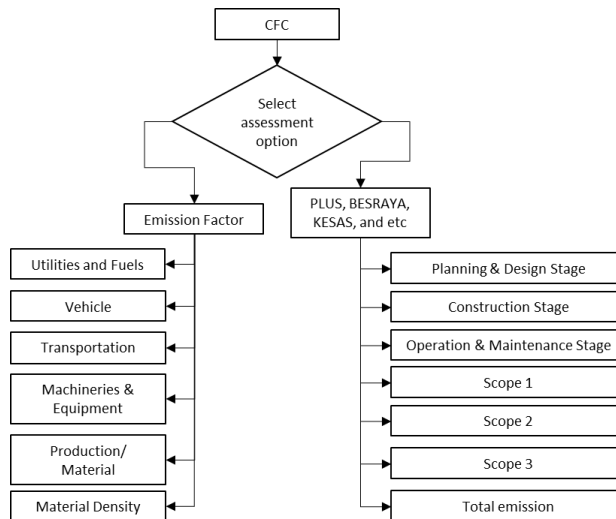


Figure 6. Workflow mapping for CFC Assessment menu

For every concessioner, users are only allowed to view and monitor the performance of elements and total emissions. In addition, users can generate report by clicking on print button. Report will be generated in pdf format. This report will be printed for evidence and record purposes as shown in Figure 10.

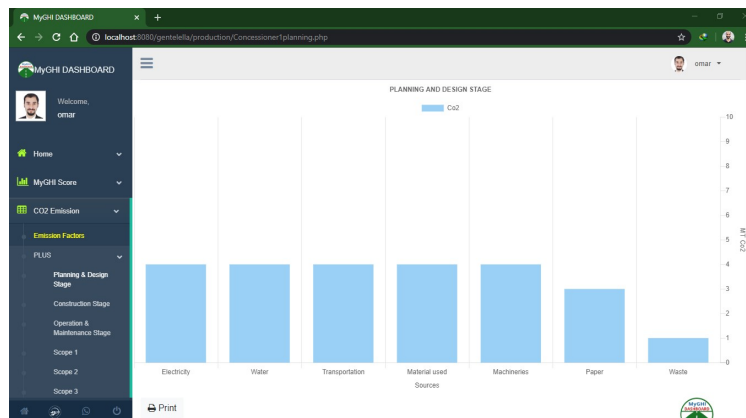


Figure 7. Concessioner (X) planning and design stage carbon emissions

Validation of the Integration Dashboard

During the development, several test methods used to validate the performance of the system. System testing offers manual and automatic means to run and check the application functionality, procedure, 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 used as an approach to examines the functionality of the application without peering into its internal structures or workings. This method used to let users who is not experienced with the internal structures of the system, providing inputs and verifying the outputs against the expected outcome (Xu, 2017). This method of test applied virtually to every level of the software testing: unit, integration, system and acceptance. The tests results will be discussed and illustrated in the following sections.

Function Test

Functional validation where the program is evaluated against the operational requirements and specifications. Properties or behaviors are evaluated by feeding inputs and inspecting the results. Functional validation to assure the application meets the requirements correctly. Such type of testing is not about how the processing happens, but about the processing outcomes. Functional validation to assure the application meets the requirements correctly. Such type of testing is not about how the processing happens, but about the processing outcomes. It imitates real usage of the system but does not make any presumption about system architecture. The following is several different detailed function tests.

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 to connect to the database and write (insert) user information in to the database, user information need to be unique, otherwise the database will return an error message. A test cases has been performed as shown in Table II. The test will find any errors in the system and database connections. The test has verified the entries are in compliance with the terms and conditions that have been set up in the system and correctly entered into the database.

Table 1. User Registration Test

Test case	Test result	Operation procedure
Username, Email, password, organization, position, upload profile picture all are empty fields	Success	Go to login page to check After filled in all required info, registration successfully
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	If user name, password is empty, or used before, registration failure
(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	Once registration success will be redirected to the login page to check

1) User Login Test: Testing of the user login is very important for any application in terms of security aspect. When a registered users logging in by filling in the login form using his login information, thereafter send it to the webserver, follow it directly the system will check if the username is exists 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 web server, 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. The following is user login test details as shown in Table III.

Table 2. User Login Test

Test case	Test result	Operation procedure
Through clicking the "Tab" key on the keyboard the user will maneuver or access the different controls.	Success	Go to login page to check After filled in all required info, should Logging in successfully If username, password is empty, or not matched with the database, Logging failure
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 login	Success	
The user is not capable to login 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 labelled "lost your password?" runs and will be routed to the "Contact Us" section by clicking on it	Success	
The create account button labelled "create account" runs and will be routed to the "registration page" by clicking on it	Success	

2) 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 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 such as menus, keys, symbols and other toolbar types, menu bar, text boxes, containers etc. The performance of this application depends heavily on how the GUI communicates with the user and how simple it is to use the various features. The following are GUI evaluating details it's been tested under the Manual evaluating approach, under this method graphical displays are manually reviewed in compliance with the specifications as can be seen in Table IV.

Table 3. GUI Test

Test case	Test result	Operation procedure
All icons and controls are available on the UI, including textbox, controls and connections, which are correctly arranged	Success	Browse through the dashboard pages to check, application operation is successful
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 logout by pressing the Back button.	Success	
All navigations and events like key press/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	

Browser Compatibility Test

The browser adaptability testing is carried out as a non-functional method of evaluating components of the application structure, which focuses on the functionality of the essential features and capabilities of the website to users on varying configurations of browser operation systems and machines. To do the test we start with verifying that all features of the software should be fully accessible in various browsers. Because checking on any possible combination of browser apps is impractical, we have to select some of the most popular ones for evaluating the web application on. According to December 2018, most of the users and represents 70.95 percent of them are using Google Chrome as their main browser. the second most usable browser is Firefox with 10.05 percent, followed by internet explorer (IE), Safari and Edge each one represents around 4 to 5 percent (Pai, 2019). These statistics are the reason that makes browser compatibility testing essential. To avoid causing disturbance to the users, the application should be evaluated on various browsers and devices to verify that it is working properly at all. The application is tested on Microsoft Edge, Firefox, Google Chrome and Apple Safari, All the pages and functions run correctly in these browsers as shown in Table V.

Table 4. Browser Compatibility Test

Test case	Test result
All icons and controls are available on the UI, including textbox, controls and connections, which are correctly arranged	Verified
The font style and width of the labels are visible and easy to understand	Verified
The scale and coloring of the various UI components shall be as per the requirements	Verified
The interface is flexible and can conform to various screen and system configurations	Verified
When logging in, the user will not logout by pressing the Back button	Verified
All navigations and events like key press/mouse click	Verified
Data integrity	Verified
The date field and numeric field formats	Verified
Graphs/charts appear according to the standards and the data are correct	Verified

The browsers do not all operate in the same environment, they face browser adaptability problems at different stages. because of that, we may see the loss of uniformity of dashboard over browsers and operation machines. We do not want the users to be unable to access all the features of the dashboard. Although Google Chrome and Firefox have the highest percentage of users, still there are users using old and different versions, and their numbers are too large to be overlooked.

Conclusion

This research develops a new framework to build a bridge between the Malaysia Green Highway Index, the Carbon Footprint Calculator of the highway projects and the important decision support system. This study transformed the integration into 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 the concessionaires.

This innovation is making the assessment process more user friendly and efficiency, reduce 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 is to identify the agreement level of the users on the functionality, reliability, usability, efficiency, and portability of the dashboard. This dashboard resilient green technology conceivably will build an industry to shift faster, strong, and simple in strategizing projects decision making. This project can be utilized by governmental authorities and be incorporated in their existing tools for more and better green certified highway development locally and globally.

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