Outcome of the Project

The biodiversity web module is incorporated into the University of Malaya Living Lab System. The outcome of the whole web module is shown and discussed in this chapter. The user interface is also included and describe in detail.

Website: http://umlivinglabsystem.com/

Description of the Project

The University of Malaya Living Lab System biodiversity web module is a module especially for biologist and ecologist to calculate the biodiversity indexes and to learn and visualize the diversity patterns on Google Maps.

As a result, users will obtain the plant species information, which are the coordinates of the plant species, its common name, genus species name, diameter of breast height (dbh) and the record date whereby the plant species location is identify. At the same time, the most common diversity indexes are also calculated, which are the Species Richness, Shannon-Wiener Index, and the Simpson's Index.

Homepage of University of Malaya Living Lab System (UM Living Lab System)

Below shows the homepage when the users enter the website on the web browser. A brief description regarding the UM Living Lab System is displayed in the homepage.

Figure: Homepage for UM Living Lab System

Polygon Builder

The polygon builder page allows users to draw a polygon on the area of interest on the Google Maps and download as Keyhole Markup Language (kml) file.

This page is added in the web module is that not every user downloaded software that are able to generate kml file, such as ArcGIS and Google Earth.

Just search for the place on the search bar and click on the polygon button, and begin to create polygons. Next, under the KML tab just click on download the kml file.

This page is an iFrame of another website: https://www.doogal.co.uk/polylines.php

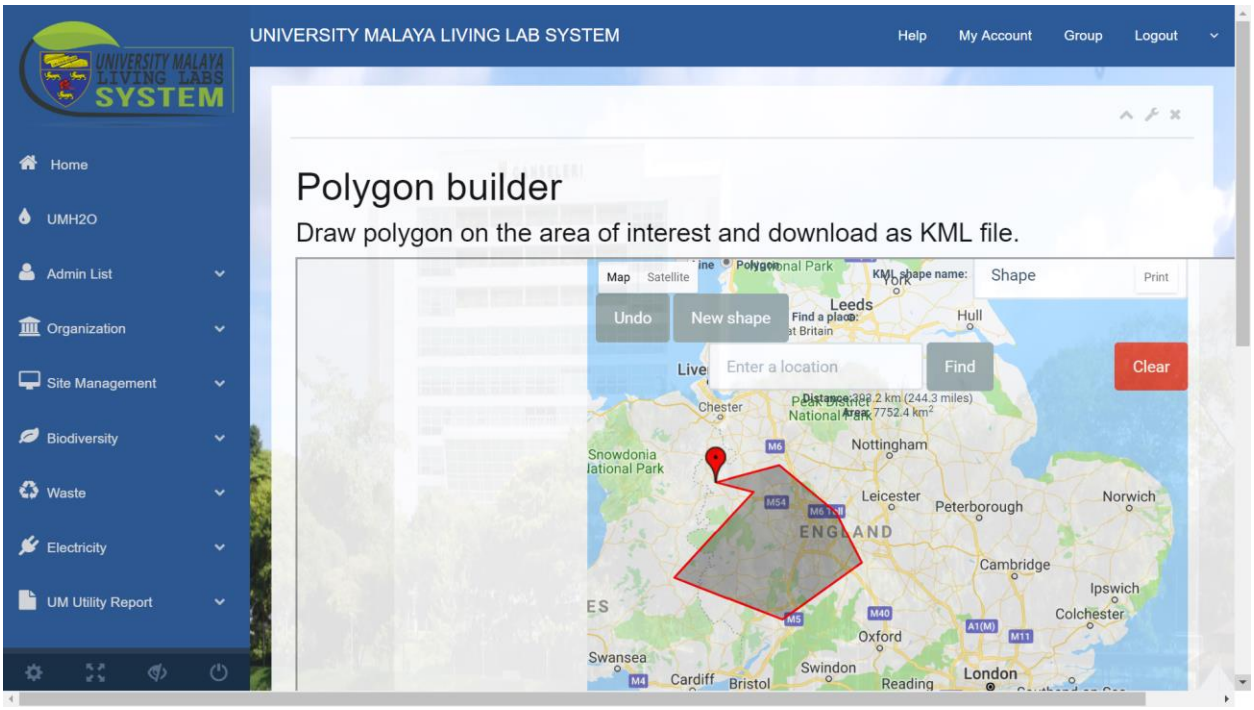

Figure: Polygon Builder Page

Import Polygon File

This page is the Import Polygon File page that allows users to upload the polygon file in kml format. The kml file is download from the polygon builder page or perhaps the users created own kml file using Google Earth.

Selecting the desired polygon file and enter specific name for the polygon, the polygon file will automatically be into the database uploaded by clicking the Upload button and able to view in Polygon Map page. An example of polygon file is shown on the right-hand side of the page.

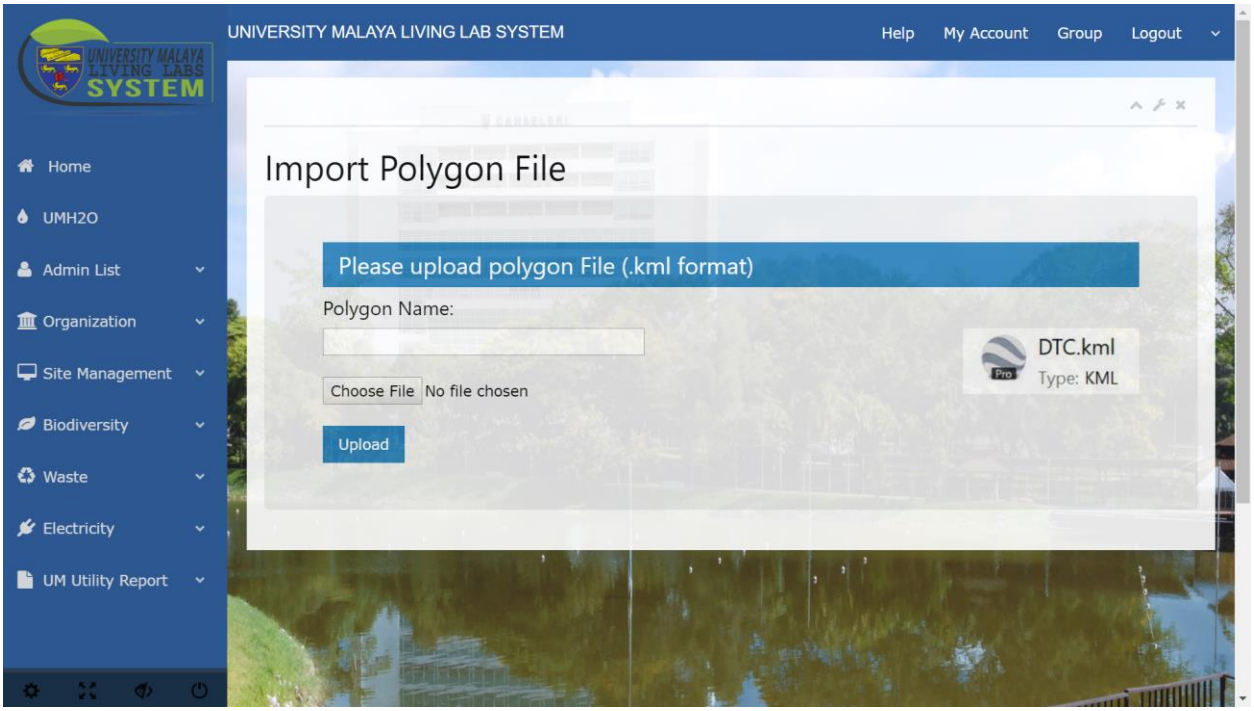

Figure: Import Polygon File page

Polygon List

This page shows the list of polygons where the users uploaded. Any further modification and changes are allowed where the user can click on the '**Edit**" text, and it will link to another page, which is the Edit Polygon Information page.

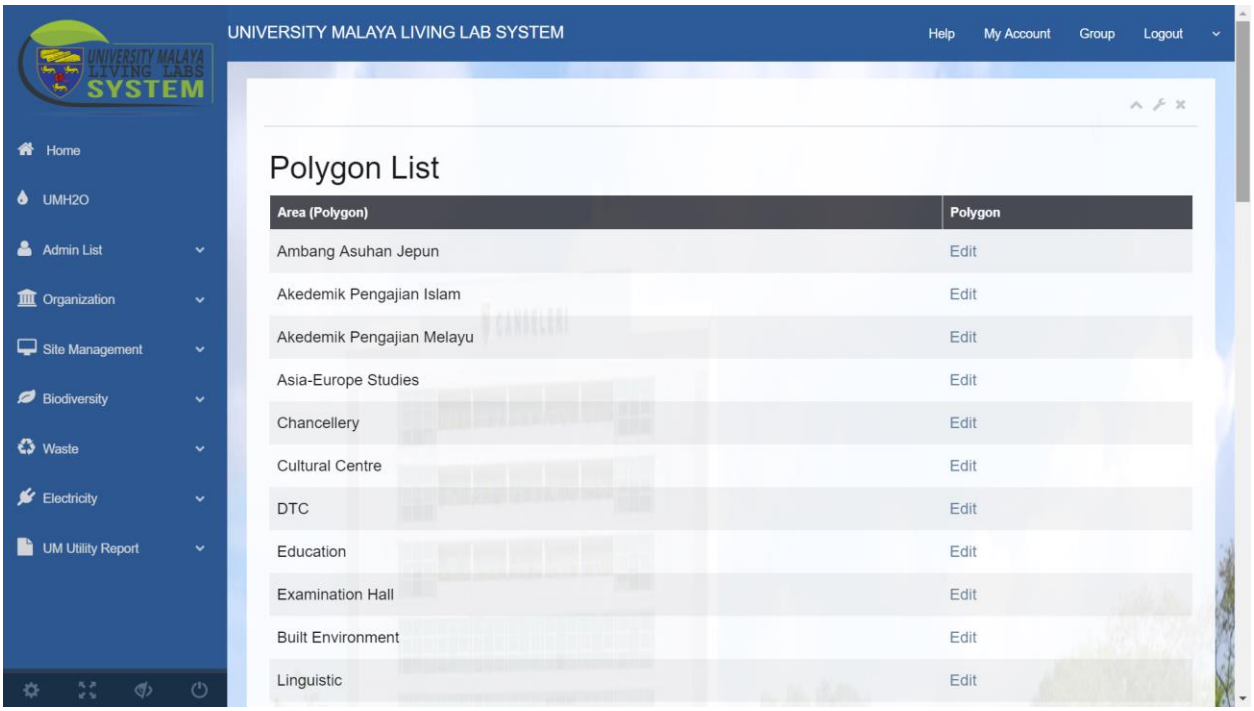

Figure: Polygon List page

Edit Polygon Information

In this page, users allow to make changes on the polygon names and update the polygon name by clicking on the Update button. Else, users may also delete the file they uploaded by clicking on the Delete button.

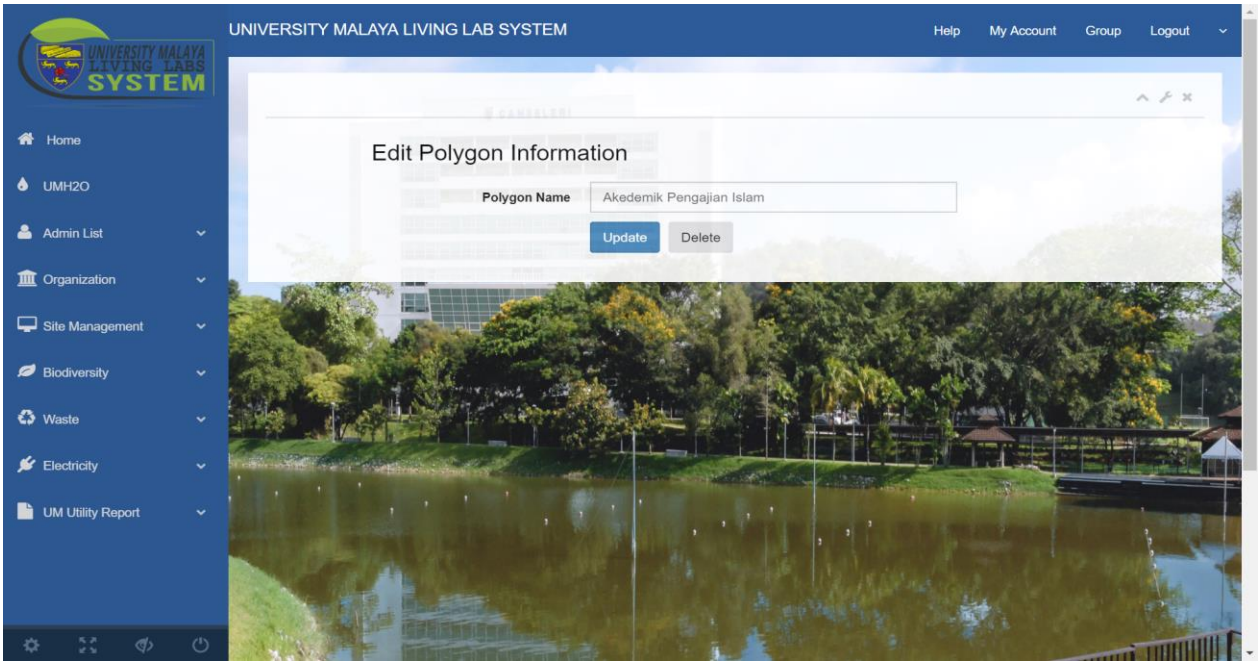

Figure: Edit Polygon Information page

Import Biodiversity Data

If the users have a set of data in a spreadsheet, it is advisable for the users to upload the data in excel format (.xlsx), users do not need to enter the plant species data one by one on the 'Add Plant Species' page.

This page whereby users can select the excel file and upload into the system, however the users need to follow the format of the spreadsheet, only then the data is readable by the system. A reference template is given, and users can download it as a reference, to prevent any mistakes. Once the users click on the Upload button, the selected excel file will be uploaded into the database.

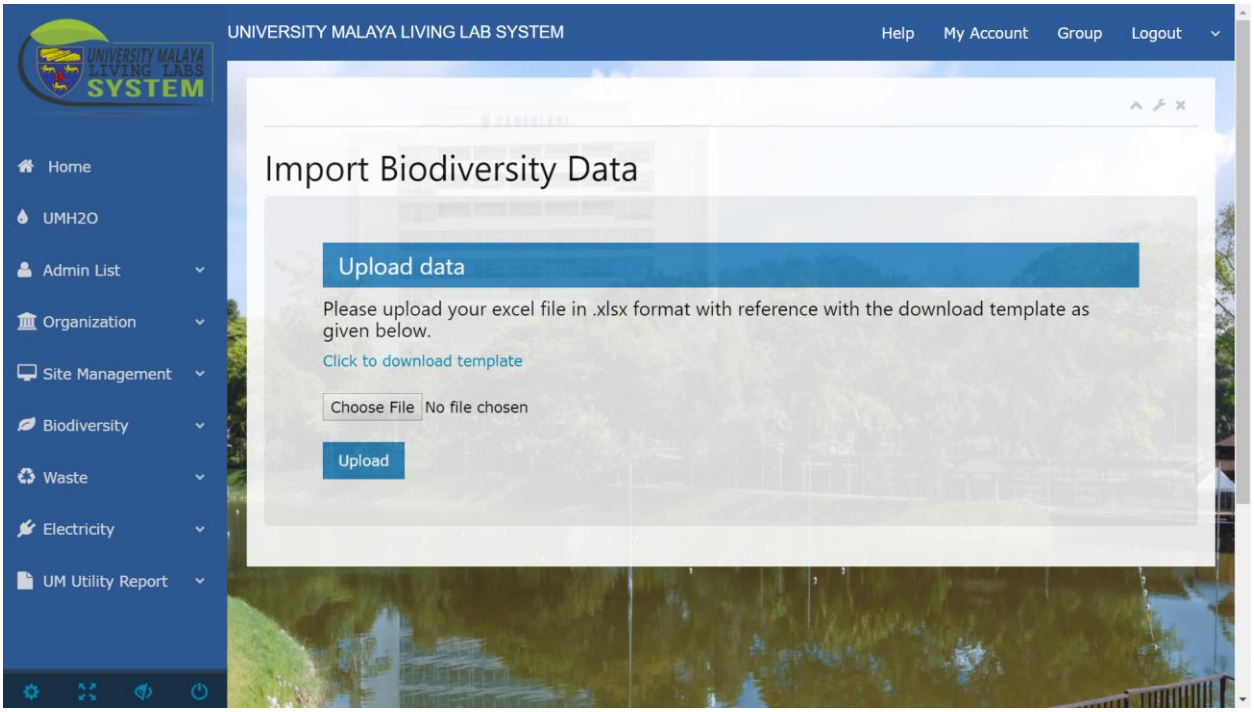

Figure: Import Biodiversity Data page

Add Plant Species Information

This page allows researchers or users to add plant species information where they encountered and contribute to the system.

The researchers and users must enter the plant details, such as:

Genus Name

Species Name

Common Name

Latitude

Longitude

Diameter of Breast Height (dbh)

Record Date

Next, click on the ‘Save’ button to save the record.

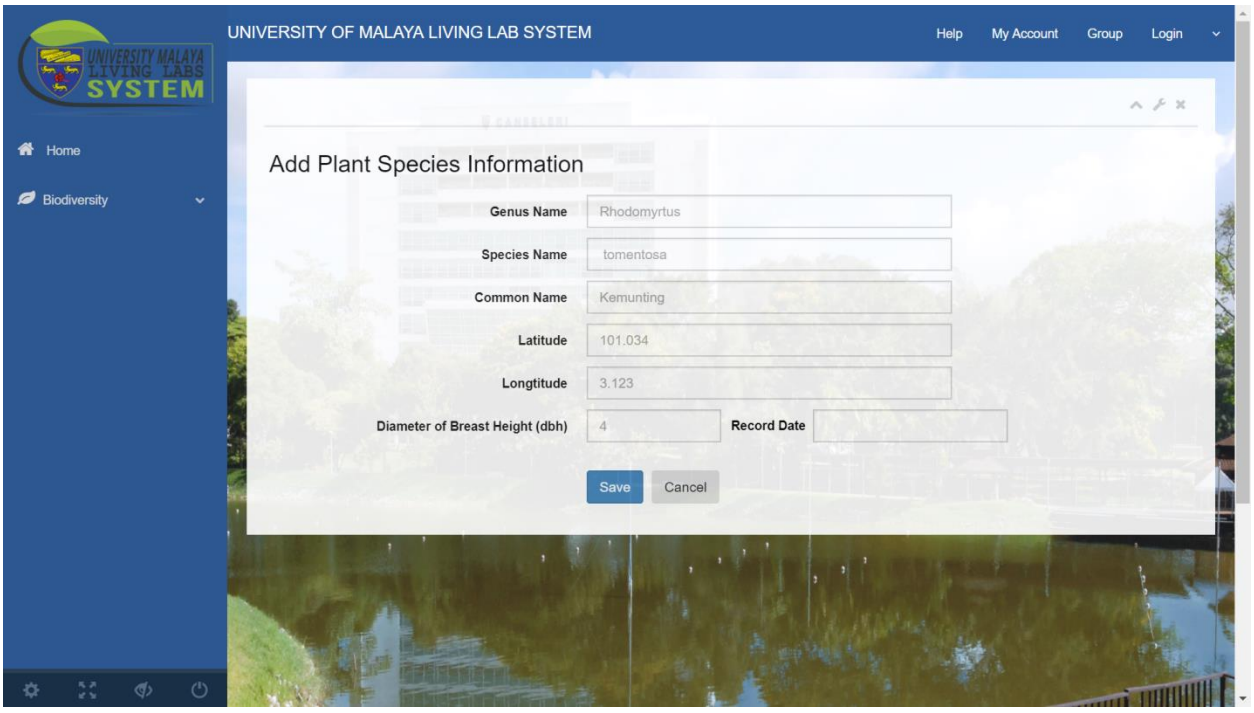

Figure: Add Plant Species Information page

Plant Species List

The added plant species is then can view on this page. This page users can view the available plant species records on the database. The users can search the plant species records by record date on the search bar. Users can enter the specific date and can click on the date on the display calendar.

The list shows the Record date, latitude, longitude, diameter of breast height, common name, genus and species of the plant species. By clicking on the 'Edit', it will directly link to Edit Plant Species Page, where user can manage and edit the plant data.

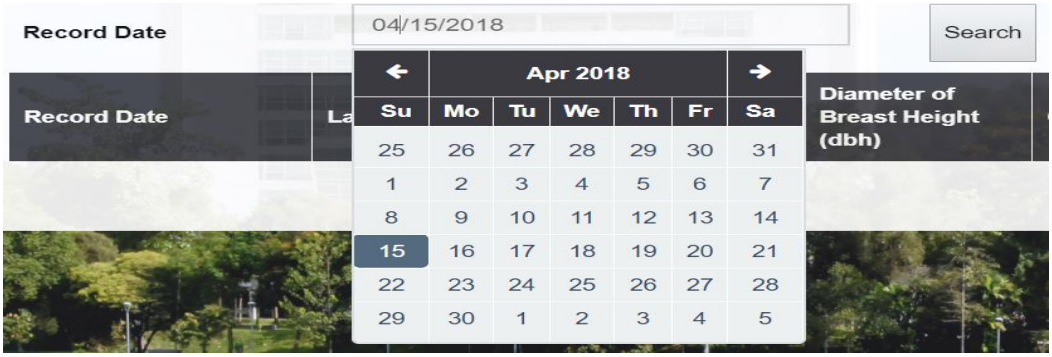

Figure: Record date search bar

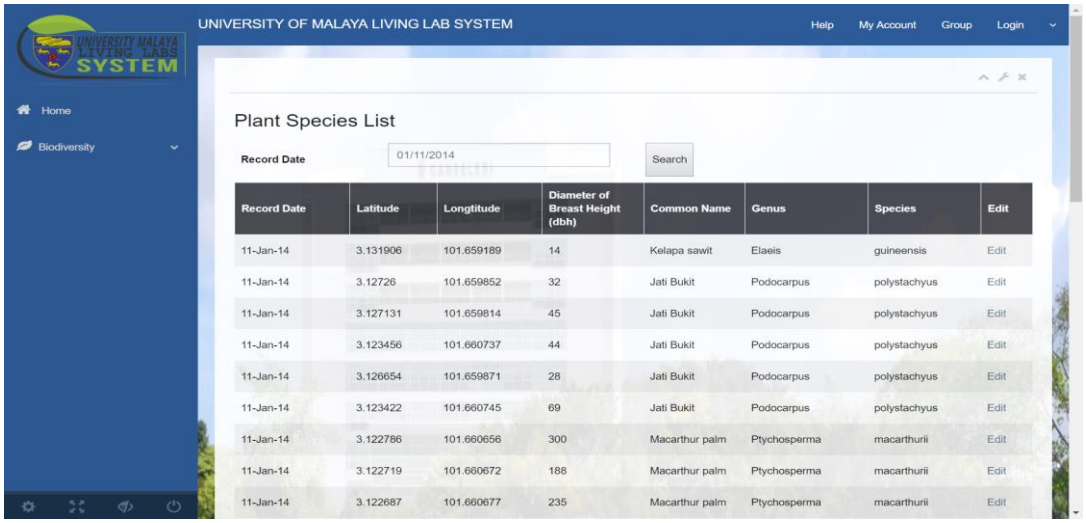

Figure: Plant species list page

Edit Plant Species Information

From the Plant Species List, when the users click on the ‘Edit’ text, it will directly link to this page. Whenever there are mistakes or any addition on the plant species data, users are free to perform any modification and update the plant species information by clicking on the Update button. Else, the Delete button is also available, which allows the users to delete the records.

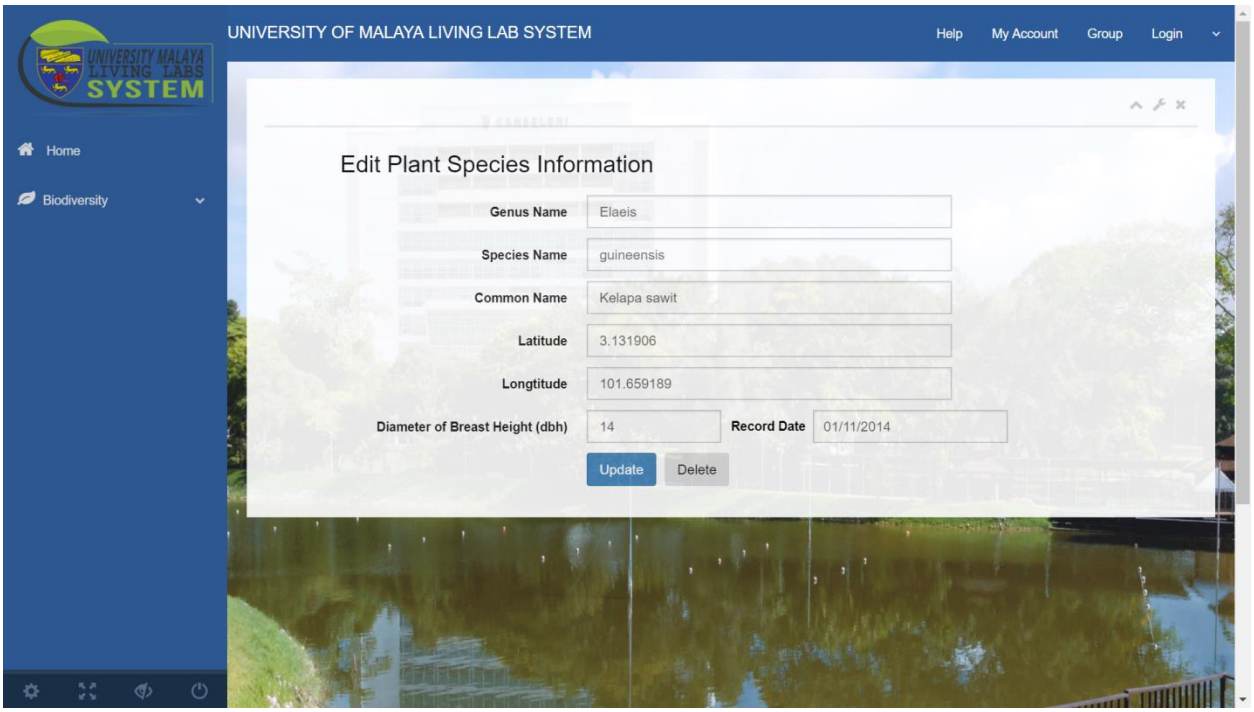

Figure: Edit Plant Species Information Page

Polygon Map

The Polygon Map display the uploaded polygon file on the Google Maps. First, the users can select the area of interest on the drop-down list. The Generate button, will automatically generate the polygon and eventually will display the selected polygon.

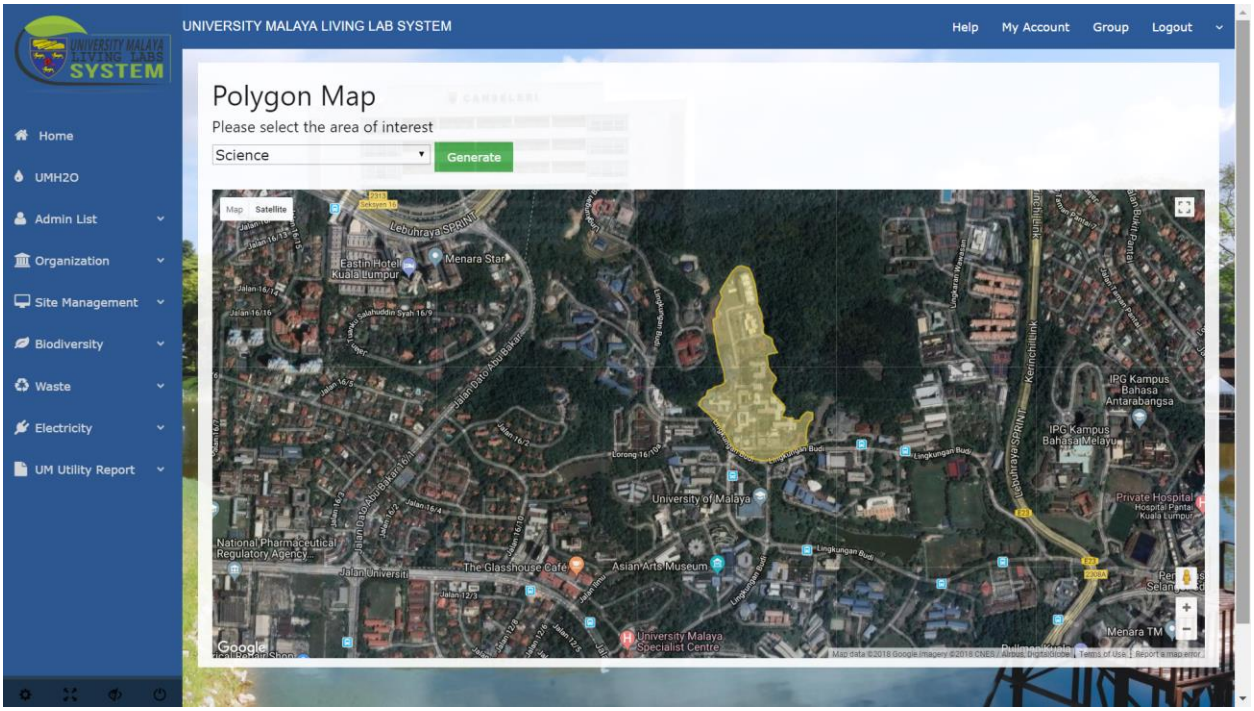

Figure: Polygon Map page shows the polygon of Faculty of Science

Polygon Species Map

In this page, when the users select the polygon on the drop-down list, and click on the Generate Tree button. The map will display the selected polygon together with the plant species which represent in the marker .

When click on the marker , it will show the species information, which are the plant genus and species name, the coordinates and together with image of the species.

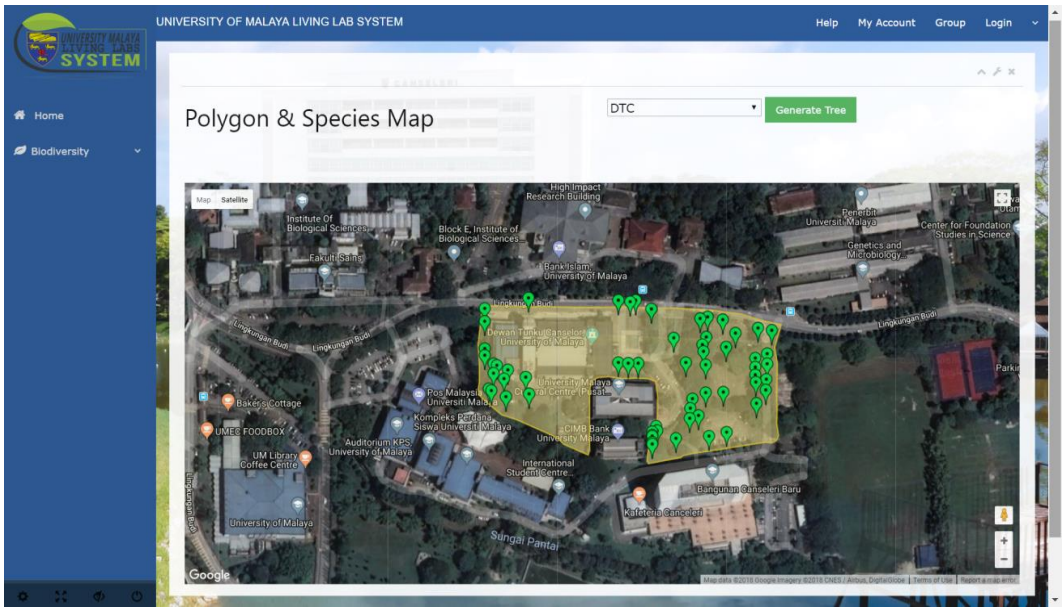

Figure: Polygon and Species Map in DTC

Figure: Float window shows the information of the plant species Mimusops Elengi

Species Topology

This page allows users to select the plant species either based on the plant species, plant genus or the common name of the plant. After selected a specific plant species, this page will show all the trees available in the campus together in the specify polygon.

Eventually, it allows user to compare the species available and which site has more species selected. The polygon is represented in color with a specific biodiversity range that enhance the representation of data.

Besides, by clicking the Export button, the users can download the csv file which contains the value of the diversity index together with the plant species.

The species is then show on the map together with the polygons, the species also represented in a marker  , when user click on the marker, it can show the plant information on a float window.

The float window consists plant species information and the diversity index, such as the Genus Species name, common name, coordinates, image of the trees and the diversity indexes, which are the Species Richness, Shannon-Wiener index and the Simpson's index is calculated as well.

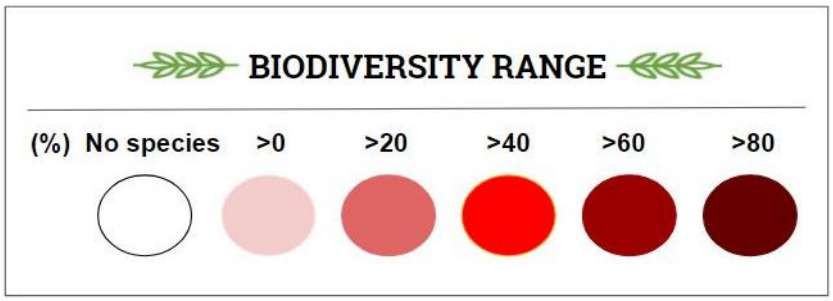

Figure: Colour Indicator of Polygon of Biodiversity Range

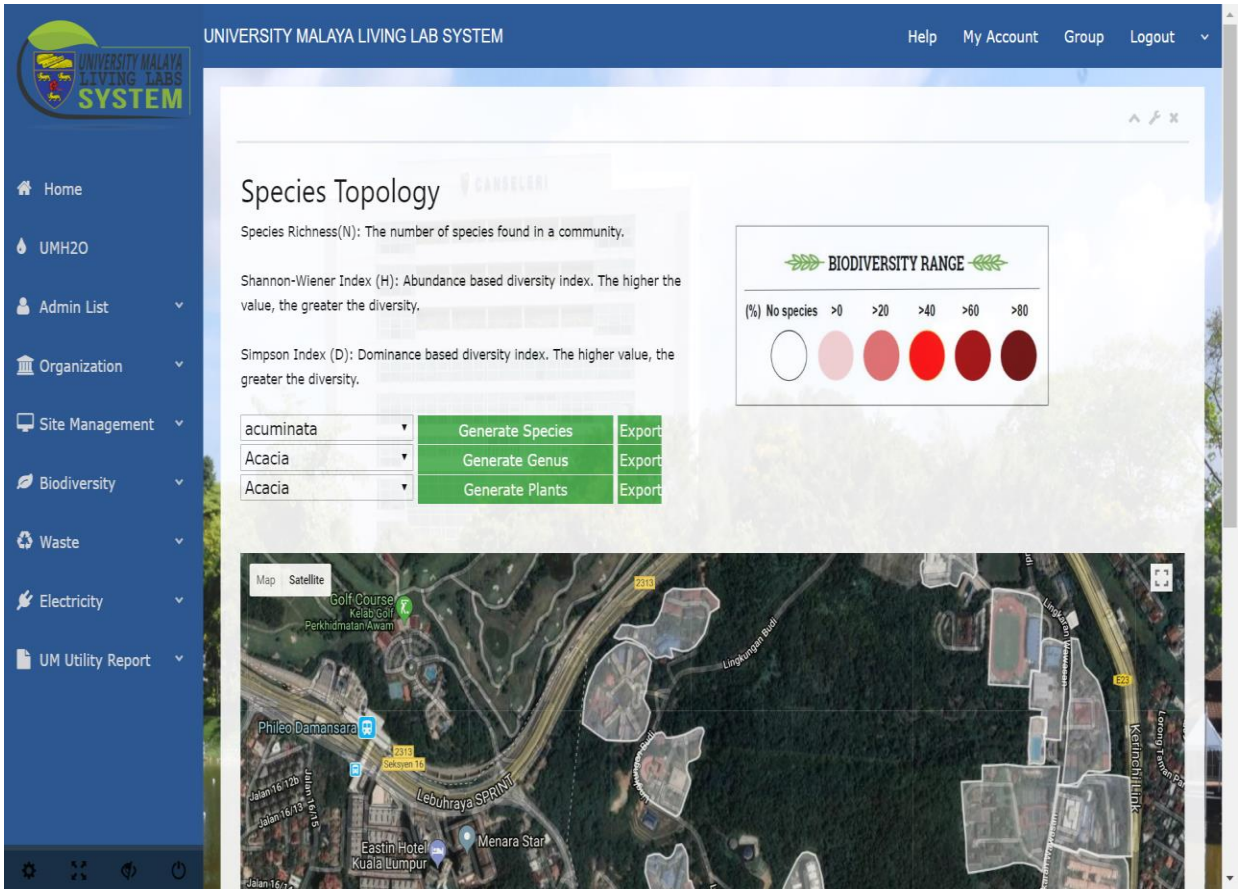

Figure: Species Topology page

Figure: Multiple polygon is shown on the map with colour indication

Figure: Float window that shows species information and diversity indexes

Figure: Polygon is shown on the map with colour indication and species information

Biodiversity Index Report

In this page, the users can generate a report based on the index type and plant species. First, users must select an index type, which are Species Richness, Shannon-Wiener Index or the Simpson's Index. Follow by select a plant species from the drop-down list. After that, click on Submit the button. The script will return and generate a biodiversity index report. The Export button is where the user can download the biodiversity index report in .csv file.

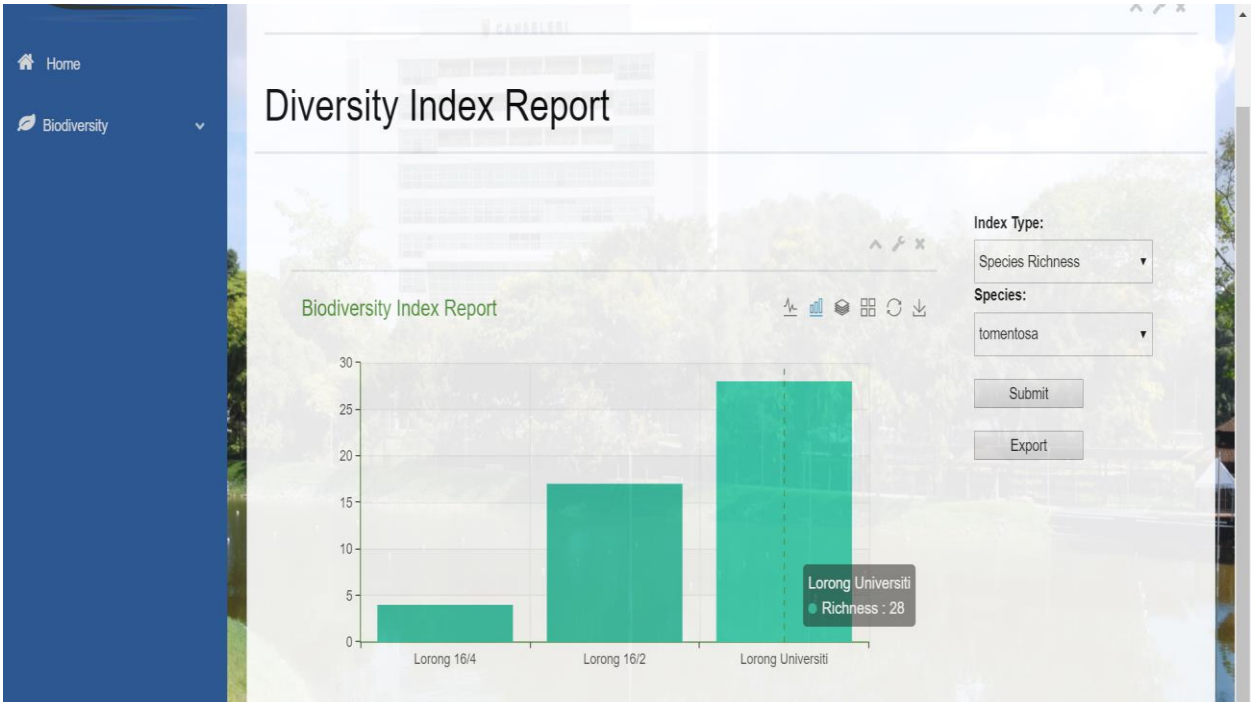

Figure: Diversity Index Report Page

Overview of the Biodiversity Web Module

The University of Malaya Living Lab System biodiversity web module is a module especially for biologist and ecologist to calculate the biodiversity indexes and to learn and visualize the diversity patterns on Google Maps.

As a result, users will obtain the plant species information, which are the coordinates of the plant species, its common name, genus species name, diameter of breast height (dbh) and the record date whereby the plant species location is identify. At the same time, the most common diversity indexes are also calculated, which are the Species Richness, Shannon-Wiener Index, and the Simpson's Index.

Thus, this site provides several features such as:

- Polygon (.kml) creator.
- Upload polygon (.kml) file.
- The list of uploaded polygons and the users can update/delete previous records.
- Upload biodiversity data in excel with a reference template.
- Add plant species information.
- The list of added plant species information and the users can update/delete previous records.
- Visualize the uploaded single polygon on Google Map.
- Shows all the plant species within the selected area on Google Map.
- Select interest plant species based on either common name, genus or species name and shows the location of the plant species and calculate the diversity index at the same time.
- Colour indication of the number of species based on area.
- Diversity index report based on the index type and the plant species.

This manual explains how to use the website to have a clearer picture on the uses of this biodiversity module. Users need to be logged into the website to add or make any modifications.

Website: http://umlivinglabsystem.com

Outcome of The System Usability Test

The evaluation form is created based on the System Usability Scale (SUS) which comprises ten questions to assess the usability and functionality of the website. A system usability evaluation form is given to several users that are related to the project.

- Lecturer from Institute of Biological Science, Faculty of Science, University of Malaya.
- Lecturers for the Faculty of Built Environment, University of Malaya.
- Researchers from the Rimba Ilmu, University of Malaya.

The users will rank each of the questions as the following table shown.

Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
1	2	3	4	5

The scores are then convert into numbers and calculate the usability score using SUS. The outcome of the calculated score is average at the SUS score of ____ with a ___ grade, which can consider as ____.

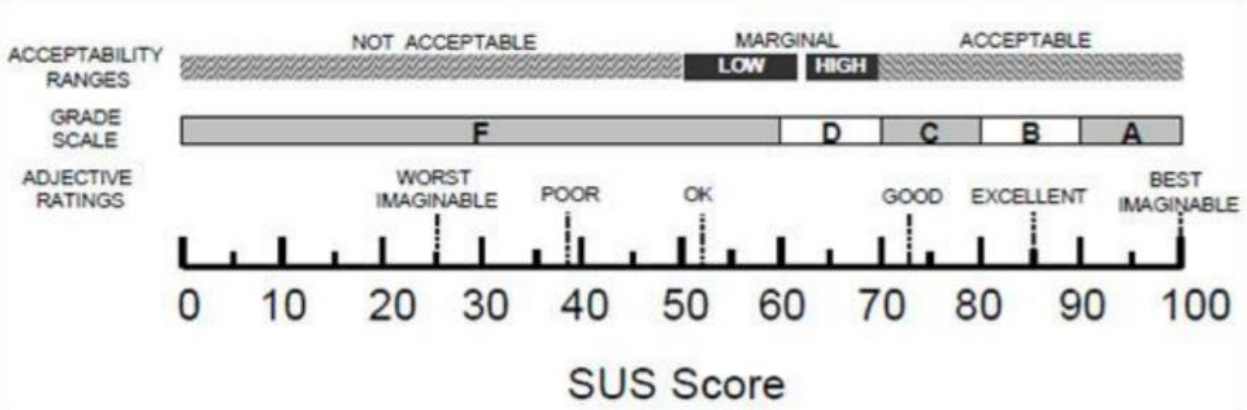

Figure: Grade rankings of SUS scores from "Determining what individual SUS scores mean: Adding an adjective rating scale." By Bangor, A., Kortum, P., & Miller, J. in 2009

Several comments and opinions regarding the website given by the users are as follows:

- The website can be improved.
- Include a picture glossary for ease of the users in case some of the users do not know the name of the plant species together with the plant information.
- _____
- _____
- _____
- _____

The overall impression towards the website is average at the score of 4, indicates “Somewhat satisfied”, for the features of the website. However, future enhancement can be done.

Encountered Problems

The following are some of the problems encountered during the research project analysis and development.

1. **Confusion in using which biodiversity indexes**

   There are many biodiversity indexes available to measure the biodiversity. Confusion on which biodiversity index should be incorporated into the system. By reading pass research study and interview some experts from this field, Shannon-Wiener index and Simpson's index is the most commonly used index. This is why only these two indexes are incorporated into the system.

2. **Limited Plant Species Images**

   At first, there are only 10 images provided. However, the image can be included from time to time.

3. **New Programming Language**

   This web-based module is written in C# and ASP.net, together with HTML, CSS and Javascript. Some knowledge in database management is also required. These languages are not taught during lectures and require a lot of time to master it.

Biodiversity Web Module Strengths

The following features illustrate the strength of the biodiversity web module.

1. **Simple and user-friendly interface**

   The website is designed to simplify the instruction and operability of the website. A side menu is included so that the users can navigate to different page at ease.

   Simplistic is the basic concept of designing the interface, description is added to for those that are not proficient in using the website.

2. **Manageable polygon and plant species database**

   The information of polygons and plant species can be added, edited and deleted by the users including the name of polygons, and the plant species details.

   It encourages users' participation in managing the data from time to time and expanding the database, and more and more relevant information can be retrieve from the website making the website more comprehensive and complete.

3. **Ease of use**

   The biodiversity web module is easy to use and get started with. The website is design in a sequential fashion, start with managing the polygon and plant species data, follow by visualization of the plant data on the map.

   This website is designed and planned according to the users, especially biologist and ecologist to meet their requirements.

   Besides, this website can be access on various web browsers such as Google Chrome, Microsoft EDGE, Internet Explorer, Mozilla Firefox and others.

4. **Graphic representation**

The uploaded polygon and plant species data will retrieve from the database including the images of plant species. The images of the plant species are obtained from the researcher in Rimba Ilmu. The retrieved information will then display on the map.

5. **High functionality**

The Biodiversity Web Module contains many features and users do not need to download extra software, especially the polygon builder. The users can draw a polygon and download as kml file automatically.

Besides, the data can easily manage online and visualize it at the same time. The biodiversity index is also calculated and a biodiversity index report can be generated. All the functions and features are all included in a single web based module. Compare with other website, it only provides stand-alone functions, where it can calculate the biodiversity index or it can just visualize the species on the map.

6. **Web module transparency**

It refers that users do not need to know where exactly the database resides, how are the system architecture, the database management system and anything regarding the system built.

For instance, the users can easily identify the species topology and the diversity index is automatically calculated. This is to determine the users will not be disturbed and confuse by the complexity structure of the web module.

Biodiversity Web Module Limitations

The following points are the limitations of the system.

1. **Rigid Google Map**

   Unlike the Google Map in Pericopsis.org, the users can draw a polygon on the map and show trees automatically. This biodiversity web module only can select based on polygon or plant species, since the polygon is already drawn. However, users do not need to draw the polygon each time use the website.

2. **Unable to locate tree species accurately**

   The users unable to check in the species quickly and directly. The users need to pin point in another map that gives the latitude and longitude, then only key into the system.

3. **Require update from the users**

   The polygon and plant species data need to keep updated always. Since biodiversity is dynamic and it varies from time to time, thus, researcher needs to update the data, whether there is any new species or the specific plant species is already gone to ensure the accuracy.

4. **Limited number of plant species image.**

   The image given by the researcher from Rimba Ilmu is limited, some of the image cannot be shown due to unavailable of the data.

Future enhancements

There are several enhancements can be considered in the future to increase the usability of the website. Since the web module is built using the dynamic system development method (DSDM), increment on the web module is allowed.

The recommended enhancements are described in the following:

1. **Picture Glossary**

   A picture glossary is strongly recommended to be added into the web module, since not everyone able to recognize the species name, especially the scientific names. A page with all the plant species information together with plant image, will help users in identifying the plants.

2. **Increase the biodiversity indexes**

   There are much more biodiversity indexes that has not been included in the module, if there is any request for it, it still can be embed on the web module as well.

3. **Increase the flexibility of the map**

   The map can be enhanced, where the users can draw the polygon on the area of interest and show the trees on the map. Besides, screen capture function can be added, where users can save the image of the map.

4. **Species Check-in module**

   This module allows users to add the plant species data by automatically identify the location of the plants. The users are required to identify which is the species and where it is.

5. **Carbon Emission Calculator**

The web module can further expand by adding a carbon emission calculator, since the data regarding the number of plants is available in the database.

Overall Conclusion

In overall, the University of Malaya Living Lab System Biodiversity Web Module has achieved and fulfilled the objectives and requirements of the users, which are the biologist, ecologist and urban planners. However, this web module is not limited within the University of Malaya, other users also can contribute to the website too. In this research project, our study site is the University of Malaya.

There are few empirical study regarding the visualization of biodiversity index. Most of the study just focus on the calculation of the diversity index. With this module, the users can calculate the index and at the same time visualize the species distribution on the map. Besides, providing related information to the users about the location and details of the plants.

There was a lot of knowledge gained throughout the development of the web module. These include learning new programming languages, database management, software development methodology, development platforms tools as well as the biodiversity indexes and conservation biology. Meanwhile, software development includes planning, design, engineering implementation and testing are crucial in completing the project within the given timeline. The actual practice and application about the theories learned before.

There are still ways for improvement of the web module as discussed before. The improved version of the biodiversity web module may be implemented in future based on the functional requirements of the users. Currently, the web module fulfills the needs and objectives of the users.

Finally, the project was completed successfully as part of my final year research project in bioinformatics program. Nevertheless, the project has embedded on the University of Malaya Living Lab System, the website is http://umlivinglabsystem.com

References

Bangor, A., Kortum, P., & Miller, J. (2009). Determining what individual SUS scores mean: Adding an adjective rating scale. *Journal of usability studies*, *4*(3), 114-123.