WEB-BASED GIS DEVELOPMENT FOR LAND USE CHANGES

by

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STUDENT DECLARATION

I declare that this thesis entitled "Web-Based GIS Development for Land Use Changes" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature: ______________________________

Name : ______________________________

Date : ______________________________

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Web-Based GIS Development for Land Use Changes

ABSTRACT

Web-based geographic information system (GIS) is a GIS system which uses web technology to serve users. By utilizing the internet to access information over the web, the GIS user can fully utilize the geospatial information despite the distance between the server and client. Through presenting the land use changes via web based GIS, it will estimate the percentages of land use change that helped the local authority to mitigate any conflict that might happen during the development. The study site chosen is Jeli, Kelantan as to see how the land use changes have occurred during the past years. To demonstrate the land use changes, Landsat 8 satellite data of 2014 and 2018 has been chosen and the implementation based on web site is developed. This work designed in two parts such that data visualization on map and data presentation to users. The first part used the ArcMap, QGIS and Open Layer software to develop the land use changes to present on map whereas PHP language and MySQL is used in second part by manipulating the data to be shown on web site. The results show that the proposed system can be used to assist any organization, public and individual to access the geospatial data by using web-based GIS for land use changes information.

Web berasaskan GIS untuk Perubahan Guna Tanah

ABSTRAK

Sistem maklumat geografi (GIS) berasaskan web adalah sistem GIS yang menggunakan teknologi web untuk memberi maklumat kepada pengguna. Dengan menggunakan internet untuk mengakses maklumat melalui web, pengguna GIS berupaya menggunakan maklumat geospatial sepenuhnya tanpa mengira jarak antara pelayan dan klien. Melalui penyampaian perubahan guna tanah melalui GIS berasaskan web, ia akan menganggarkan peratusan perubahan penggunaan tanah yang dapat membantu pihak berkuasa tempatan untuk mengurangkan sebarang konflik yang mungkin berlaku semasa pembangunan. Tapak kajian yang dipilih adalah Jeli, Kelantan untuk melihat sejauh mana perubahan penggunaan tanah berlaku pada tahun-tahun yang lalu. Untuk menunjukkan perubahan penggunaan tanah, data satelit Landsat 8 bagi tahun 2014 dan 2018 telah digunakan untuk pelaksanaan berdasarkan laman web. Kajian ini direka dalam dua bahagian iaitu visualisasi data melalui persembahan peta dan data kepada pengguna. Bahagian pertama menggunakan perisian ArcMap, QGIS dan Open Layer untuk membangunkan perubahan penggunaan tanah untuk dipaparkan di peta manakala bahasa PHP dan MySQL digunakan dalam bahagian kedua untuk memanipulasi data bagi paparan di laman web. Hasilnya menunjukkan bahawa sistem yang dicadangkan boleh digunakan untuk membantu mana-mana organisasi, orang awam dan individu untuk mengakses data geospatial dengan menggunakan GIS berasaskan web untuk perubahan maklumat guna tanah.

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LIST OF ABBREVIATIONS

CSS	Cascading Style Sheets
GIF	Graphics Interchange Format
GIS	Geographic Information System
HTML	Hyper Text Markup Language
JPEG	Joint Photographic Experts Group
OLI	Operational Land Imager
PHP	PHP : Hypertext Preprocessor.
PNG	Portable Network Graphics
TIRS	Thermal Infrared Sensor
USGS	United States Geological Survey

LIST OF SYMBOLS

%	percentages
$\lvert\Sigma_i\rvert$	determinant of the covariance matrix of the data in class ω_i
i	class
m_i	mean vector
$p(\omega_i)$	probability that class ω_i occurs in the image and is assumed the same for all classes
x	n-dimensional data (where n is the number of bands)
Σ_i^{-1}	its inverse matrix

CHAPTER 1

INTRODUCTION

1.0 Introduction

A geographic information system (GIS) is a system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data (Dempsey, 2018). There are many uses of GIS as it can be used as a mechanism to solve problem and making decision. It can also visualize spatial data. As the internet technology has widely progressed, GIS also affected by this technology and a new technology which is Web GIS appeared.

1.1 Background of Study

This study is done to analyse the land use change in the study area by using web based GIS as to see how the community development affected the land use change. The web based GIS is used as it provides more accessible information for government and also for public. The study sites that was chosen is Jeli district in which Universiti Malaysia Kelantan (UMK) is located.

1.2 Problem Statement

As the population increase, there are many development needed to fulfil the demand of the community. This demand will add to the factors that affect the land use change. Although GIS is used widely to get the geospatial data, it may not be easy to access the information. Urban land use and land covers have considerably been changed throughout worldwide. Urban information is very limited and crucial and not updated in a systematic manner in some cases. The art tools widely used for the management of urban resources are Remote Sensing (RS) and Geographic Information System (GIS) (Jayakumar & Malarvannan, 2015). Available spatial information is not in single end. To overcome this problem, open source based Web GIS is developed and spatial datasets were incorporated for wider distribution of urban information to all the stakeholders for better planning and management through web. Thus the outlined key problems of this study are:

- How does the development of community affect the land use change?
- How the available information about the land use change can be accessed?

1.3 Objectives

The objectives of this study are as follow:

- To analyse and generate land use changes map at Jeli district based on Landsat satellite data of the year 2014 and 2018.
- To develop a web based GIS on land use changes map at Jeli district.

1.4 Scope of Study

This study focused on the land use change in Jeli district from the year 2014 to 2018 with a four-year interval based on Landsat 8 satellite data. A land use map will be created to see the land use changes throughout the years. The classification of the land use change will cover the aspects that have direct relation with the community in Jeli by using supervised classification method. In addition, the classification of land use changes will be mapped into four classes which are urban or built-up land, agricultural fields, forest, and water bodies. The information about the land use change will be presented using web based GIS.

1.5 Significance of Study

The study were able to provide the current analysis of the land use changes for past years with a more interactive medium which is by using Web based GIS. With remote sensing data, the land use changes can be analysed. The land use change data would be useful to the community such as government, public sector and private sector towards land use planning and sustainable management. Also, by having a proper planning for the land use, the data could assist in formulating mitigation measures as well as minimizing the environmental degradation in the study area in future.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

The literature review of this study discussed about GIS and web based GIS, land use and land cover, the need of this study and also change detection techniques.

2.1 GIS and Web-Based GIS

2.1.1 Geographic Information System (GIS)

According to the definition by Esri, GIS is a computer-based tool for mapping and analyzing things that exist and events that happen on earth. GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps.

Bossomaier & Hope (2016), stated that GIS is a computer programs for acquiring, storing, interpreting and displaying spatially organised information. GIS can be used in many disciplines such as urban planning, geological surface and environment management.

By using GIS, there are numerous types of information that can be analysed. The information about people, such as population, income, or education level is the examples of the information that can be analysed. In addition it can include information about the landscape, such as the location of streams, different kinds of vegetation, and different kinds of soil. In national geographic web, it is stated that with GIS technology, people can compare the locations of different things in order to discover how they relate to each other.

2.1.2 Web-Based GIS

Li et al., (2011) stated that web GIS is the process of designing, implementing, generating and delivering maps, geospatial data and GIS functionality or services on the web.

There are three main dimensions in the open GIS that have been enhanced by the Web GIS which composed of (1) spatial data access and dissemination, (2) spatial data exploration and geovisualization, and (3) spatial data processing, analysis and modelling. These technologies has added two more to the list which are (4) collaborative spatial decision support using public participatory GIS, and (5) integration of web based geospatial services in mainstream and enterprise computing processes and environments.

The last few years have seen a tremendous increase in the number of proprietary geographic information system (GIS) packages offering web-based add-ons. The global GIS industry seems to have fully endorsed the web, and distributed systems as a way of serving GIS data to the world and getting the world in return to use its software (Carver, 2001).

Bossomaier & Hope (2016), stated that access to geographic information online has increased over the last decade due to the World Wide Web becoming the standard platform for delivery and integration of geographic information. The users of traditional GIS can now integrate with other geographic information online using dynamic access to external data sources.

Web GIS applications evolved from the delivery of static maps conveyed in raster formats such as JPEG, GIF and PNG formats to an actual stage in which users may choose the window, the scale, and possibly also the data layers to be displayed, and the map is generated dynamically from a database and transmitted in the vector format. Web mapping deals at least with two basic problems: map generation, and map transmission (Paiva, 2009).

In order to support the next generation of multi-process big data and service-oriented computing, a Web-GIS platform is considered a feasible solution for gathering and sharing of collected data from various case studies so that the information flows are easily managed and interpreted, by means of spatial thematic maps related to specific levels of information, within the various case studies (Gobakis et al., 2017).

The rise of web-based GIS resources has expanded the scale and scope of spatial information seeking in both non-GIS professionals and GIS professionals. Even without formal GIS training, users can search for spatial information, create customized maps, as well as perform simple spatial analysis (Kong et al., 2015).

2.2 Remote Sensing

According to Anon (2016), remote sensing is the process of detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance from the targeted area. The images of the Earth are collected by special cameras which can be a help for researcher to find out the information about the Earth. For examples, the cameras on satellites can help us to see more than our usual stand on ground. By using remote sensing also, the growth of a city and changes in farmland or forests over several years or even decades can be tracked.

Yang (2011) stated that remote sensing is the science of obtaining information about objects or areas from a distance, typically from aircraft or satellites. The energy reflected from the Earth is the data which is collected by the remote sensors. Remote sensing has a wide range of applications in many different fields. For example it can be used in coastal applications, ocean applications, hazard assessment and natural resource management. The application of remote sensing in managing natural resources are, the data can be used to monitor land use, map wetlands, and chart wildlife habitats. The data can also be used to minimize the damage that urban growth has on the environment and help decide how to best protect natural resources.

GIS and remote sensing techniques have shown their importance in mapping urban land use/land cover, urban growth trends to monitor the changes in land use/land cover (Haylemariyam, 2018). The integration between these technologies was found to be effective in evaluating the impact of urbanization. The information on the nature and its associated information were able to be obtained by the digital image classification.

In order to assess the damage of urban growth on environment, remote sensing analysis and GIS techniques are of the important tools which can be used. These technologies emerged as a feasible substitute because of cost effectiveness, high-tech reliability, and offers interminable and reliable record of spatial patterns. It is also very suitable for change detection analysis. The repeated data acquisition, synoptic view and formats processed by computers have made remotely sensed products appropriate for the analysis of change detection applications (Ali et al., 2018).

2.2.1 Landsat 8

Based on Li, Wang, Ganguly, & Nemani (2018), the Landsat program provides the longest continuous climate records from space. The trustworthy information preserved by the Landsat images has improved the researches of global resilience to climate change and variability.

According to NASA (2013), the Landsat Program provides repetitive acquisition of high resolution multispectral data of the Earth's surface on a global basis. The data from Landsat spacecraft constitute the longest record of the Earth's continental surfaces as seen from space. It is a record unmatched in quality, detail, coverage, and value. Landsat 8 measures different ranges of frequencies along the electromagnetic spectrum, a color, although not necessarily a color visible to the human eye. Each range is called a band, and Landsat 8 has 11 bands (Loyd, 2013). Of its 11 bands, only those in the very shortest wavelengths (bands 1–4 and 8) sense visible light. Table 2.1 shows the list of the bands and its uses. Band 5,4,3 and 2 is use in this study to detect the land use.

Table 2.1: List of Landsat 8's band and its use.

Bands	Wavelength (micrometers)	Resolution (meters)	Use
Band 1 - Ultra Blue (coastal/aerosol)	0.435 - 0.451	30	Coastal and aerosol studies
Band 2 – Blue	0.452 - 0.512	30	Distinguish soil from vegetation
Band 3 – Green	0.533 - 0.590	30	Emphasizes peak vegetation
Band 4 – Red	0.636 - 0.673	30	Discriminates vegetation slopes
Band 5 - Near Infrared (NIR)	0.851 - 0.879	30	Emphasizes biomass content and shorelines
Band 6 - Shortwave Infrared (SWIR) 1	1.566 - 1.651	30	Discriminates moisture content of soil and vegetation
Band 7 - Shortwave Infrared (SWIR) 2	2.107 - 2.294	30	Improved moisture content of soil and vegetation
Band 8 – Panchromatic	0.503 - 0.676	15	15 meter resolution, sharper image definition
Band 9 – Cirrus	1.363 - 1.384	30	Improve detection of cirrus cloud contamination
Band 10 - Thermal Infrared (TIRS) 1	10.60 - 11.19	100 * (30)	100m resolution, thermal mapping and estimating soil moisture
Band 11 - Thermal Infrared (TIRS) 2	11.50 - 12.51	100 * (30)	100m resolution, improved thermal mapping and estimating soil moisture

(Source : Barsi et al., 2014)

2.3 Land Use and Land Cover

Theobald (2014) stated that land use and land cover are typically defined as a systems description where human driving forces lead to actions or activities that are characterized by a land use. A land use may in turn manipulate land cover to such an extent that it results in conversion such as cropland to residential or modification from fertilization of cropland. Land cover is defined as the observed bio-physical cover on the earth's surface, whereas land use is characterized by the arrangements, activities and inputs of people to produce change or maintain a land cover. For example, grassland is a cover type, but rangeland is a use.

According to Konana et al., (2017) in managing natural resources and monitoring environmental changes, land use and land cover change has become a central component. Land use and land cover is dynamic in nature and provides an understanding of the relationship of human activities with the environment. In order to mitigate human impacts on the environment from the socio-economic processes such as agricultural, urban land, forestry, a shape land cover and land use, therefore need to be understood.

Konana et al., (2017) also stated that transitions in land use and land cover can be caused by negative socioecological feedbacks that arise from a severe degradation in ecosystem services or from socio-economic changes and innovations. There are two types of transitions which are random and systematic. Random transitions can be characterized by abrupt changes, whereas systematic transitions evolve steadily or gradually. Therefore, it is essential to have the information on land use/cover change and possibilities of their optimal use for the selection, planning and implementation of land use strategies to meet increasing human needs and welfare.

Land is one of the most important natural resources. All agricultural, animal productions depend on the productivity of the land. The entire eco-system of the land, which comprises of soil, water and plant, meets the community demand for food, energy and other needs of livelihood. Viewing the Earth from space is now crucial to the understanding of the influence of man's activities on his natural resource base over time. Observations of the Earth from space provide objective information of human activities and utilization of the landscape in situations of rapid and often undocumented and unrecorded land use change. The classified images provide all the information to understand the land use and land cover of the study area (Hegazy & Kaloop, 2015).

In this study, the Anderson classification system used in USGS LULC datasets is used as the guidelines. However only four out of nine level 1 classification is used. The description of the land use classification is as in Table 2.2.

Table 2.2: Land use classification system

Land Use Class	Land-uses and land-covers included in class
Urban or Built-up Land	Structures of all types: residential, industrial, agricultural commercial and services. Transportation and utilities. Mixed urban or built-up land.
Agricultural Fields	Cropland, orchards, vineyards, and nurseries.
Forest	Deciduous, evergreen, and mixed forests.
Water Bodies	Reservoirs, coastal water.

(Source : Rozenstein & Karnieli, 2011)

2.4 The Importance of Land Use Change

One of the key drivers in environmental change is land use and land cover changes. There are many changes of land use has occurred in the red soil hilly region of southeast China in the past three decades due to rural land reform, population pressure and rapid economic growth (Shi et al., 2009). Land–use change is arguably the most pervasive socioeconomic force driving changes and degradation of ecosystems. Deforestation, urban development, agriculture, and other human activities have substantially altered the Earth’s landscape. Such disturbance of the land affects important ecosystem processes and services, which can have wide–ranging and long–term consequences (Wu, 2008).

Changes in the extent and composition of forests, grasslands, wetlands and other ecosystems have large impacts on the provision of ecosystem services, biodiversity conservation and returns to landowners. The results of the study shows the importance of taking ecosystem services into account in land-use and land-management decision-making and linking such decisions to incentives that accurately reflect social returns (Polasky et al., 2011).

An integrated study of urbanization trends in Shijiazhuang City, Hebei Province of China, by using Geographical Information Systems (GIS) and remote sensing shows that there were rapid changes in the land use change from the year 1987 until 2001. The land use/cover conversion relationship implies that these changes are governed by urban expansion, which produces a force to drive the land use changes in search of a higher return (Xiao et al., 2006). The study about land use/cover changes and urban expansion in Greater Dhaka, Bangladesh, between 1975 and 2003 indicates that rapid urban expansion through infilling of low-lying areas and clearing of vegetation resulted in a wide range of environmental impacts, including habitat quality (Dewan & Yamaguchi, 2009).

With the use of land use change models, the analysis of the causes and consequences of land use dynamics can be supported. This scenario analysis with land use models can support land use planning and policy. Numerous land use models are available, developed from different disciplinary backgrounds (Verburg et al., 2004). According to Veldkamp & Lambin (2001), land use change modelling, is an important technique for the projection of alternative pathways into the future, for conducting experiments that test our understanding of key processes in land use changes, especially if done in a spatially-explicit, integrated and multi-scale manner. Land-use change models should represent part of the complexity of land use systems as they offer the possibility to test the sensitivity of land use patterns to changes in selected variables.

The impact of land use changes on surface warming has been studied and the result suggests that half of the observed decrease in diurnal temperature range is due to urban and other land-use changes (Kalnay & Cai, 2003). Land-use change has a significant impact on the world's ecosystems.

Therefore, this study is conducted to project the analysis of the land use changes that occurred in Jeli for beneficial in decision making by the local authorities

2.5 Change Detection Techniques

In understanding how an area has changed between a period of time, change detection is one of the method that need to be used. It is a method which is helpful for understanding the change in forest coverage and land use. Change detection involves comparing changes between aerial photographs taken over different time periods that cover the exact same geographic area (Dempsey, 2012).

Shalaby & Tateishi (2007), stated that digital change detection is the process of determining and/or describing changes in land-cover and land-use properties based on co-registered multi-temporal remote sensing data. The basic premise in using remote sensing data for change detection is that the process can identify change between two or more dates that is uncharacteristic of normal variation.

In addition, Macleod & Congalton (1998), had mentioned that post-classification change detection is probably the most straightforward change-detection process, but it also has the most potential for being the least accurate. The accuracy of the post-classification change-detection technique may be poor because of combining the errors from both of the classifications. Other change-detection techniques like image differencing and principal components can minimize some of the classification errors by only classifying the areas that have changed for the second date.

Different change detection algorithms have their own merits and no single approach is optimal and applicable to all cases (Lu & Weng, 2007). In practice, different algorithms are often compared to find the best change detection results for a specific application.

Thus in this study, to identify the change between the two dates of the year 2014 and 2018 the post classification techniques is used based on Macleod & Congalton (1998) statement in which post -classification change detection is the most straightforward change-detection process.

CHAPTER 3

METHODOLOGY

3.1 Study Area

The study area comprises of Jeli district which is located at latitude 5.7457 and longitude 101.8640. The location is illustrated as in Figure 3.1.

According to information from the official website of the Jeli Land and District Office, Jeli is a territory located on the border of Perak and Kelantan bordering southern Thailand. In terms of its geographical position, the north of Jeli is bordered by Thailand, Tanah Merah to the east, Kuala Krai and Gua Musang to the south and the state of Perak to the west. Jeli is the gateway to the state of Kelantan from the West Coast of the Peninsular. Jeli is also the main connection to southern Kelantan via the Jeli-Dabong road. 82% of the district is hilly or mountainous, heavily forested and blessed with many river tributaries. The altitude ranges from 90 to 500 meters above sea level. The main rivers which run through the district are the Pergau, Renyut, Suda and Balah rivers.

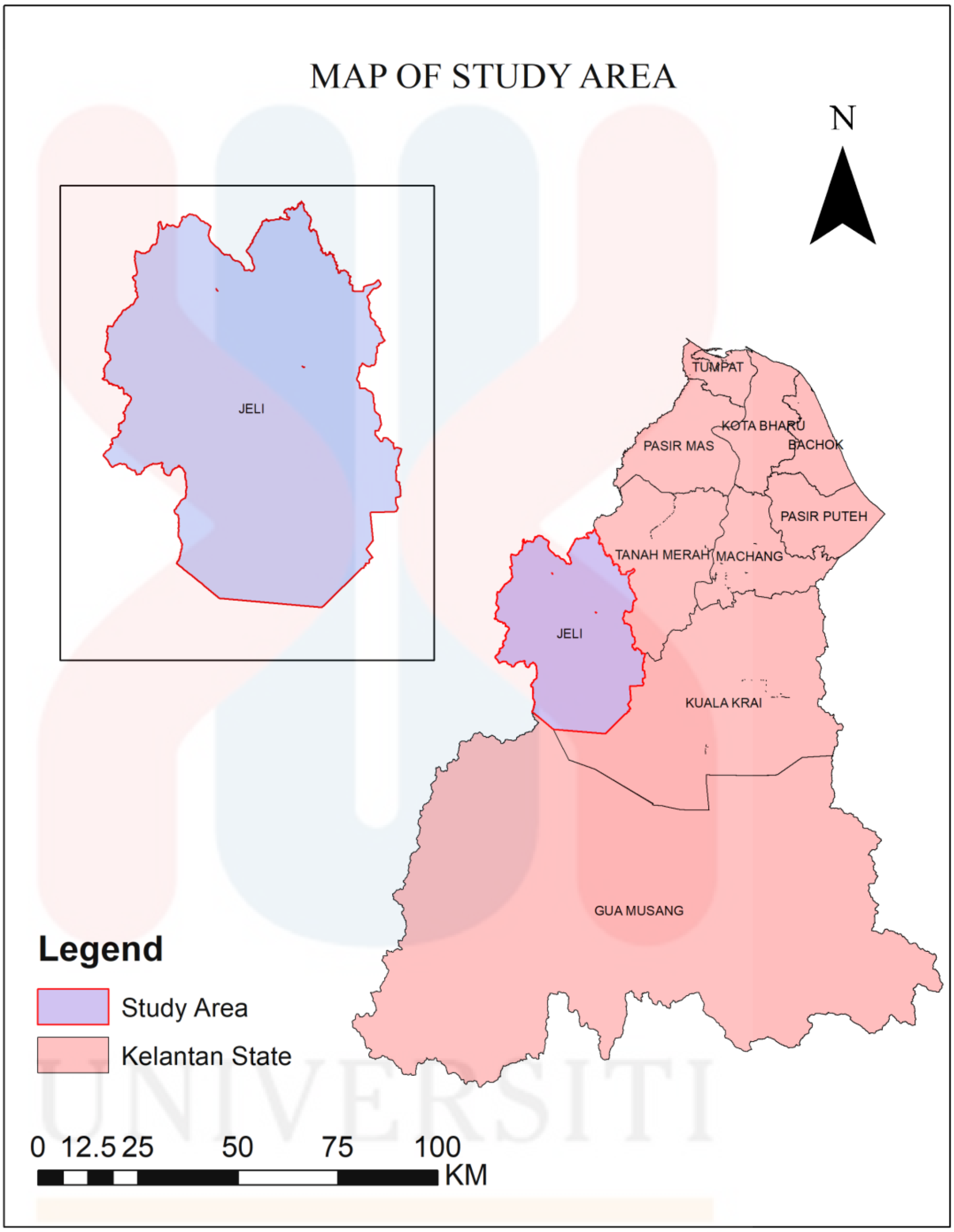

Figure 3.1 : Map of study area at Jeli district

3.2 Web Based GIS development

There are several steps for Web based GIS development that will be used. They are data collection, data processing, data analysis and data representation. The data that will be used are the satellite images of Jeli for the year 2014 and 2018 which were taken from Landsat TM. The data then will be processed and analysed by using software such as ArcMap and QGIS. Then the data for web of land use change will be designed and developed. The methods are summarized as in Figure 3.2.

3.2.1 Data Preparation

This section involves the data collection and data processing. Satellite data from Landsat 8 OLI/TIRS were downloaded from the United States Geological Survey (USGS). Two Landsat 8 satellite images with spatial resolution of 30m were chosen with the information illustrated as in Table 3.1. Both dates were chosen due to the factors that the images on both dates had better view of image and less cloud coverage compare to other images on those years. Next, the data processing is done by using the ArcMap 10 software. All the layer bands were stacked into a single layer by using the image analysis tools with ArcToolbox. The obtained images were clipped and extracted by Jeli district which is the study area.

Table 3.1 : Satellite images for study area

Acquisition date	Path/ Row
4th February 2014	127/ 56
19th March 2018	127/ 56

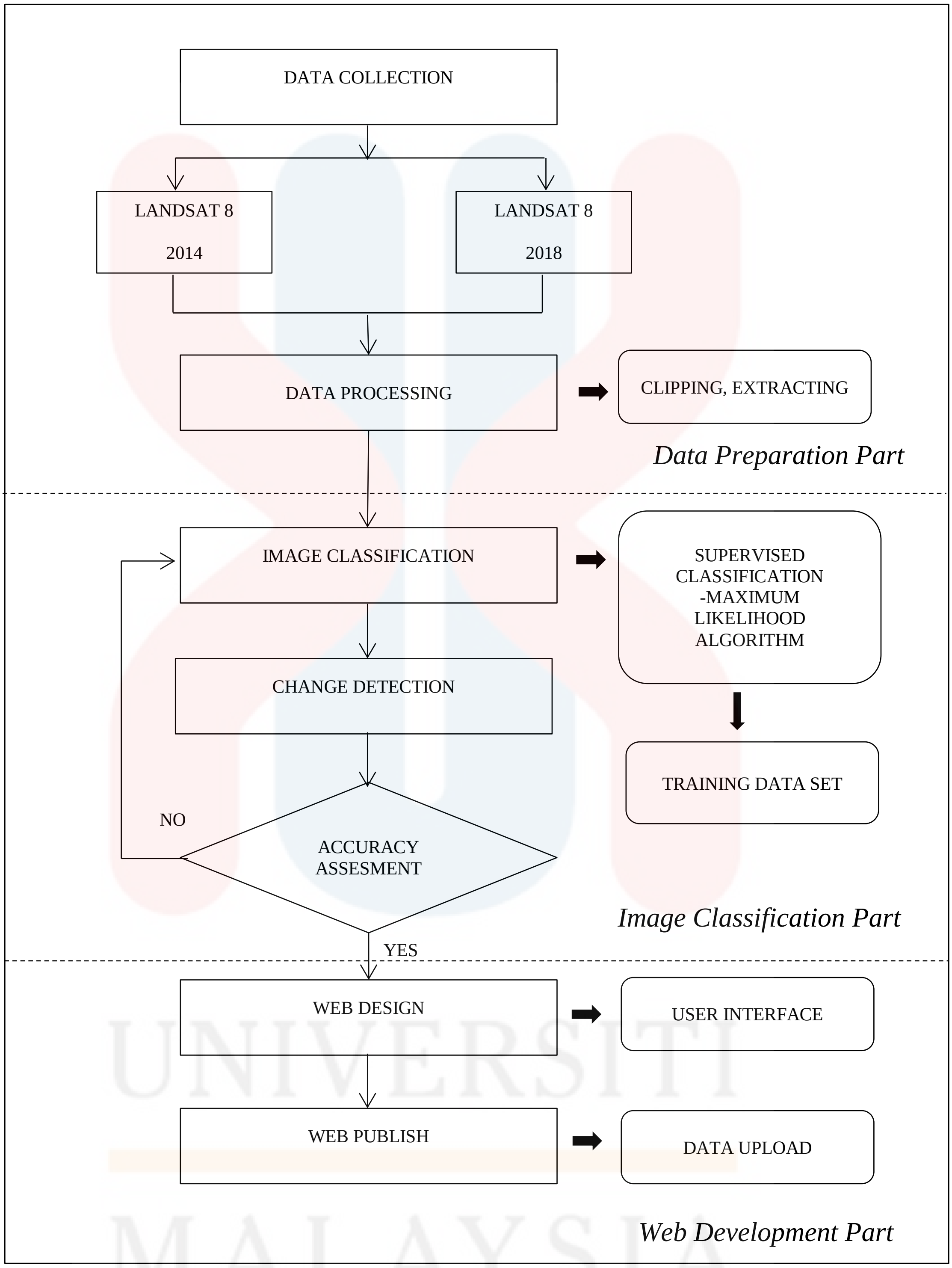

Figure 3.2 : The methodology framework of the proposed system

3.2.2 Image Classification

The data preparation part provides the images of study area to classify the interested group of land use changes between 2014 and 2018. Both images then undergo training for classification. For this study, a supervised classification method of Maximum Likelihood Algorithm has been used. According to Rawat & Kumar (2015), this algorithm is one of the most popular algorithm used for classification. The best part of this algorithm is it assumes that the probabilities for each class are equal and have normal distribution for input bands. Despite that, this method seems to take longer time for computation and tend to over-classify signatures with relatively large value in the covariance matrix. Nair & Pg Scholar (2016) also agree to this statement as they said that Maximum Likelihood Classification, with a training set which is strong to fully describes mean and covariance structure, is a sophisticated classifier with good separation of classes. Also the algorithm of Maximum Likelihood is computationally intensive and use to compute by as in equation (3.1).

$$g_i\,(x) = \ 1\text{n}\,p(\omega_i)\ -\ {}^1\!/_2\ln|\Sigma_i| - {}^1\!/_2\ (x - m_i)^T\,\Sigma_i{}^{-1}\,(x - m_i) \qquad (3.1)$$

where:

i = class,

x = n-dimensional data (where n is the number of bands),

$p(\omega_i)$ = probability that class ω_i occurs in the image and is assumed the same for all classes,

$|\Sigma_i|$ = determinant of the covariance matrix of the data in class ω_i

Σ_i^{-1} = its inverse matrix,

m_i = mean vector.

According to Jin et al., (2014), the classification accuracy is largely affected by the sample size. For example, for conventional statistical classifiers such as the maximum likelihood classification algorithm, the suggested number of training samples per class should be at least 10 to 30 times the number of wavebands used. Critically, however, this heuristic rule is often enforced in determining the per-class sample size, irrespective of the characteristics of the study site or the aim of the classification. Therefore, the allocation of training sample size to classes such that a more representative training set can be obtained with desired information for target objectives.

For the classification, the data were trained according to the definition of each land use class as per described in Chapter 2. The training sample size In this study, the data were classified into four classes which are forest, agriculture, urban and water. The classified data were then reclassified by using the subset tool. After that, the raster calculator was used to calculate the land use change for the two years. The change detection map was obtained after the calculation.

In the post-classification change-detection technique, each image was classified separately using supervised classification techniques and then compared to create a change image map. The 2014 image was classified first followed by the 2018 image according to the classification procedures described. The results of the post-classification change-detection were a new classification with "from" and "to" identifiers. For example, if the 2018 classification distinguished a pixel as forest and the 2014 classification distinguished the same pixel as water, then the result of the new classification would describe the pixel as "from forest to water."

According to Choy et al., (2018), accuracy assessment is important in evaluating the final results of remote sensing thematic map. This is to ensure the validity of the classified land use map. In this study the land use map is compared with the aerial image by using Google Earth Pro. Random points of 160 samples were created in ArcMap and exported to Google Earth Pro as kml layer. Next, Kappa Coefficient is used to calculate accuracy assessment.

For each map class, both producer's and user's accuracy are evaluated. User's accuracy is a prediction of the percentage of points mapped as certain types which are confirmed to belong to that mapped vegetation type when visited in the field. In other words, user's accuracy is a measure of the reliability of the map to predict what is found on the ground. Producer's accuracy is the percentage of points observed to be of a given vegetation type in the field that are correctly mapped to that type. In other words, producer's accuracy is a measure of the reliability of the aerial photo interpretation to distinguish the vegetation types. In addition to the user's and producer's accuracy, measures of the overall map accuracy are calculated, and contingency tables showing the frequency of confusion between associations are presented (Summer & Nordman, 2008).

3.2.3 Web Development Part

Web application is one of the best tools for information sharing and raising people's awareness about environmental changes. The information from web and internet can be easily accessible by everybody (Ibrahim & Ludin, 2015). In this study, PHP language is used to create the web for the land use changes derived from QGIS which provides qgis2web plugin which enable the user to share data through web. Qgis2web does its best to interpret a QGIS project and to export HTML, Javascript, and CSS to create a web map as close to the QGIS project as possible. The qgis2web plugin provides the function and configuration tools for the user to configure the web interface based on the appropriateness of the information. The Visual Studio Code was then used for refining and optimizing the web design. Moreover, MySQL is used to storage the related data to present on dynamic web page.

3.3 System and Design

In the web, the information about the land use changes in Jeli district can be obtained by the user. The information is simplified into the case diagram that is shown in Figure 3.3

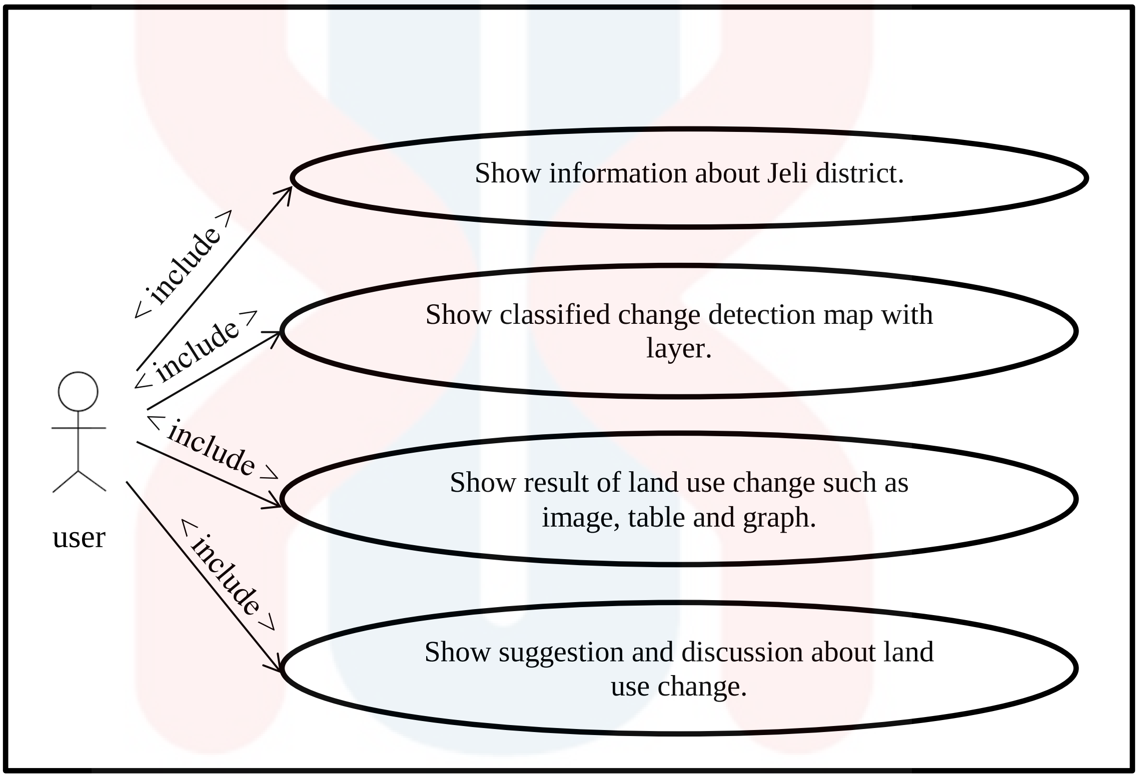

Figure 3.3: A user case diagram of the proposed system

As shown in Figure 3.3, the web will show the basic information about Jeli district. Besides that, by manipulating the GIS data from the database, the web will show the classified land use map. The user can choose the layer of the map according to each year. Besides that, the user can also see the image of classified land use map for each year. Other result from the change detection such as the table and graph are also shown in the web. To make the information more user friendly, there are also webpage for suggestion and discussion.

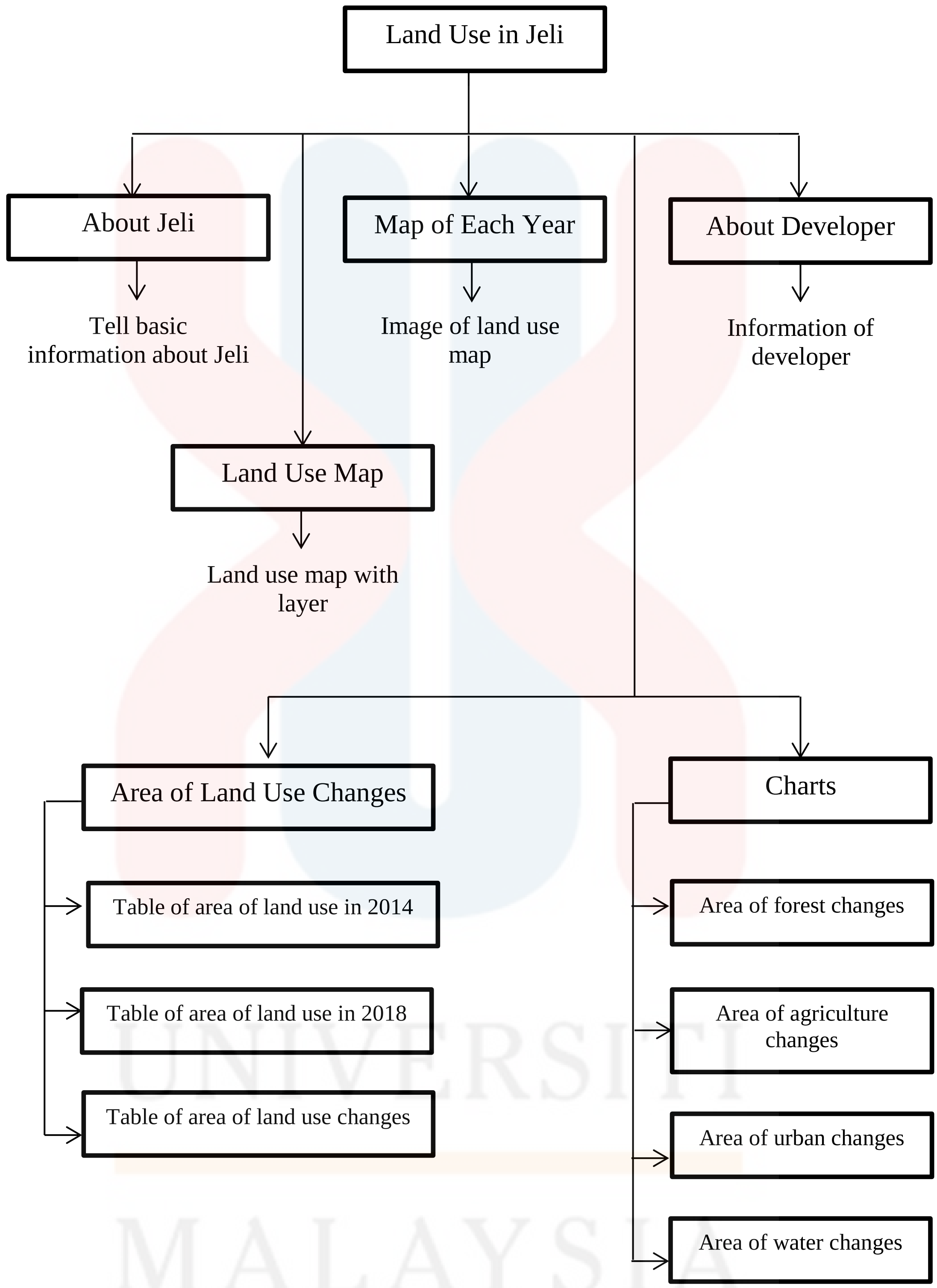

Figure 3.4 Design structure of the web.

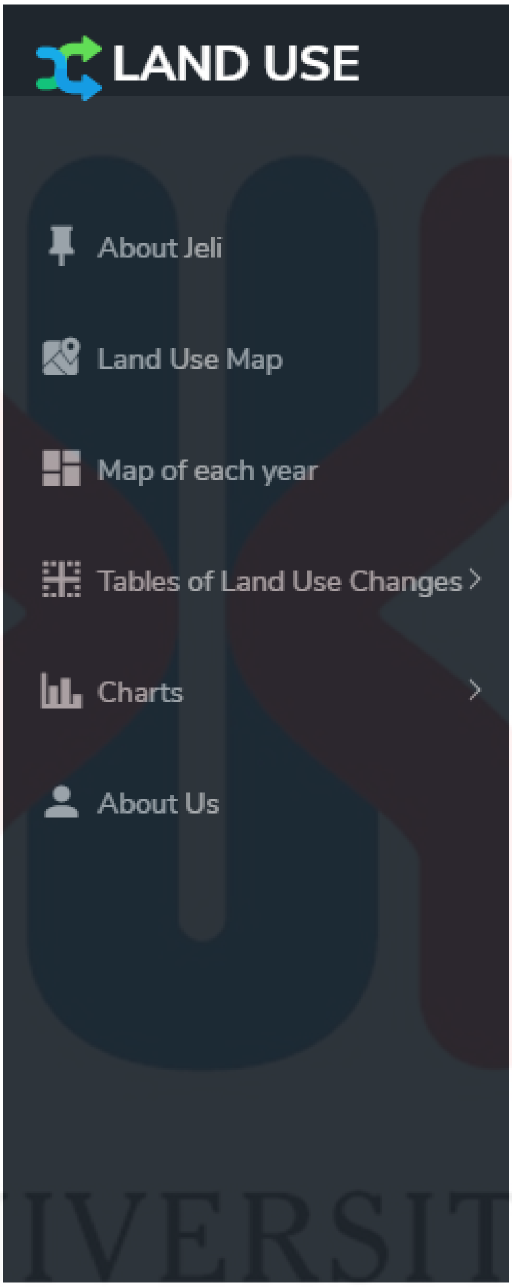

Figure 3.5 Navigation design of the web.

Figure 3.4 shows the design structure of the web. Meanwhile Figure 3.5 shows the navigation bar. From the home page, the user can navigate to other web page such as the "About Jeli" web page where the user can get the information about Jeli district. The "Land Use Map" page will bring the user to the page where the user can see the land use map of Jeli and choose the layer as of in which year they want. Next, the "Map of each year" page will bring the user to see only the images of the map. Meanwhile, the “tables of Land Use Changes” pages will bring the user to the results of land use in Jeli. From this page, the user can navigate to other page as of to see the results of which year between 2014, 2018 and the land use changes that occurred.

In addition, the user can also choose the charts page where the users will see the detailed results of land use change that occurred. For instances, if the users choose to see the forest land use changes, they can see the area of forest converted to other land use such as from forest to agriculture, forest to urban area and forest to water area. From this, the user can see the pattern of land use changes that occurs in Jeli district. The users can see the same type of information in other land use which includes the agriculture land use, urban land use and water land use.

Lastly, in the “about us” page, the user can see the information of the developer. All the team members’ names will be put so that users can get to know who developed the web of the land use in Jeli.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Overview of the System

In this chapter, a few subtopics will be discussed which included the collected data, processed data, land use map of Jeli and the developed web. To sum up, Figure 4.1 below shows the overall process of this project which is basically divided into a few parts. Starting with data preparation part where the data were collected from and processed. Then continue with the design of the web and manipulating the data to publish the data obtained for the public.

As shown in Figure 4.1, the data was prepared by getting the satellite image from USGS website. The images then were processed in ArcMap software to get the data for classified land use. Next, in QGIS software, the data was manipulated using Open Layers so that the map can be produced on the web. After that Visual Code Studio and Xampp is used for the PHP language to manipulate data to show on web site. Lastly, all the data obtained were published through the web.

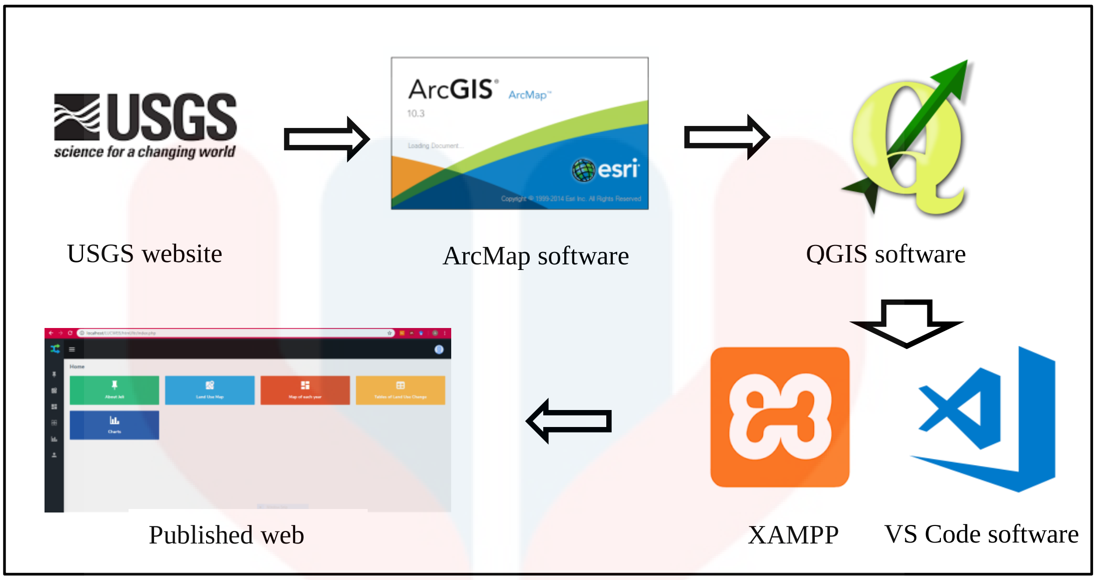

Figure 4.1 : Overview of the process from the start to the end.

4.2 Data Processing Result

In this part, the result image clipping, extracted by study area, supervised classification and accuracy assessment are being discussed.

4.2.1 Image clipping and extracting

The satellites images that were acquired were clipped as shown in Figure 4.2. The acquired satellite image from Landsat TM covers a wide range of area beyond the research area. Thus, the image must be extracted by the study area which is the Jeli district as the region of interest. The outputs of the images are shown in Figure 4.3.

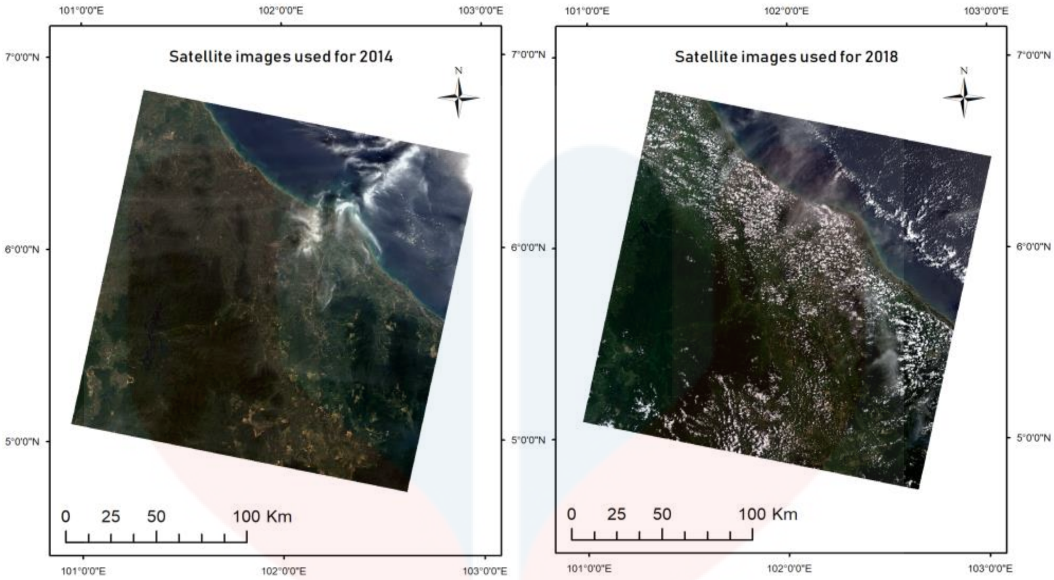

Figure 4.2 : Satellite images of Landsat 8 for the year 2014 & 2018 with true colour composite (Band 4,3,2).

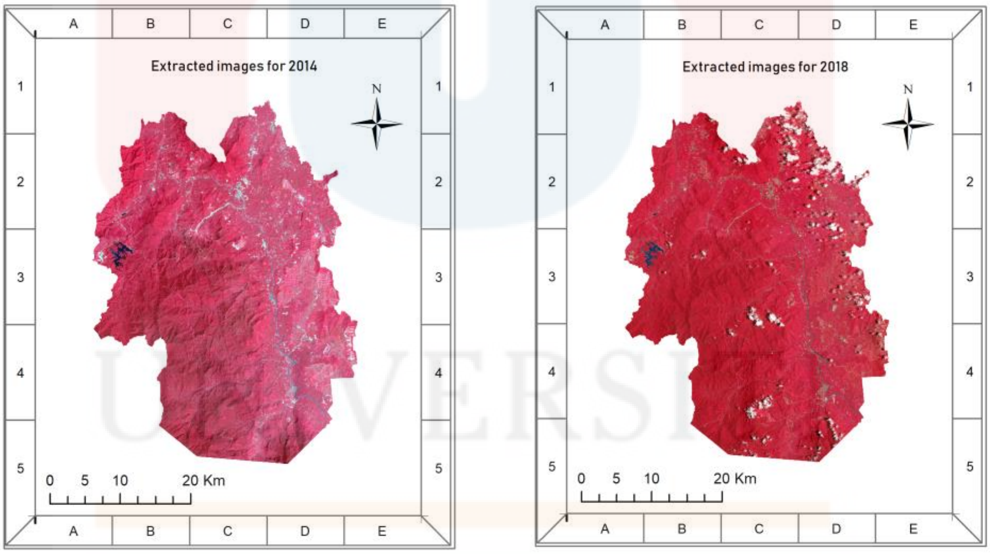

Figure 4.3 : False colour composite of the satellite images with band 5,4,3 after extracted by Jeli District area.

4.2.2 Supervised Classification: Maximum Likelihood

For the classification, the data will need to be trained. As for this study the data has been trained into four classes which are forest, agriculture, urban and water land use. Figure 4.4 shows the sample of the data during the training for maximum likelihood classification. Meanwhile, Figure 4.5 shows the sample of the land use which has been classified.

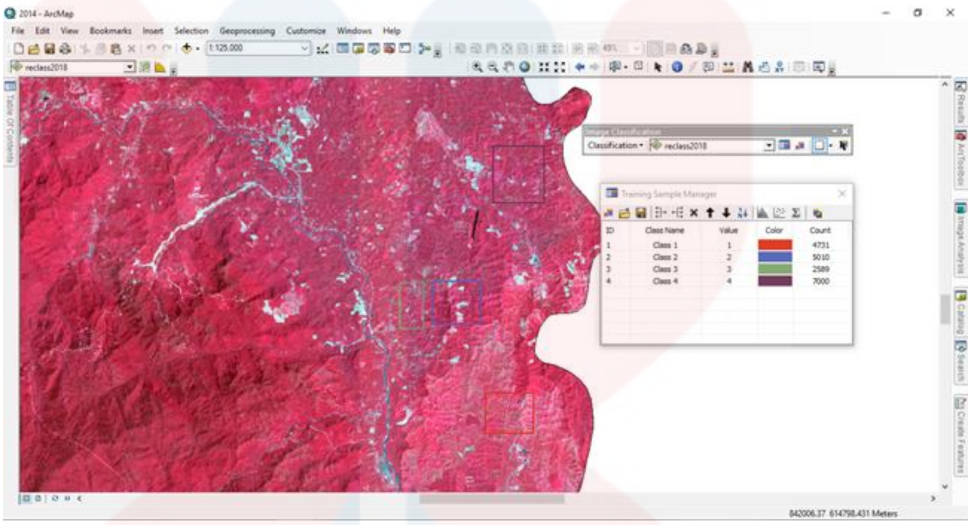

Figure 4.4 : Sample of data training for classification.

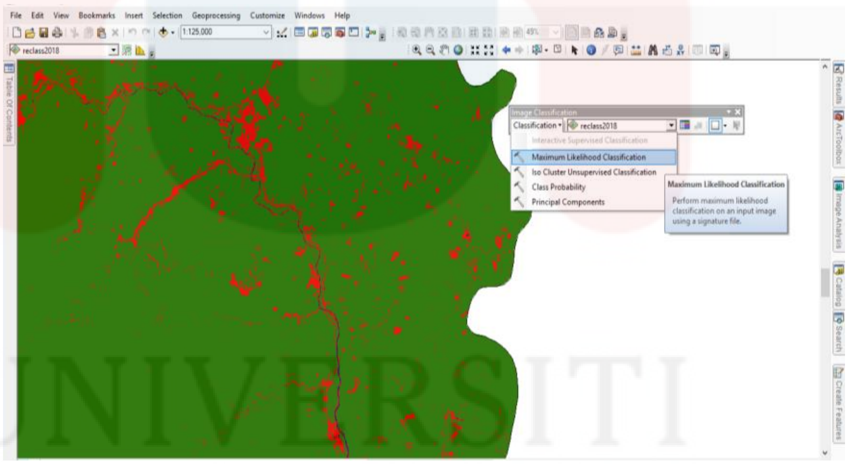

Figure 4.5 : Sample of classified land use.

4.2.3 Accuracy Assessment

Accuracy assessment is conducted to determine the level of precision of the classification that has been made by using Error Matrix (refer to Table 4.1). During this assessment, the overall accuracy as well as Kappa Coefficient was calculated. Table 4.2 indicates results of overall accuracy and kappa coefficient. Based on the accuracy assessment, the overall classification accuracy is 90.06%. The misclassification of the pixels might be caused by the present of scattered clouds.

In this study, the land use map was compared with the aerial image by using Google Earth Pro. Random points of 160 samples were created in ArcMap and exported to Google Earth Pro as kml layer. The results of the random sampling points are shown in Figure 4.6. Next, Kappa Coefficient was used to calculate accuracy assessment.

The Kappa Coefficient is generated from a statistical test to evaluate the accuracy of a classification. Kappa essentially evaluates how well the classification performed as compared to just randomly assigning values. The Kappa Coefficient can range from 0 to 1. A value of 0 indicated that the classification is no better than a random classification. A negative number indicates the classification is significantly worse than random. A value close to 1 indicates that the classification is significantly better than random. The results show that the Kappa Coefficient is 0.87 which is near to 1. This indicates that the classification is significantly better than random.

Table 4.1 : Error matrix table of accuracy assessment

Class	**Forest**	**Agriculture**	**Built Up / Urban**	**Water**	**Total**
Forest	40	3	0	0	43
Agriculture	0	32	2	1	35
Built up /Urban	0	5	39	5	49
Water	0	0	0	34	34
Total	40	40	41	40	161

Table 4.2 : Results of accuracy assessment

Overall accuracy	**90.06 %**
Kappa Coefficient	0.8678

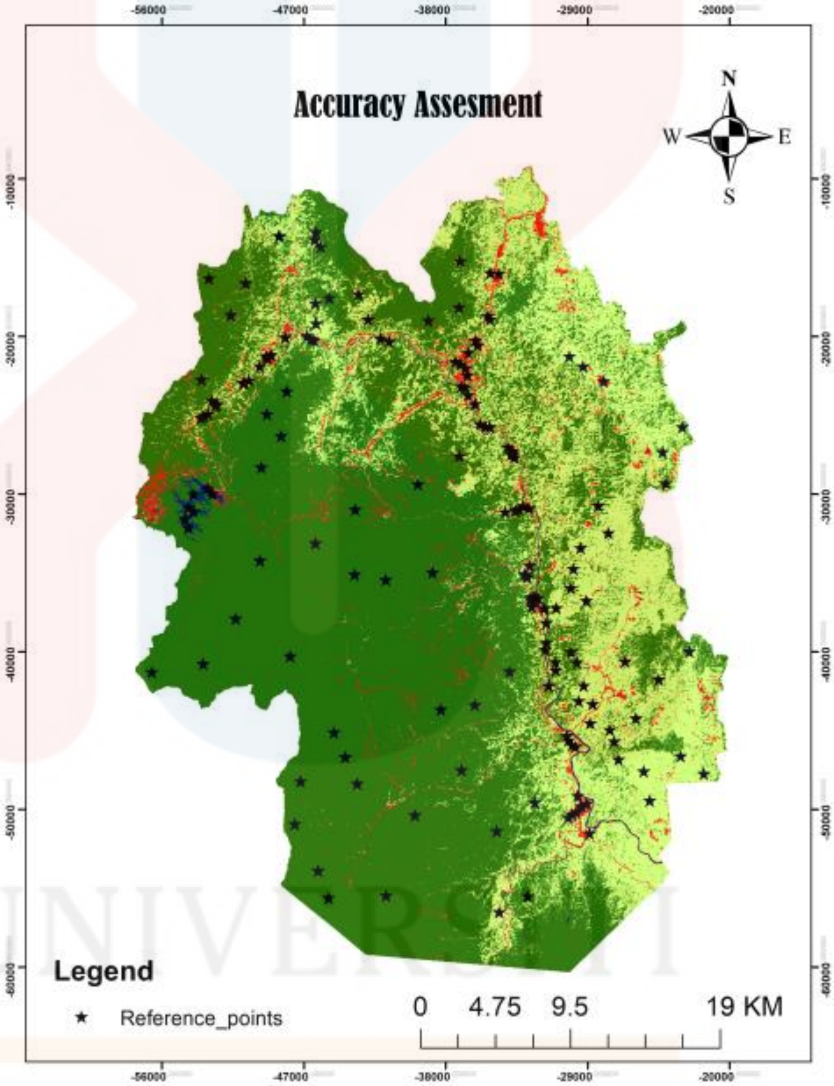

Figure 4.6 : Random sampling on classified images for accuracy assessment

4.3 Land Use Map of Jeli

Two land use maps were produced in this study. The statistical analysis was done in order to understand about the data that was obtained. This part will discuss briefly about the land use data that was obtained for the year 2014 and 2018.

4.3.1 Land Use Map of Jeli for the year 2014

The results of total area of each land use categories are represented in figure 4.7 and tabulated in table 4.3. For 2014, 66.33 % of Jeli land use was made up with forest area, followed by agriculture area with 29.31 %. Next built up / urban area cover 3.70 % of Jeli district followed by water area which covered 0.66 %.

Table 4.3 : Total area of each land use categories in 2014

Type	Pixel Count	Hectares (ha)	Percentages (%)
Forest	977877	88008.93	66.33
Agriculture	432180	38896.2	29.31
Built up / Urban	54522	4906.98	3.70
Water	9731	875.79	0.66
Total	**1474310**	**132687.9**	**100**

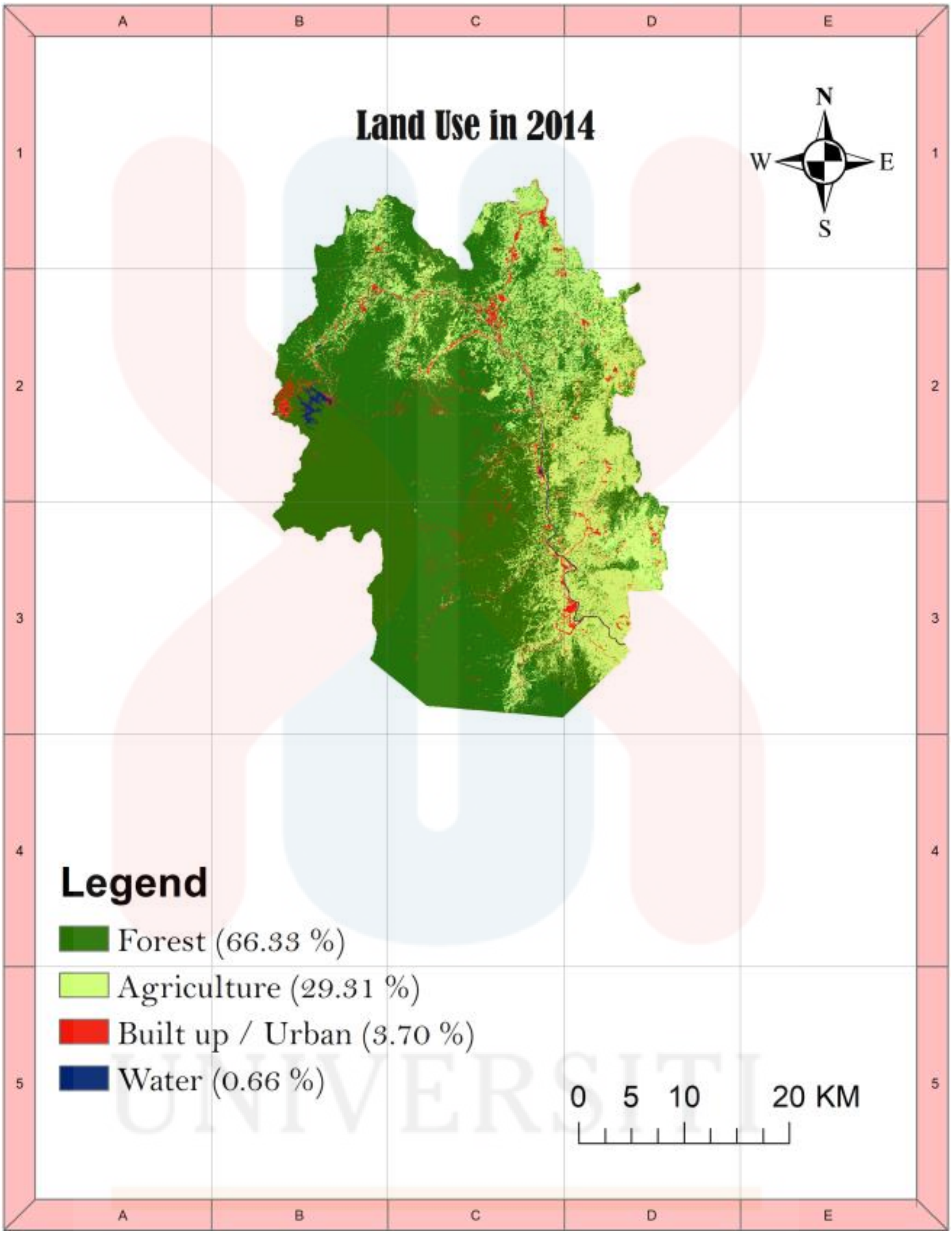

Figure 4.7 : Classified map of land use in 2014

4.3.2 Land Use Map of Jeli for the year 2018

The results of total area of each land use categories are represented in Figure 4.8 and tabulated in table 4.4. The land use in Jeli for the year 2018 is made up of 58.61 % forest area, followed by agriculture area with 30.73 %. Next built up / urban area made up 10.05 % of Jeli land use followed by water area 0.61 %.

Table 4.4 : Total area of each land use categories in 2018

Type	Count	Hectares (ha)	Percentages (%)
Forest	864158	77774.22	58.61
Agriculture	453029	40772.61	30.73
Built up / Urban	148161	13334.49	10.05
Water	8962	806.58	0.61
Total	**1474310**	**132687.9**	**100**

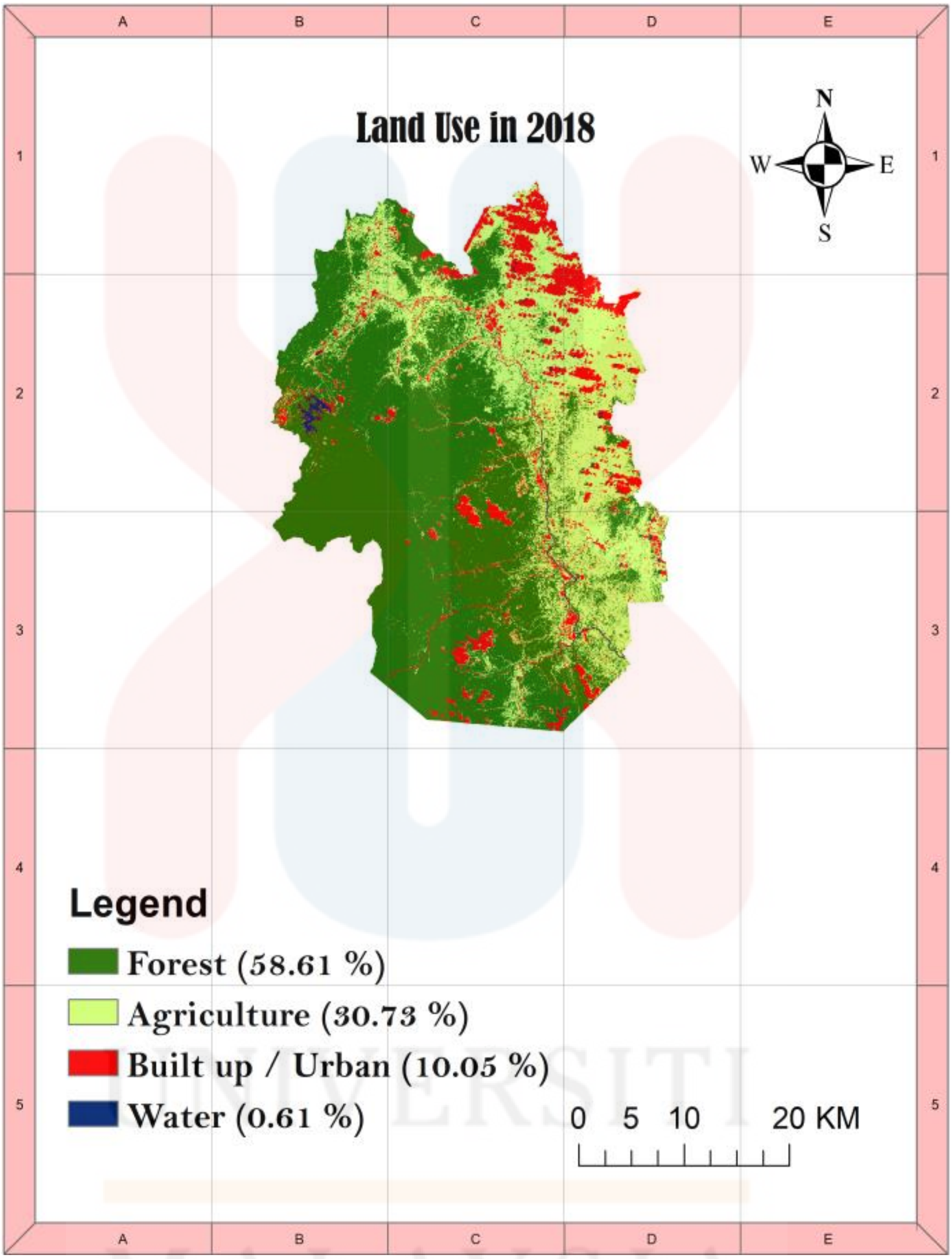

Figure 4. 8 : Classified map of land use in 2018

4.4 Land Use Changes in Jeli (2014-2018)

The results in this study shows that the area of forest land use has the most significance changes compared to other land use. The decreased of forest area is caused by the increased land use of agriculture and urban area. Meanwhile, the second most changed land use is the urban area. The increase in this area may be caused by the increasing number of human population in the community. However, there might be some misclassifies pixels during the classification which is caused by the cloud. Water body only shows a slight decreased toward the latter year. Table 4.5 shows the results of change detection analysis of land use according to each class. However, the changes between classes to other class did not show much significant impact. For instance, the conversion of water area to forest area only has small percentages of changes. All of this information was used in the web. Figure 4.9 shows the result in bar graph.

Table 4. 5 : Pattern of the land use change

Change from	to Forest	to Agriculture	to Built up / Urban	to Water	Total	Changes (%)
Forest	53.07	9.33	3.89	0.04	66.33	-7.71
Agriculture	4.93	20.22	4.11	0.06	29.31	1.41
Built up / Urban	0.60	1.17	1.88	0.05	3.70	6.35
Water	0.02	0.01	0.17	0.46	0.66	-0.05
Total	58.61	30.73	10.05	0.61	100.00	

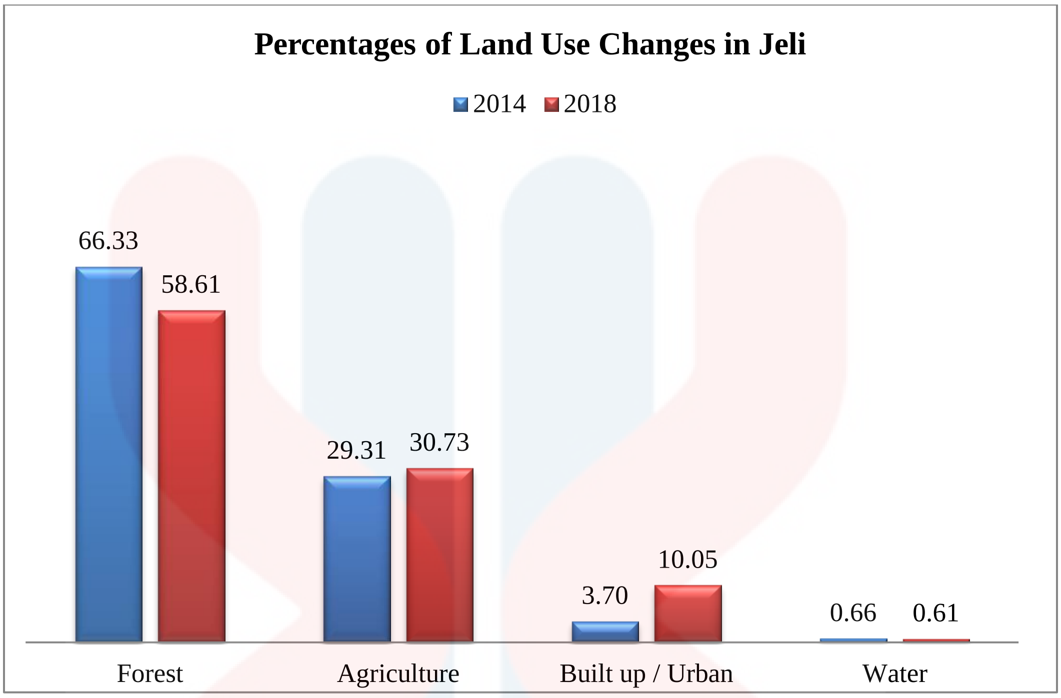

Figure 4.9 : Percentages area of land use changes in Jeli

4.5 Publishing Land Use Change Information through Web

As mentioned by Ibrahim & Ludin (2015), publishing information through web is one of the best platforms to share land use change study. By using this medium, the public and stakeholders can easily access and review the land use change and their environment characteristics. In the web, maps and tables are posted to share detail information of the study. In the webpage, user can access the land use change information, select the layer detail, and make decision or future plan based on the land use change. Figure 4.10 shows the homepage of the web. Meanwhile Figure 4.11 shows one of the web pages and its function. In the page, users can use the tools (refer to Figure 4.11 (1)) to locate, measure as well as zoom in and out of the map. In addition, users can also know the information on the map as the pop up will show the details (refer to Figure 4.11 (2)). Besides that the user can also select layer for the land use information that they want (refer to Figure 4.11 (3)).

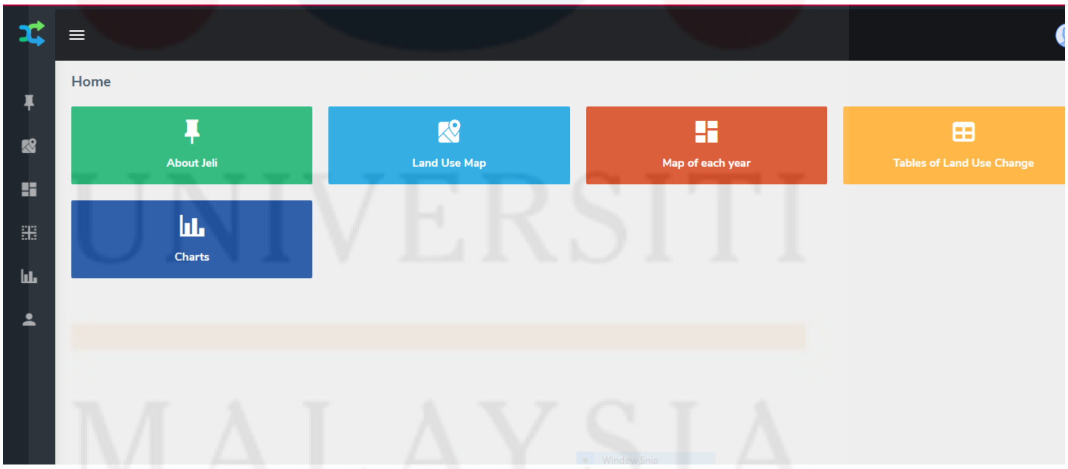

Figure 4.10 : The homepage of the web

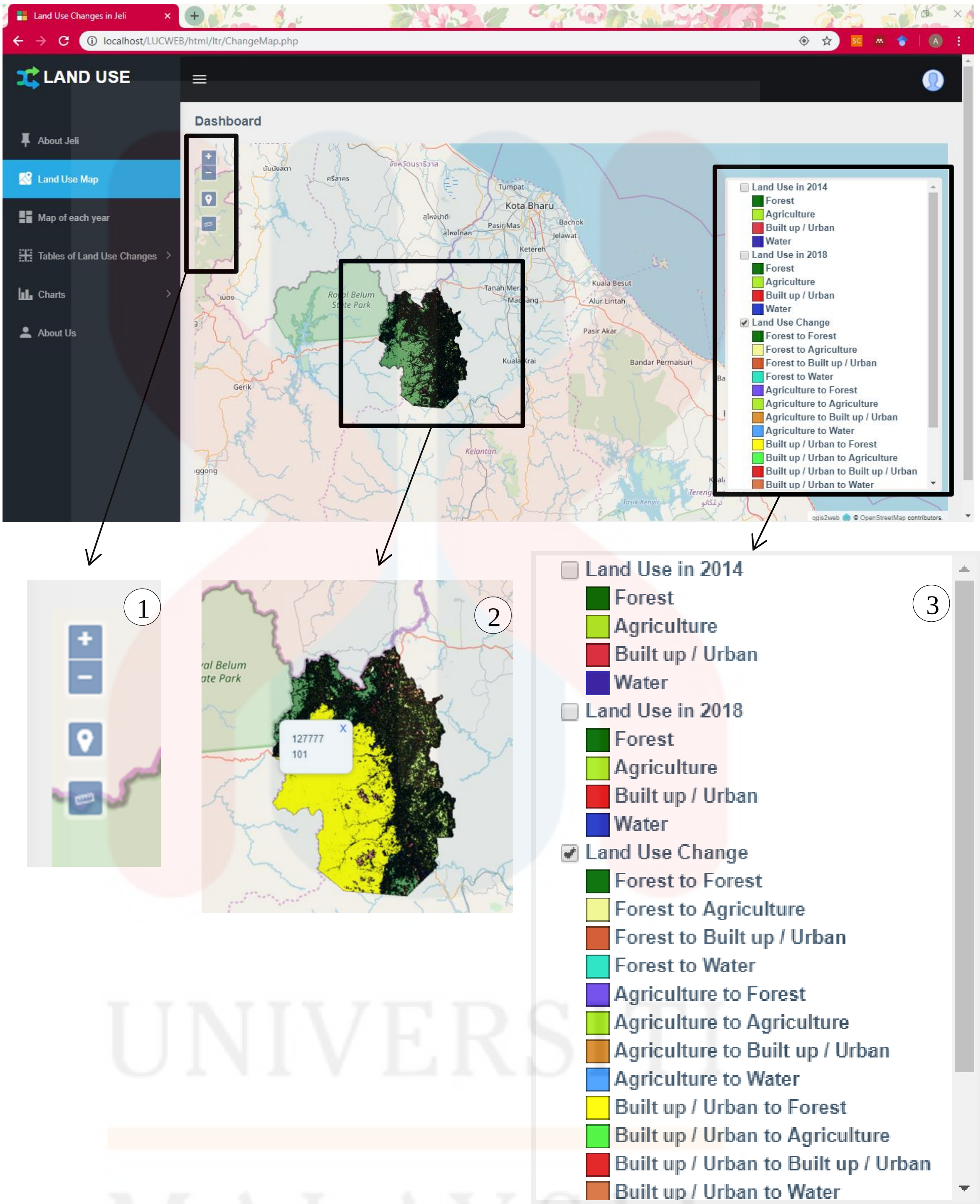

Figure 4.11 : Land Use Map with layers

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

From this study the two objectives that were outlined were fulfilled. For the first objectives, the land use change in Jeli has been classified into four classes which are forest, agriculture, urban and water. Two land use maps have been generated for the year 2014 and 2018. The results for the analysis of land use changes have been discussed in chapter 4. Next, for the second objectives the web for the land use in Jeli was created using the method outlined in chapter 3.

As a conclusion, the forest and urban area have the most significant changes among the land use changes class. This may due to the factor of increment in community population affected the land use changes. This shows that land use changes study is important for land use planning. With the aid of web GIS approached, the information can be easily accessible by the public and government.

To demonstrate the land use changes, the implementation based on web site was developed. This work were designed in two parts; data visualization on map and data presentation to users. The first part used the ArcMap, QGIS and Open Layer software to develop the land use changes to present on map whereas PHP language and MySQL is used in second part to manipulate data to show on web site. The results show that the proposed system can be used to assist any organization, public and individual to access the geospatial data by using web-based GIS for land use changes information.

5.2 Limitation of Study

There are a few limitations in this study such as variability of available data, and data errors. Firstly, there is lack of various data gathered especially the data on economic and agricultural development of Jeli. This has limit the reliability of the data support and reasoning about the changes that occur. Besides that, resolution of satellite images is relatively moderate to low which affected the classification accuracy.

5.3 Recommendation

To get better and more reliable information, the researcher should do some pre-research so that variety of data can be obtained. This is in order to support the reasoning of the land use changes that occurs. To improve the classification, the researcher should use a high resolution image so that the classification can be more accurate. Besides that, from the data obtained for the year 2014 and 2018, a model prediction of the future land use can be build.

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APPENDIX A

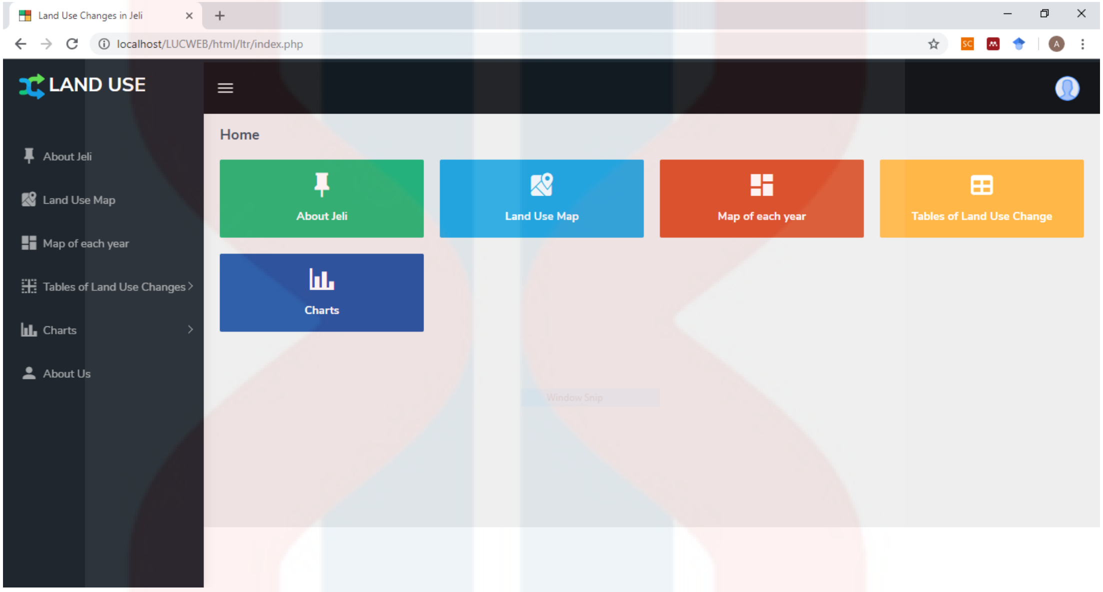

Figure A.1: Homepage of the web

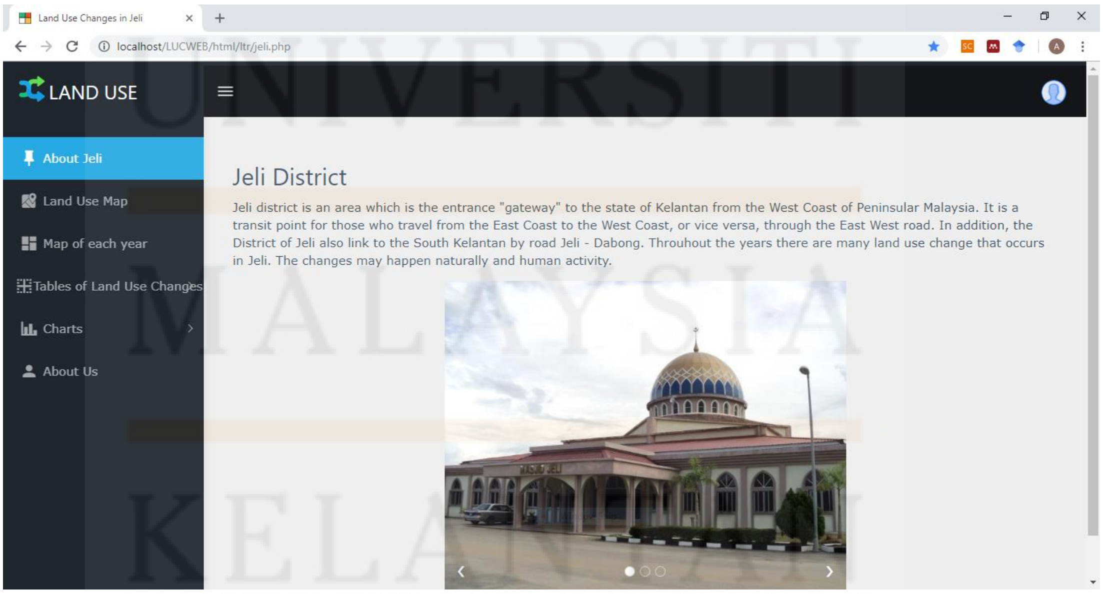

Figure A.2: About Jeli page

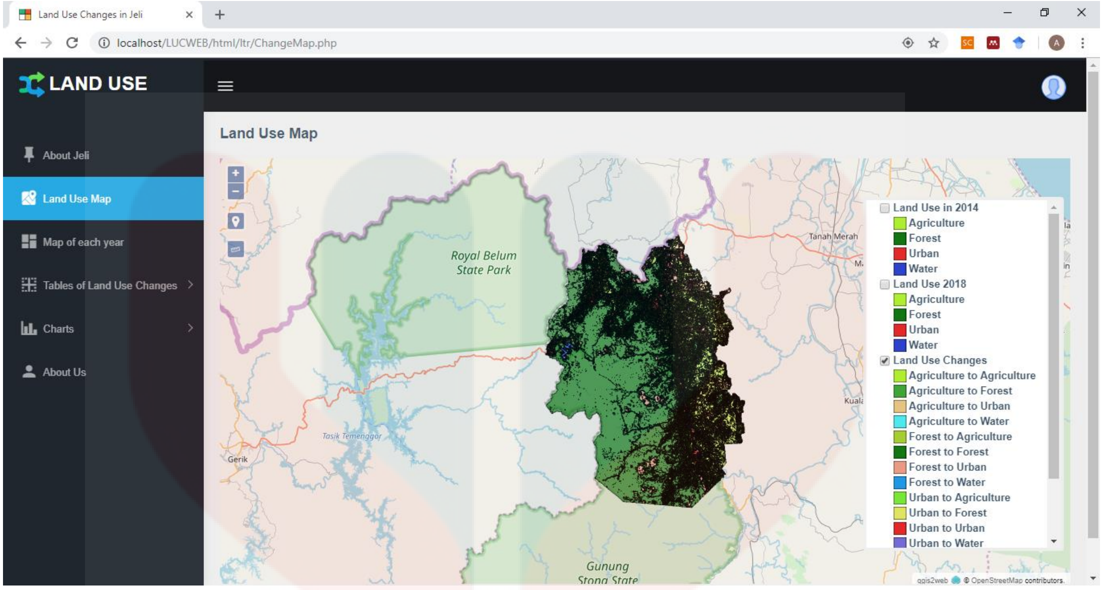

Figure A.3: Land Use Map with layer

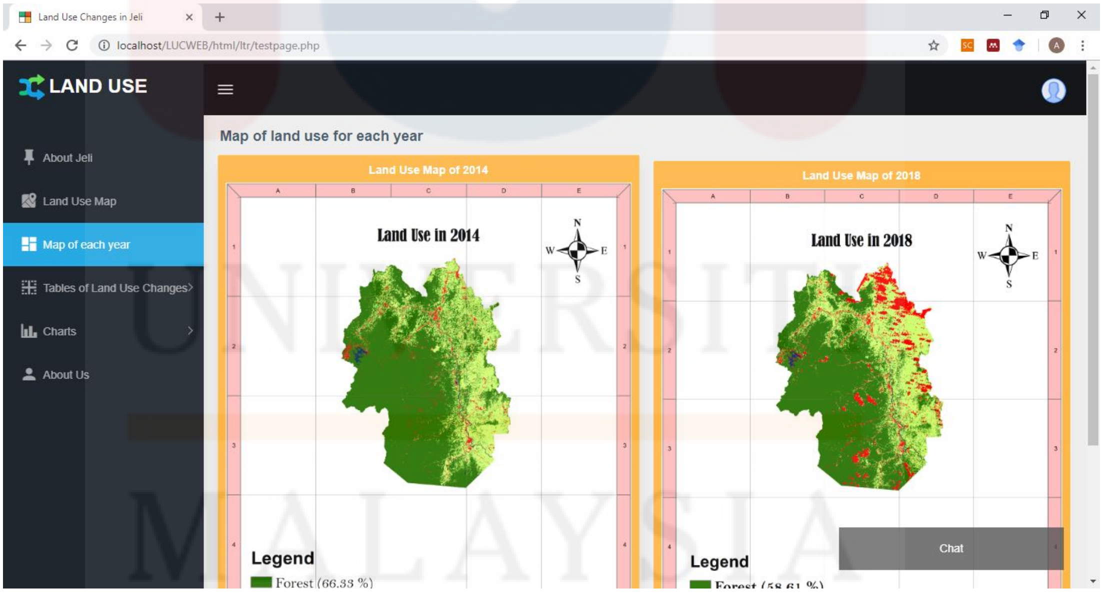

Figure A.4: Map of each year

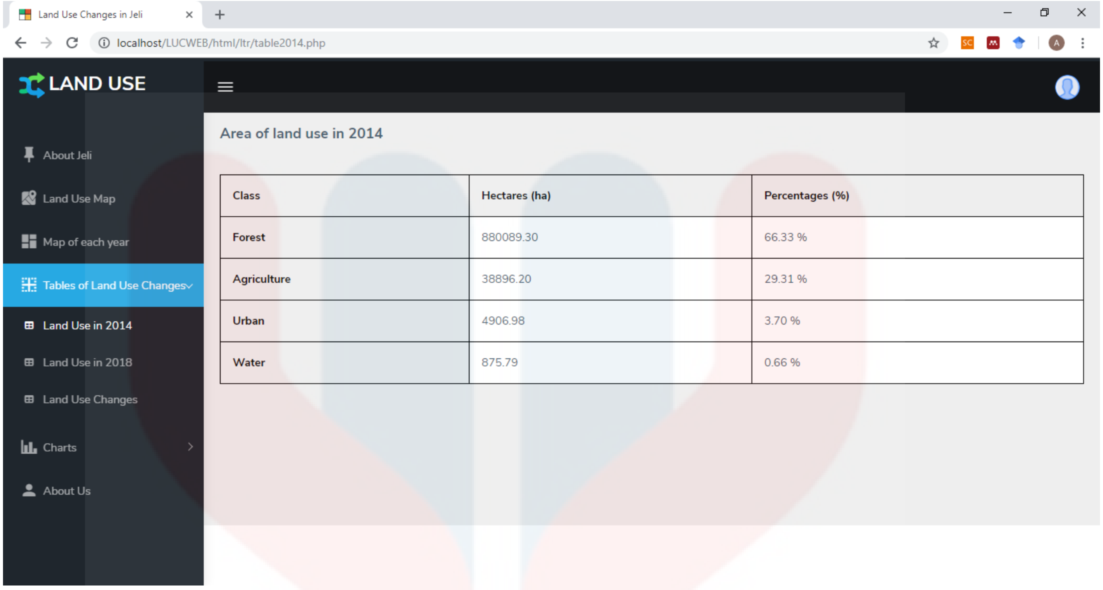

Figure A.5: Area of land use in 2014

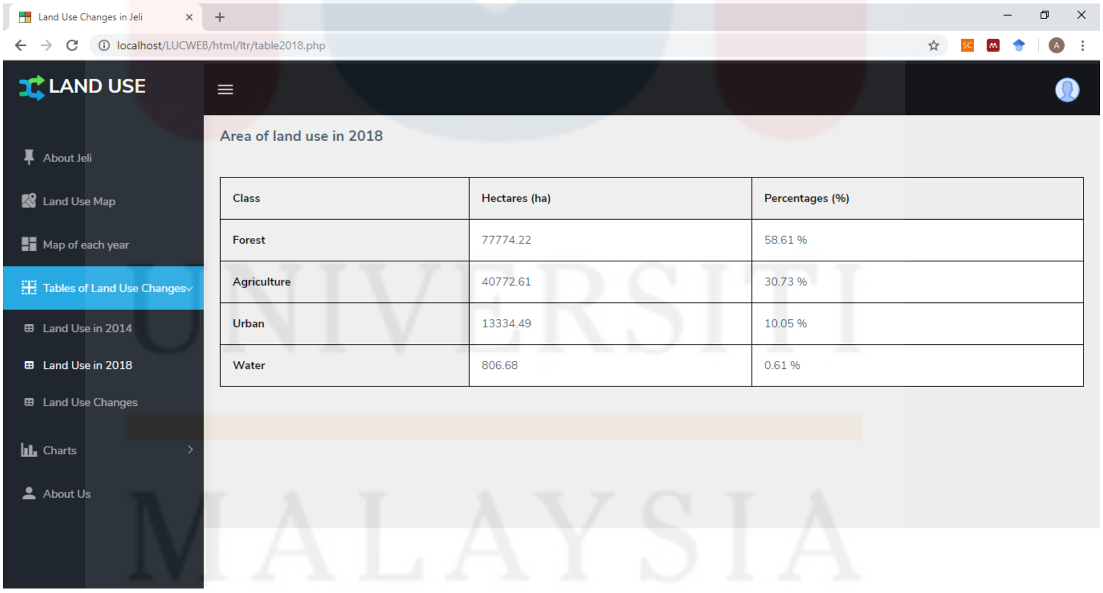

Figure A.6: Area of land use in 2018

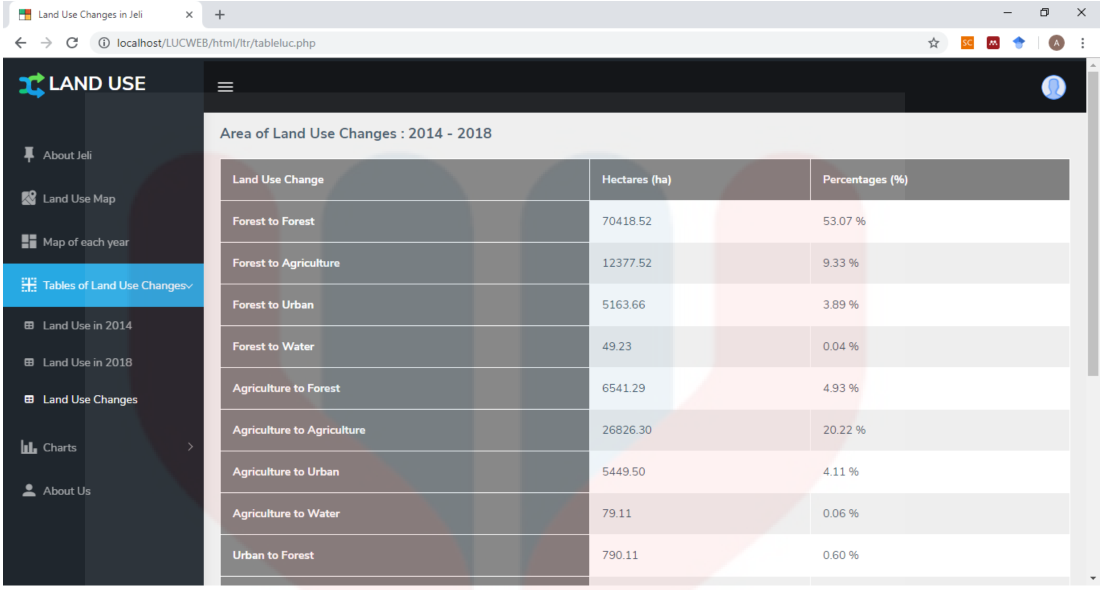

Figure A.7: Area of land use changes

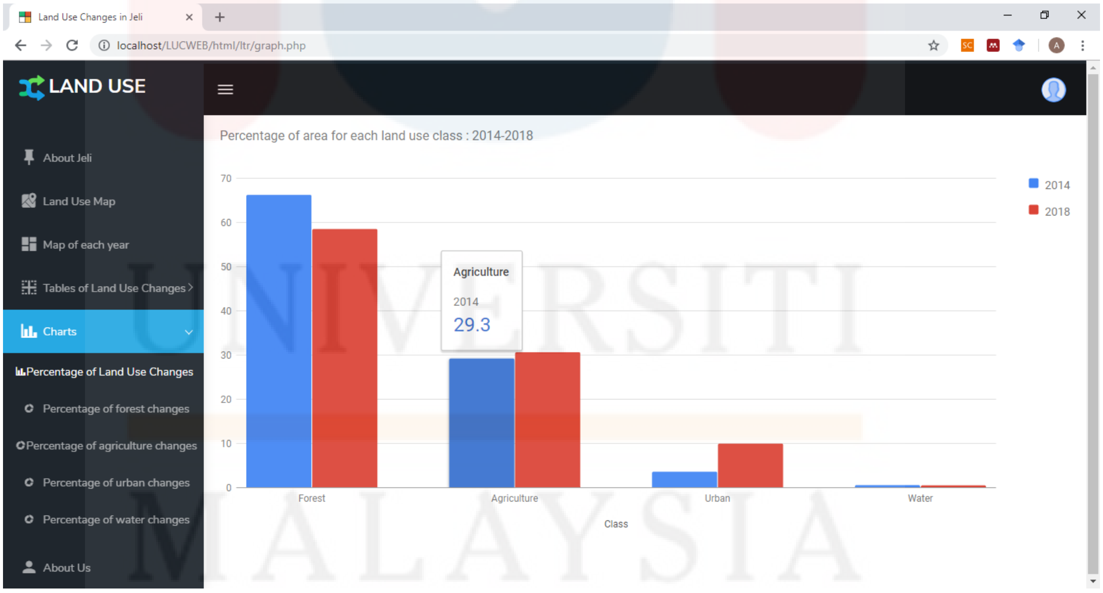

Figure A.8: Percentage of land use area

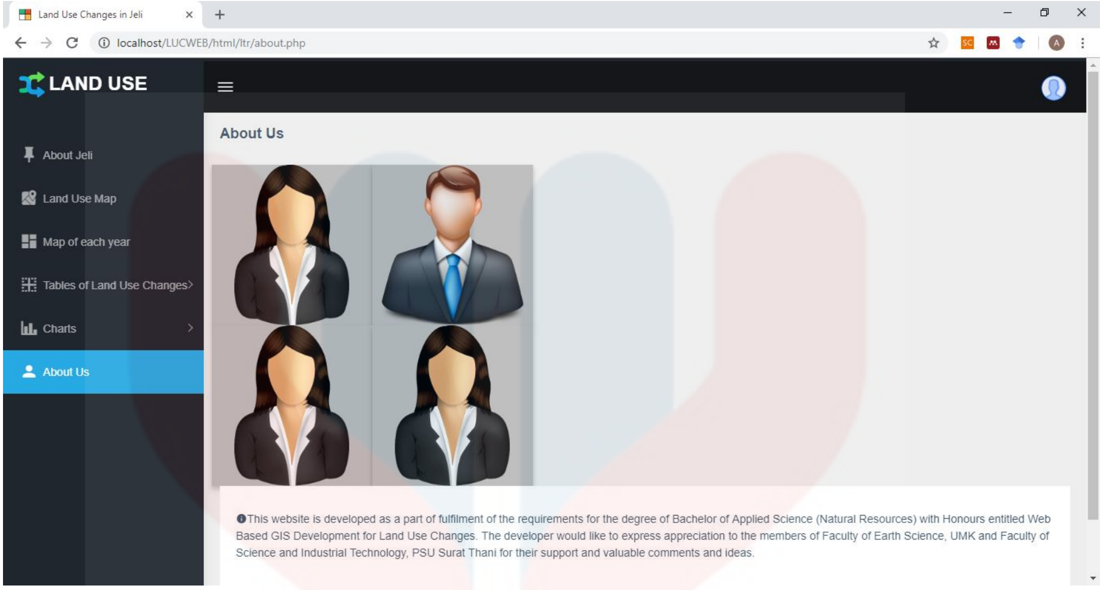

Figure A.9: About developer