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Information System of Land Use and Land Cover Change Based on Geospatial Data: A Case Study in Batu Pahat, Johor

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Abstract: Over the past few years, humans have always modified land to achieve the necessities for living, but the rate of exploitation was not as high as it is now. Land resources must be managed more efficiently in the future to assure that future generations can benefit from them. This study was conducted to identify land use changes in Batu Pahat area by integrating remote sensing and Geographical Information System (GIS) in developing land use and land cover map. Land use time series comparison between 2013 and 2020 was used in this study to discover changes in land use. In this research, data sets from Landsat 8 OLI satellite imagery used were obtained from United States Geological Survey (USGS). The satellite images were classified into several classes including water body, vegetation, built up area and barren land using the unsupervised classification technique. The use of ArcGIS software to analyze the data, revealed the changes in land usage in Batu Pahat area. The result indicates that there was an increase in area of built-up area and vegetation class by 11.01% and 2.02% respectively. Meanwhile, the area of water body reduced by 0.34% and barren land was reduced by 12.70%. The declination of barren land within seven years can be attributed to the increasing of built-up area due to urbanization and growth population in the study area. The mapping and information provided will be beneficial to the public and related authorities or decision-makers and scientists working on sustainable development, management of natural resources and investigation of global changes.

Keywords: Land Use Changes, Remote Sensing, GIS

1. Introduction

The term "land" refers to a location on the Earth's surface where human activities take place. Land cover corresponds to the physical characteristic of land, such as coastal area, forest and agricultural whereas land use relates to how consumer beings utilize their lands based on their roles for various economic and social activities [1]. Land Use and Land Cover Change (LULCC) pertains to how land use and land cover have changed through time. One of the key driving forces for climatic changes is the concepts of land use and land cover change that is crucial to the environmental sustainability issue. Reliable statistics on land use and land cover corresponds to their changes provide good information

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for decision-makers and scientists working on sustainable development, management of natural resources and investigation of global changes.

Collection of the information about land use and land cover changes is vital to provide better understanding of the relationship between humans and natural environment. The integration of Geographical Information System (GIS) and Remote Sensing (RS) technique is one of the most recognized and frequently used by researchers in this field. It is feasible to analyse and identify the changing trend of LULC change over a long period using this combination technique and consequently, to comprehend the changes within the selected region. GIS's most essential data resources is the remote sensing imagery where the identification of synoptic data of the earth's surface is done using satellite images [2]. The use of remotely sensed data has allowed researchers to analyse numerous changes on land in a shorter amount of time and with a high degree of precision [3]. The aim of this research is to analyse the LULC change by using application of GIS and remote sensing and identify the factors that influence by land use and land cover change at the study area.

2. GIS Application for Land Change Detection in Batu Pahat Area

2.1 Study Area

Batu Pahat is the capital of the Batu Pahat District in the Malaysian state of Johor. It is located in southern Peninsular Malaysia, at 1°51′N, 102°56′E. In 2012, Batu Pahat was the 16th most populous city in Malaysia in terms of population. The population growth in 2000 was 1.55%. As a result, there has been an increase in land consumption as well as modifications and alterations in the status of LULC change over time. Thus, it becomes an important matter to study on how the condition of the land profile in this area changes from time to time. Batu Pahat district was selected as the study area due to its rapid development in Johor after Johor Bahru district. The climate in the study area is tropical, with uniform temperature, high humidity and moderate rainfall. The average annual temperature of Johor is between 26 ºC to 27 ºC with the average annual rainfall of the state between 2000mm to 2500mm per year. Figure 1 below shows the map of study area which covers an area of 1,872.58 km^2.

Figure 1: Location of study area

2.2 Data Acquisition from Remote Sensing Satellites

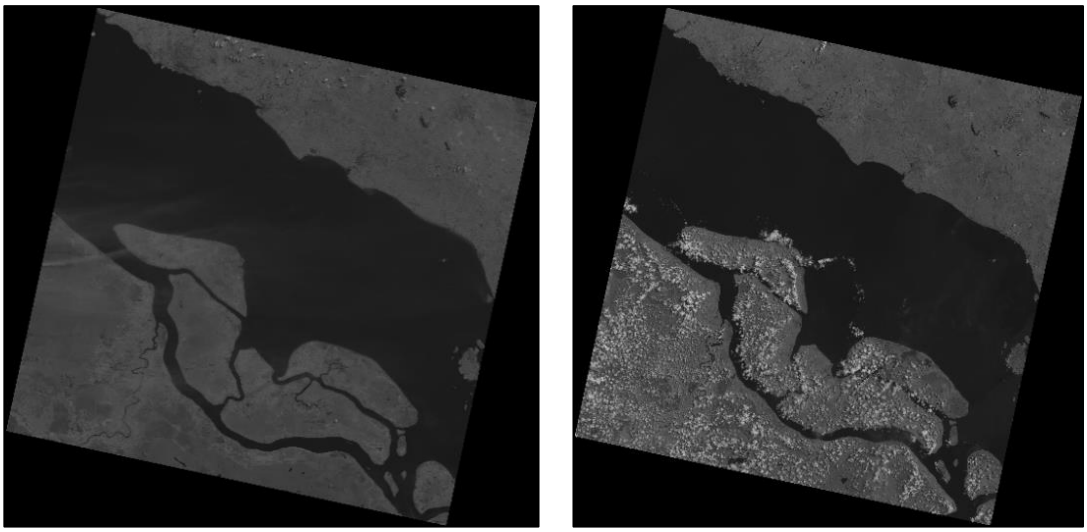
The Landsat image sensor is a unique sensor onboard the Landsat satellite platform that can capture multispectral imagery [4]. This study used Landsat 8 Operational Land Image (OLI) and Thermal Infrared Sensor (TIRS) satellite data with a spatial resolution of 30 metres, whereas adequate for land use change detection. Satellite images for the year 2013 and 2020 had obtained from USGS Earth explorer (https://earthexplorer.usgs.gov) as the aim of this research is to identify the changes over these time periods. Table 1 lists the specification of the satellite data used for analysis of the study. The satellite images used in this study were selected based on three criteria: (1) satellite images with less than 10% land cloud cover (2) satellite images with less than 10% scene cloud cover (3) the satellite images indicate during the day.

Table 1: Landsat data used in Batu Pahat area

Year	Satellite (Sensor)	Spatial Resolution	Path/Row	Acquisition Date
2013	Landsat 8 (OLI/TIRS)	30m	126/59	18/4/2020
2020	Landsat 8 (OLI/TIRS)	30m	126/59	18/6/2013

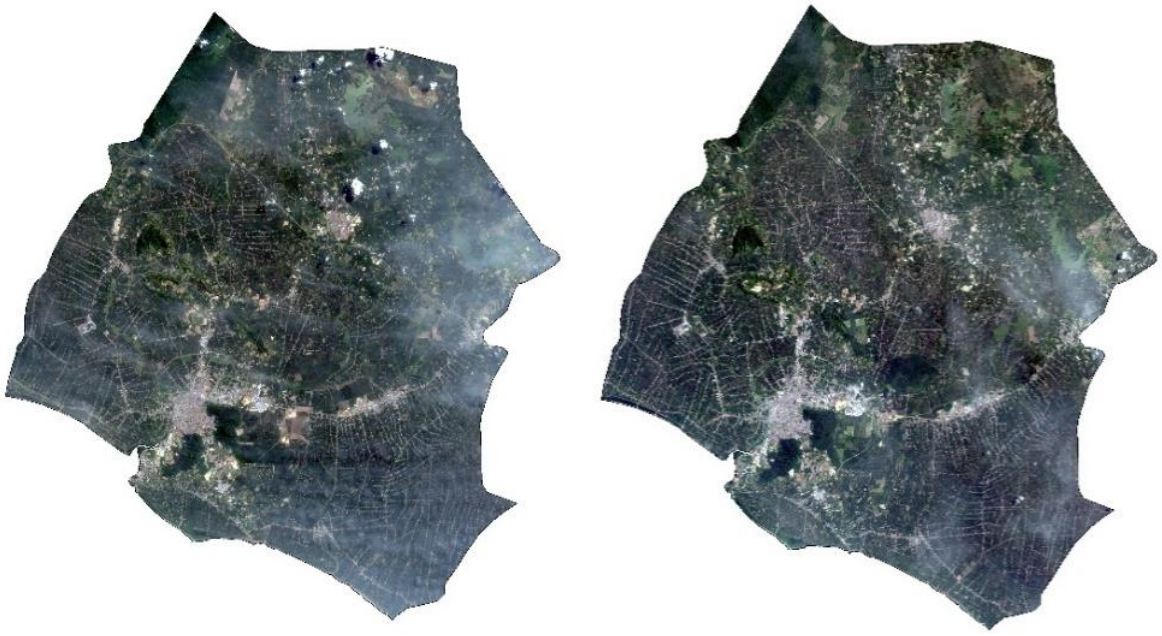
2.3 Image Processing

Digital image-processing software ArcGIS 10.8 is used to process, analyse and combine spatial data and geographic information to achieve the goal of this study. The purpose of processing satellite images is to detect changes in land use by develop a more direct correlation between the data and biophysical phenomena [5]. To process the satellite images, all of the spectral bands were integrated into a single image file by composition of band 1 to band 7. This study used 4(red), 3(green), 2(blue) band composition approach that referred to standard false colour composite. The vegetation area will appear in red colour, urban areas in blue and soils colour range from dark to light brown. Figure 2 showed band 5 Landsat images used for both year, 2013 and 2020 used in this study before it is processed. The results of this band combination of the study area are shown in Figure 3.



(a) (b)

Figure 2: Band 5 Landsat scenes in year 2013(a) and 2020(b) in Batu Pahat area



(a) (b)

Figure 3: Combination of band 4,3,2 for Batu Pahat area in year 2013(a) and 2020(b)

2.4 Classification System

A classification method that defines the land use classes was considered when creating the land use and land cover map using satellite images [6]. The results of unsupervised classification are based on a software examination of the image without the usage of example classes provided by the user. Meanwhile, supervised classification is based on the assumption that the user can select sample pixels in an image that represent particular classes and then enable image processing software to utilize these training sites as guides for the categorization of all other pixels in the images. In this study, unsupervised classification technique was used in classifying the satellite images. During classification system, all satellite image pixels will be assigned according to the designated number of land use classes. This study featured four type land use class including water body, vegetation, built-up area and barren land. The blue colour was represent to indicate water body, while the green colour was chosen to represent various type of vegetation including agricultural plantation. In addition, yellow was selected to depict barren land whereas for built-up area, red colour was picked.

2.5 Change Detection

Change detection is the process of observing an object or phenomena at different periods to find alterations in its condition. The purpose of change detection is to recognize which land use class is transforming from one to the other. This study will cover the classification comparisons of land cover statistics. For the various periods, the areas covered by each land use class were compared. The areas of the land classes then interpreted to statistical data such as graph for analysis purposes. The use of Microsoft Excel to create graphs makes it easier to quantify all of the data gathered throughout the mapping process.

3. Result Discussion and Analysis

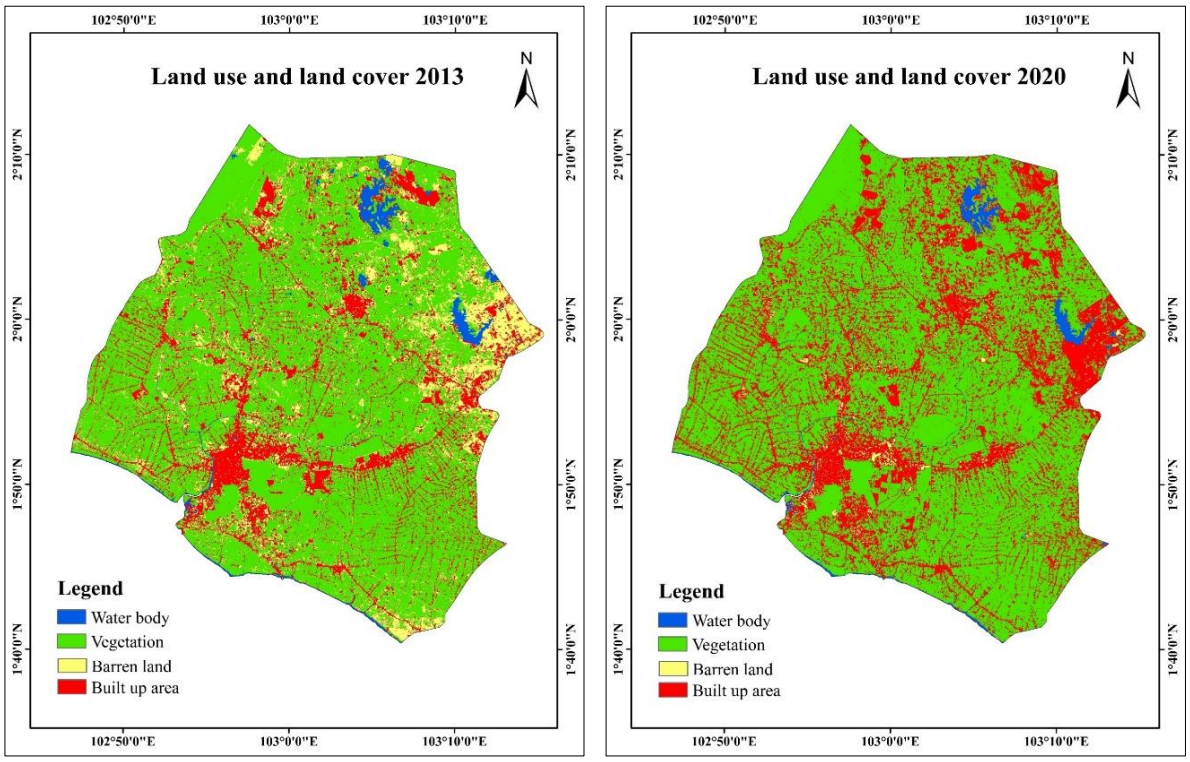
3.1 Land use and land cover classification

Classification and mapping of land cover are two processes that help users better comprehend Earth's biophysical systems [7]. The classification of land use and land cover shows four distinct land use types. These classes specifically are described in the following:

Table 2: Land use and land cover classes

Land use class	Description
Water body	Ocean, rivers, lakes, ponds and bays
Vegetation	Trees, shrubs and various plantation including oil, rubber and coconut
Built-up area	Residential, industrial, commercial and services, transportation, commercial complexes and mixed urban
Barren land	Bare soil, sandy areas, bare exposed rocks, transitional areas and construction site

3.2 Land use maps



(a) (b)

Figure 4: Land use and land cover of Batu Pahat between 2013(a) and 2020(b)

The use of vegetation is the most dominant for both years of land use and land cover map in Batu Pahat area (Figure 4). It was shown that large surface area of vegetation in both years was indicated means this district happened to be a plantation site. Mapping showed that barren land area was declined as well as land use of water body from 2013 to 2020. This is based on the area of barren land becomes smaller in 2020 compared to 2013 due to urban development. Regarding the changes of climate that shows various chapter in global warming and the intensity of people around it, the water body in selected location was larger in 2013 but in 2020, the water body in particular location dried or being eliminated.

3.3 Land use change detection

Process of classification the land use and land cover map require various source of data including aerial pictures, satellite images and maps of different social and cultural variables such as boundaries and density of property [8]. Table 3 shows the distribution of land use change in Batu Pahat district between 2013 and 2020 and Figure 5 illustrate the changes proportion:

Table 3: Summaries of land use and land cover classes in Batu Pahat between 2013 and 2020

Class type	2013		2020		Magnitude of land use change	
	Area (Ha)	Percentage (%)	Area (Ha)	Percentage (%)	Area (Ha)	Percentage (%)
Water body	3741.03	2.00	3097.99	1.66	-643.04	-0.34
Vegetation	124573.07	66.61	128360.43	68.63	3787.36	2.02
Built-up area	32747.86	17.51	53341.83	28.52	20593.97	11.01
Barren land	25969.50	13.89	2228.72	1.19	-23740.78	-12.70

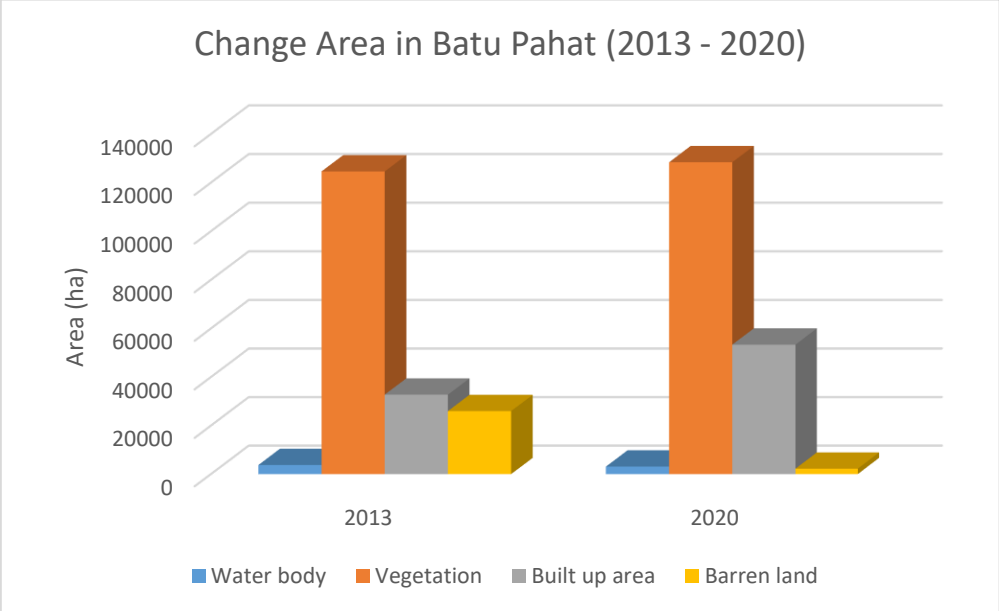


Figure 5: Proportion of land use change in Batu Pahat between 2013 and 2020

i. Change in water body

Water bodies in Batu Pahat area was affected with decreasing 0.34% from 2.00% to 1.66%. The changes might be occurred due to exploitation of small areas of water bodies. These water bodies area such as swamp area may be reclaimed and used for other land use purposes such as built-up areas and vegetation. Water body in Batu Pahat area has decreased by 643.04 hectares from 3741.03 hectares to 3097.99.

ii. Change in vegetation

On the year 2013, Batu Pahat was having 124573.07 hectares of vegetational area covering the area of trees, shrubs and various plantation such as oil and rubber plantation. By the year of 2020, the capture image of vegetation surfaces increased slightly to 128360.43 hectares which turned 66.61% covering

area of Batu Pahat to 68.63%. The changes occurred between 2013 and 2020 which is 3787.36 hectares (2.02%) is not too significant as vegetation class was still dominant in this study area for both years. This indicates that this area is still not fully explored and has many plant resources that need to be conserved.

iii. Change in built-up area

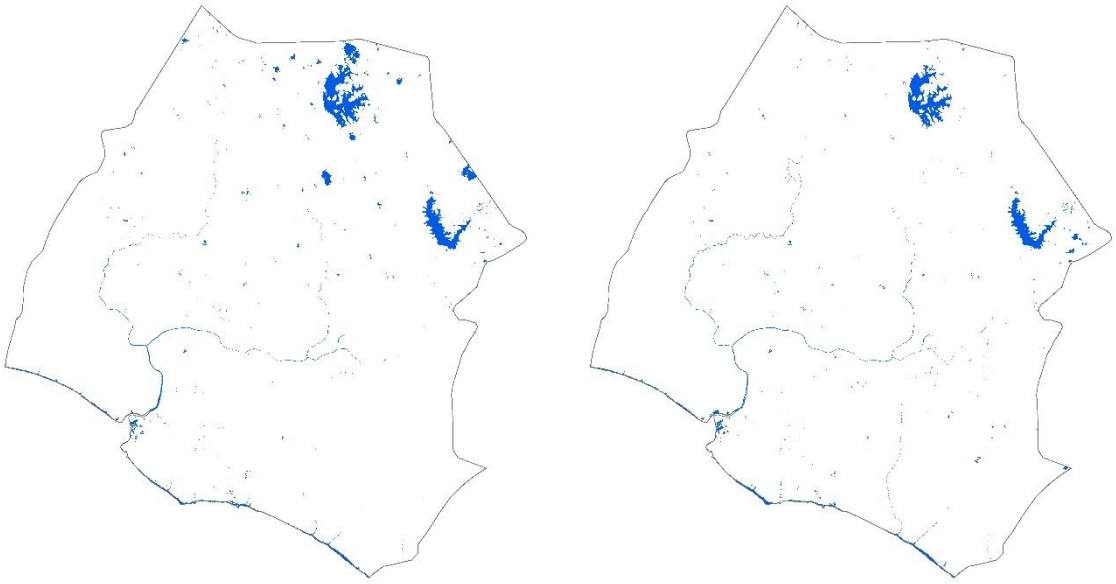
According to the municipal development plan, the reasons for the increase in built-up area were the growing need for additional residential area, as well as opportunities for business and services. This could be seen through land use and land cover map of Batu Pahat between 2013 and 2020 where the built-up area increases drastically from 17.51% to 28.52% represent 32747.86 hectares to 53341.83 hectares. The magnitude of change in built up area which is 20593.97 hectares (11.01%) tabulated in Table 3 is expected to expand due to increasing of population in this district. The shift from rural to urban migration has been fueled by significant social and economic advancements, such as improved educational and communication facilities [9].

iv. Change in barren land

On the year 2013, the barren land in Batu Pahat area took up 13.89% area. However, barren land use areas experienced 12.70% decline in 2020 which took only 1.19% areas due to increased built up area because development that took place in the Batu Pahat district. The declination that occurred to barren land in this area which turned 25969.50 hectares area in 2013 to 2228.72 hectares in 2020 with magnitude change of 23740.78 hectares as seen in Table 3 was probably because of rapid development to accommodate the growing population and human need. The changes that took place in the Batu Pahat district are related to various factors such as the increase in industrial areas, development and oil palm cultivation which caused land use in Batu Pahat to change dramatically.

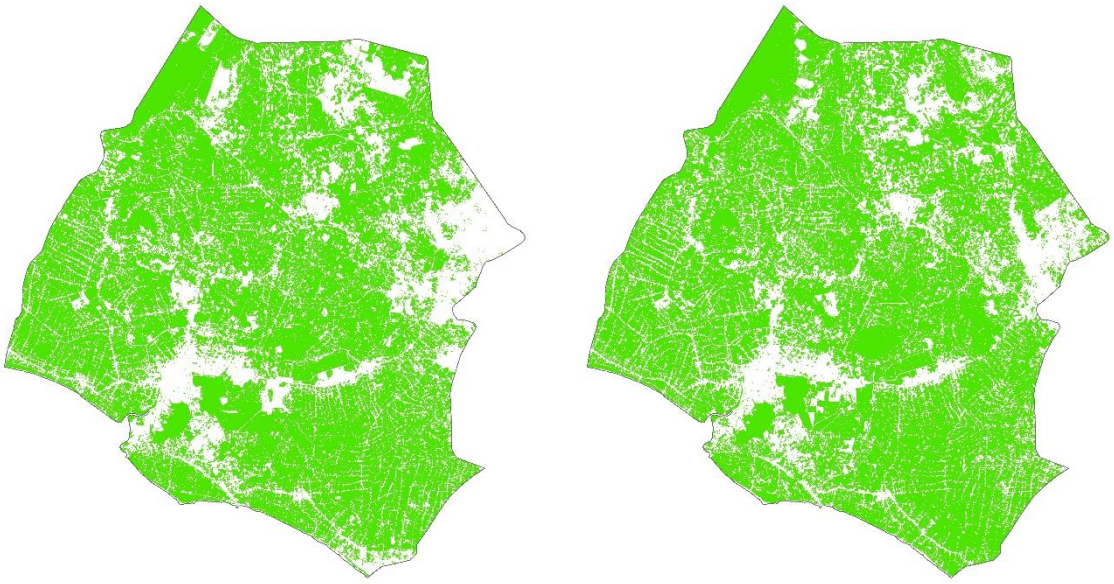
3.4 Summary of findings

Analysis of the results revealed that vegetation accounted the biggest amount area of Batu Pahat for both years. This result indicated that apart from the vegetation, which is agriculture was the primary source of revenue during this time period. Analysis of the 2013 and 2020 Landsat 8 OLI images showed that there have been major changes occurred to the land use of built-up areas and barren land class between these two years as illustrated in Figure 8 and Figure 9. The decreased in barren land is closely related to the addition of built-up areas. This is due to increased human needs and population growth. Besides, this might have been due to the growth of population which attracted more people to the cities with various government establishment and commercial activities. Consequently, the government began a major allocation for residential and commercial area, resulting in more barren land for the construction of built-up region. There are not many changes took place to the other land use classes, which are water body and vegetation as shown in Figure 6 and Figure 7. This revealed that Batu Pahat district more focused on the development for this area. The changes that occur in the water body areas might be attributed to soil droughts that occurred in some areas.



(a) (b)

Figure 6: Changes in water body class between 2013(a) and 2020(b) in Batu Pahat area

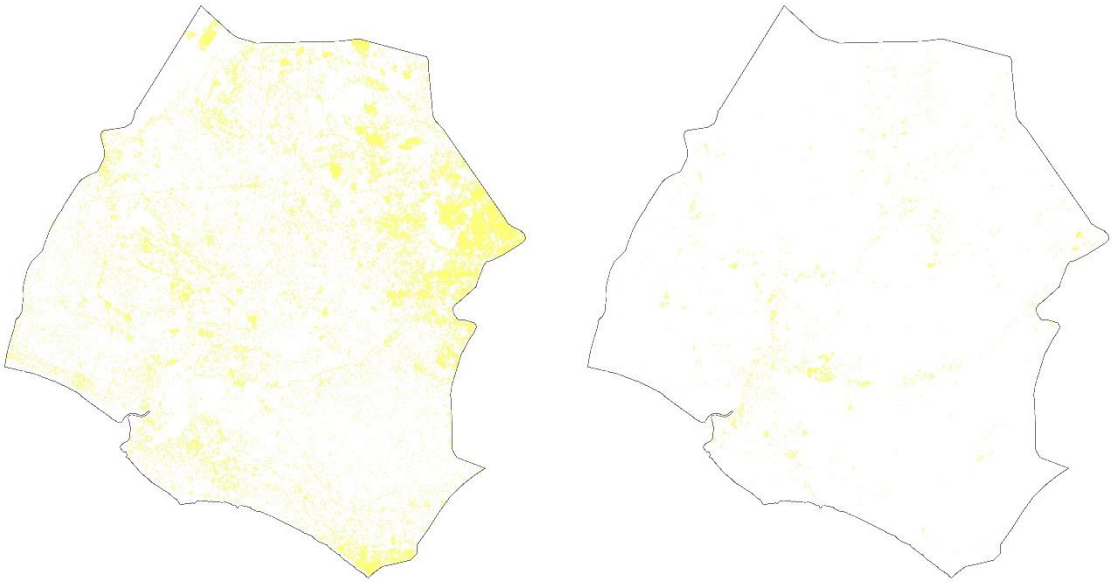


(a) (b)

Figure 7: Changes in vegetation class between 2013(a) and 2020(b) in Batu Pahat area

(a) (b)

Figure 8: Changes in built-up area class between 2013(a) and 2020(b) in Batu Pahat area



(a) (b)

Figure 9: Changes in barren land class between 2013(a) and 2020(b) in Batu Pahat area

4. Conclusion

Changes in land use and land cover are natural phenomena that occurred in the most areas around the world [3]. Within seven years, significant changes in the land use of the study area were observed. The area under built up land has expanded, whereas the area under barren land shows drastically decreased. The change detection indicated that the shifting of barren land had significantly change to

built-up area due to high population growth in this area. For further research, this study could be done using high-definition satellite images, such as WorlView3 and SPOT to categorize land use and land cover class due to high resolution of the results. However, other spatial data that will be used should also have a high resolution as well that could result in more accurate and reliable classification results. In general, land use and land cover map play a vital role for the planning, management and monitoring of programs [10].

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