LAND COVER AND LAND USE CHANGES ANALYSIS USING GOOGLE EARTH ENGINE IN KELANTAN

by

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DECLARATION

I declare that this thesis entitled "Land Cover and Land Use Changes Analysis Using Google Earth Engine in Kelantan" 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 : IZZAH NADIAH BINTI ISMAIL

Date : 28/07/2024

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Land Cover and Land Use Changes Analysis Using Google Earth Engine in Kelantan

ABSTRACT

This study looks at how land cover and land use have changed in Kelantan from 2014 to 2023. It uses Google Earth Engine (GEE) to analyze satellite images from Landsat. This study aims to identify the changes and what effects they have, which can be due to things like cities growing, forests being cut down, climate change, and farming. This research utilizes Google Earth Engine (GEE), a cloud-based platform for planetary-scale environmental data analysis, to investigate the land cover and land use changes in Kelantan, Malaysia. By leveraging multi-temporal satellite imagery and advanced classification algorithms, this study aims to map and quantify land cover transitions and land use dynamics from 2014 to 2023. The methodology includes the collection and preprocessing of Landsat data, followed by supervised classification using machine learning techniques such as Random Forest and Support Vector Machine. Accuracy assessment is performed to validate the classification results using a confusion matrix to see how accurate it was. In the end, this study gives important information about land cover and use in Kelantan, which can help people make better decisions about taking care of the environment and managing land. It shows how useful GEE in identifying and monitoring environmental changes and adds to our knowledge of how land use affects the environment.

Litupan Tanah dan Analisis Perubahan Guna Tanah Menggunakan Google Earth Engine di Kelantan

ABSTRAK

Kajian ini melihat bagaimana litupan tanah dan guna tanah telah berubah di Kelantan dari 2014 hingga 2023. Ia menggunakan Google Earth Engine (GEE) untuk menganalisis imej satelit daripada Landsat. Kajian ini bertujuan untuk mengenal pasti perubahan dan kesannya, yang boleh disebabkan oleh perkara seperti bandar yang semakin meningkat, hutan ditebang, perubahan iklim dan pertanian. Penyelidikan ini menggunakan Google Earth Engine (GEE), platform berasaskan awan untuk analisis data alam sekitar berskala planet, untuk menyiasat litupan tanah dan perubahan guna tanah di Kelantan, Malaysia. Dengan memanfaatkan imej satelit berbilang masa dan algoritma pengelasan lanjutan, kajian ini bertujuan untuk memetakan dan mengukur peralihan litupan tanah dan dinamik guna tanah dari 2014 hingga 2023. Metodologi termasuk pengumpulan dan prapemprosesan data Landsat, diikuti dengan klasifikasi yang diselia menggunakan teknik pembelajaran mesin seperti Hutan Rawak dan Mesin Vektor Sokongan. Penilaian ketepatan dilakukan untuk mengesahkan keputusan pengelasan menggunakan matriks kekeliruan untuk melihat sejauh mana ketepatannya. Akhirnya, kajian ini memberi maklumat penting tentang litupan dan penggunaan tanah di Kelantan, yang boleh membantu orang ramai membuat keputusan yang lebih baik tentang menjaga alam sekitar dan mengurus tanah. Ia menunjukkan manfaat GEE dalam mengenal pasti dan memantau perubahan alam sekitar dan menambah pengetahuan kita tentang cara penggunaan tanah mempengaruhi alam sekitar.

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LIST OF ABBREVIATIONS

GEE	Google Earth Engine
LULC	Land Use and Land Cover
LULCC	Land Use and Land Cover Change
NDVI	Normalised Difference Vegetation Index
ROI	Region of Interest
RS	Remote Sensing
USGS	United States Geological Survey

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Land cover data shows how much of an area is made up of forests, marshes, hard surfaces, fields, and other types of land and water. There are two kinds of water, open water and wetlands. Land use refers to how people use the land, whether for building, protecting, or a mix of the two. Different types of land cover can be kept up and used in a lot of different ways (Bruce Moravchik et al., 2023). Changes in land use and land cover are very important for figuring out how natural and human- made forces will affect the landscape in the long run (Quitero-Gallego et al., 2018). Most of the cause for these changes in land use and land cover should lie with people and the places where they live (Kamaraj et al., 2022). In semiarid areas, land use affects both local economic growth and the environment, as well as changes in the environment around the world (Yan et al., 2019). To address these issues, the Google Earth Engine (GEE) can be used as a cloud computer tool along with machine- learning methods to process satellite images (Ngongo et al., 2023). It was just recently found that this technology could be used for Remote Sensing research (Kruasilp et al., 2023). Google Earth Engine (GEE) is a large, cloud-based platform that has a complex tool for processing, analysing, and visualising huge amounts of remote sensing data (Basheer et al., 2022).

1.2 Problem Statement

Kelantan's land cover and land use trends have changed a lot over the years. This is because of things like weather change, urbanisation, and the growth of agriculture. Traditional ways of looking at land cover and land use change involve interpreting satellite images by hand, which takes a lot of time and work and might not give quick and accurate results. With the rise of advanced mapping tools like Google Earth Engine, it is now possible to automatically look at big changes in land cover and land use. Geography, temperature, human activities, government acts, and economic problems are some of the things that this study helps us figure out that cause these changes. The main goal is to learn more about how changes in land cover and land use affect the control of natural resources and to come up with long-term plans for land use and protecting the environment for the area.

1.3 Objective

i. To generate a land cover map using Google Earth Engine based on Landsat images year 2014 and 2023 for Kelantan.

ii. To analyze the land use changes in Kelantan by implementing Google Earth Engine.

1.4 Scope of Study

The scope of investigating land cover and land use change analysis using Google Earth Engine is broad and covers a wide range of topics. Satellite imagery and machine learning techniques will be used to analyse and map changes in land cover and land use in specific locations. This research tries to figure out what causes these changes, like climate change, deforestation, cities, and economic growth, and what effects they have. The analysis will utilize Landsat satellite images from year 2014 and year 2023 to provide a decade-spanning perspective, offering insights into spatial dynamics and their implications for sustainable land management in the region. Using Google Earth Engine makes it possible to handle big amounts of satellite data quickly as well as the use of advanced analytical techniques such as time-series analysis and classification algorithms.

1.5 Significant of Study

The examination of land cover and land use change using Google Earth Engine is relevant for a number of reasons. For starters, changes in land use and cover have big effects on the climate, affecting things like biodiversity, surface energy balance, regional rainfall trends, and the carbon cycle. Understanding these shifts is critical for good resource management and long-term development. Second, using Google Earth Engine and remote sensing data enables efficient processing and analysis of large-scale geographical and temporal data. This makes it possible to accurately track changes in land use and cover over time, which gives an important information about what causes these changes and how they happen.

CHAPTER 2

LITERATURE REVIEW

2.1 Land Use and Land Cover

The phrase “land cover” refers to the natural covering on the land's surface, while “land use” refers to the things that people do on the land. (Garcia-Alvarez et al., 2022). Land usage maps are important sources of information for land planning and management. (Yao et al., 2022). Land use and land cover at different sizes can help future study into things that happen on a world scale, like climate change, droughts, floods, erosion, migration, and land use. The proper and ongoing study of land use and land cover is an important part of any area's efforts to grow in a way that is viable. Detailed land cover maps are a crucial input for a number of scientific research investigating what climate change means for water budgets and streamflow (Sridhar et al., 2019), natural resource management based on social understanding (Sridhar et al., 2021), groundwater management (Xiao et al., 2022), and agricultural land monitoring (Rahman et al., 2020). Remote sensing photography is the most common way to map land cover and keep track of how it changes over time (Noi Phan et al., 2020). The hydrologic and water resources models’ group is excited to include and study changing land use and how it affects the water budget because of population growth and the need to build new areas to meet the needs for food production, energy generation, and water security (Setti et al., 2020). Land is where human activities happen, the most basic factor in socioeconomic growth, and the most basic resource that people in both cities and country areas need to survive.

Stronger land use has become a big problem for long-term growth around the world since the end of the 20th century. On the one hand, using too many resources on land without controlling it in places that would naturally be better for them has made the region much less sustainable. A bigger threat to food security, though, is farmland that has been left empty in poor places (Xu et al., 2019). The globe is going through significant changes right now, and these changes are entwined with epidemics like COVID-19. There are serious risks to human survival from climate change (Quintero-Angel et al., 2021). Land use transitions (LUTs), the primary contributors to greenhouse gas emissions, have significantly impacted ecosystem processes and, as a result, had a significant effect on climate change (Ojoyi et al., 2017). The issue of how to successfully deal with resource loss, the environmental impacts of human activities, food security, and a better understanding of the feedback loop between people and nature has become more important and needs to be solved right away. (Swette et al., 2021). Land cover is the actual makeup of the Earth's surface.

Land use, on the other hand, is how people and their environments use the land, with a focus on how it can be used for economic action (Mariye et al., 2020). One of the most popular methods for figuring out how the land was utilised in the past, what kinds of discoveries to anticipate going forward, and the processes and driving factors behind these changes is the study of land use land cover changes, or LULCCs (Haregeweyn et al., 2014). Because LULCCs are so persistent, when combined on a global scale, they have a significant impact on the strategic elements of how the Earth's system functions. They are a major reason why the land is getting worse, have an effect on the variety of living things around the world, and make local and global climate change happen. The capacity of biological systems to sustain and adapt to human requirements are impacted by LULCCs because they change the benefits that ecosystems provide at the neighborhood and regional levels. (Alemayehu et al., 2019). Indeed, the rapid agricultural expansion and population growth may be responsible for the substantial changes in LULC seen globally (Tolessa et al., 2020). When forests are cut down and turned into other types of land use, like grass, bare ground, farming land, grazing land, or city areas, the water cycle can be changed locally which might have a major impact on streamflow dynamics, water yields, and water quality (Dinka et al., 2019).

Significant LULC dynamics have traditionally existed in Ethiopia for many decades. But these days, deterioration and LULCCs are growing at a startling pace, which is partly responsible for the rising rate of soil erosion. The abundance of forests and grasslands has been badly impacted by the demand for more farmed land, which ultimately encourages soil erosion (Bekele et al., 2019). The major causes of environmental conversions and modifications include a variety of negative human activities, including the spread of farmlands over fertile land, the large-scale production of fuelwood and charcoal, overgrazing, and the building of farmsteads on land that was once forest. According to Tefera (Marchant et al., 2018), in terms of ecology, Ethiopia is distinguished by a wealth of biological resources such as forests, grasslands and wooded areas, shrubs, diverse species, and excellent soil that are becoming less diverse. There are big mountain ranges, high plateaus, canyons, river basins, flat areas, huge lakes, and deserts are among its other well-known features. Since the natural mountain forests have been cleared for agriculture and deforestation, soil erosion has caused significant landscape degradation in the Ethiopian highlands, endangering the lives of the Ethiopian people (Ebabu et al., 2019). This alters the equilibrium between precipitation, evaporation, infiltration, and runoff, which also has an impact on the water balance of a region. The trends that have been found show that LULCC needs to be studied in a planned way in order to fully grasp how big the changes are and implementing the required actions to reduce soil erosion (Dadi et al., 2016) protect the land cover resources in a way that doesn't harm them over time.

2.1.1 Land Use and Land Cover Effects

Most countries are now seeing a lot of change in how land is used and what it is covered with (Lekha et al., 2018). Humans and the environments in which they live should bear the most of the blame for these land use and land cover changes (Kamaraj et al., 2022). Changes in land use and land cover are very important for figuring out how natural processes and human activity will affect the landscape in the long run (Quintero-Gallego et al., 2018). There will be negative consequences for both human health and ecosystems (Twisa et al., 2019). On a worldwide scale, these developments have had a variety of negative consequences (Chamling et al., 2020), erosion, more flow, storms, running out of water supplies, and worsening water quality are just a few examples (Nedd et al., 2021). In semiarid areas, land use and land cover affect both local economic growth and the environment, as well as changes in the environment around the world (Yan et al., 2019). Reliable and long-term land use and land cover data is an essential tool in natural resource management.

2.2 Google Earth Engine

Google Earth Engine is a cloud-based tool that combines huge amounts of remote sensing data from different sources with a fast computer service. This makes it possible to handle satellite pictures quickly and easily (Kolli et al., 2020). Remote Sensing (RS) imaging is a good way to find changes at a wide range of spatial and time scales because it has a high precision and is easy to get (Zhang et al., 2018). Even though RS is needed for long-term change detection analysis, problems arise when the amount of data increases and it becomes necessary to edit and standardise images from different sensors that have varying quality and time periods (Lasaponara et al., 2022). To address these issues, using Google Earth Engine (GEE) as a cloud computer tool along with machine-learning methods to process satellite images (Ngongo et al., 2023). Recently, this technique was found to be a possible base for Remote Sensing research (Kruasilp et al., 2023). Google Earth Engine is a huge geographic cloud-based platform that makes it easy to process, analyse, and display huge amounts of remote sensing data (Basheer, et.al, 2022). Google launched Google Earth Engine (GEE), a cloud computing tool, in 2010 (Amani et al., 2020). Since then, GEE has shown that it can handle the second problem that was mentioned at the start of this section. Google Earth Engine (GEE) facilitates cloud computing and is a powerful tool for geographic big data research on a worldwide scale. Additional cloud computing systems that are suitable for handling geographic large data include Microsoft Azure (launched in 2010) and Amazon Web Services (AWS, launched in 2006) (Tamiminia et al., 2020).

CHAPTER 3

MATERIAL AND METHOD

3.1 Study Area

Kelantan is a state in Malaysia that can be looked at on Google Earth Engine to see how land cover and land use change over time. To assess changes in land cover and land use over time, the research area might be defined within the limits of Kelantan. Google Earth Engine gives users access to a massive amount of satellite images and data, enabling for the rapid processing and analysis of large-scale data sets. Researchers can use machine learning techniques and remote sensing techniques to map and look at changes in land use and cover in Kelantan. This study may assist understand the sources and consequences of these changes, better rules for managing natural resources and planning how land is used, and contribute to the region's long-term growth.

Peninsular Malaysia's northeastern part is home to the state of Kelantan (Figure 3.1). The region's principal river is the Kelantan River. It emerges in Kuala Kari at the confluence of the Galas and Lebir rivers, then winds through the plain along the coast until it meets the South China Sea. Around 85% of the surface area of the Kelantan State, is covered by the Kelantan Riverbasin. According to Pradhan et al., (2009), it has steep scrapes and high slopes in the southern part of the river basin and flat to slightly sloped areas on the floor in the northern half. In the state of Kelantan, different types of rocks, like granite, sedimentary, and metamorphic rocks, are ordered from north to south. In the area, rocks are generally categorized into four types which are granitic rocks, extrusive rocks (volcanic rocks), sedimentary or metasedimentary rocks, as well as sands that haven't been packed down (Figure 3.2).

According to Unjah et al., (2001) and Raj (2009), the topography of the state of Kelantan is classified into four categories which are pain regions, coastal areas, hilly areas, and mountainous areas. Mount Chama (Gunung), the highest point in Kelantan State is in the Gua Musang area, which is in the western part of the state close to the border with Perak at 2171 meters (Nazaruddin et al., 2014). Alluvium deposits or unconsolidated sediments make up quaternary deposits. The additional sedimentary rocks discovered in the state of Kelantan include limestone, sandstone, volcanic rocks, and marine siliciclastic from the Triassic period (Nazaruddin et al., 2014).

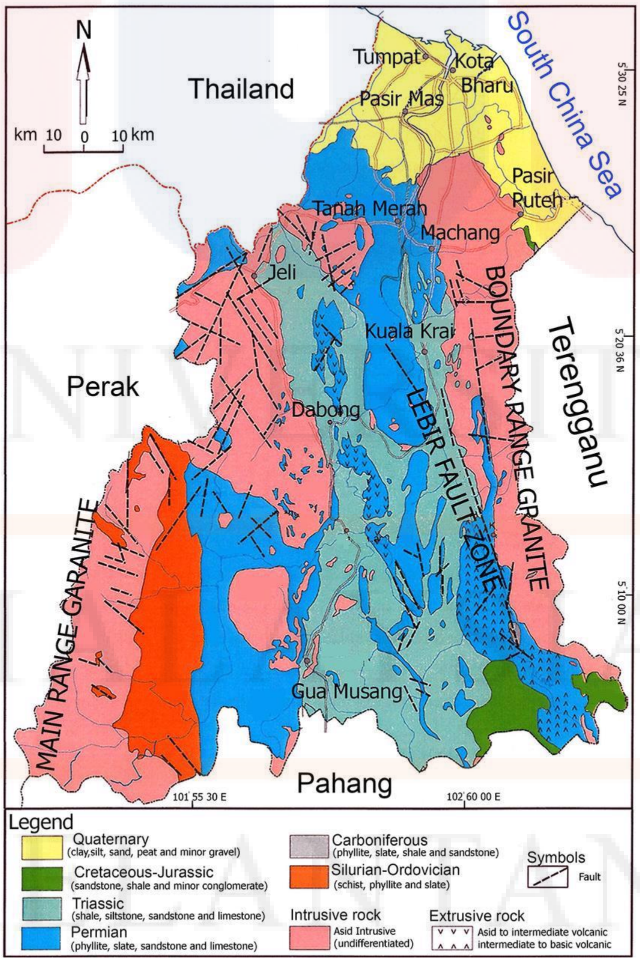

Figure 3.1: State of Kelantan

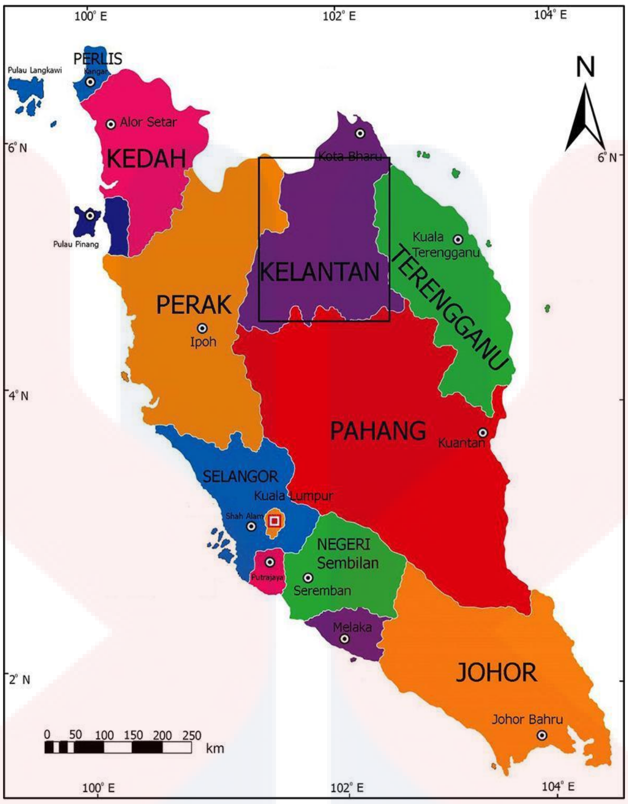

Figure 3.2: Position of the state of Kelantan

3.2 Material

3.2.1 Secondary data

To generate a land cover map using Google Earth Engine based on Landsat images year 2014 and 2023 for Kelantan. To do these things, Google Earth Engine has many datasets, tools and methods available. The study also needs to be able to see Landsat images for the specific years and area (Kelantan) in Google Earth Engine's data catalogue. The whole process is writing in the Earth Engine Code Editor. This is where write code that uses Landsat data and Earth Engine features to do each step of the research. In the Google Earth Engine manual, users can find step- by-step instructions, code examples, and detailed guidance to help them with these tasks. To analyze the land use changes in Kelantan by implementing Google Earth Engine. Landsat images, Earth Engine's huge collection of data, and the platform's many geographic analysis tools can be used to do in-depth analyses of land use change in Kelantan.

3.2.2 Google Earth Engine

Google Earth Engine is a cloud-based platform designed for planetary-scale environmental data analysis. It offers access to a vast repository of satellite imagery and geospatial datasets, including historical and current data from various sensors like Landsat, Sentinel, and MODIS. To use Google Earth Engine, users need a Google account, sign in, and request access. The platform is free for research, education, and nonprofit use, but has limitations on computation and storage. For commercial use, paid options are available. The interface consists of a map, layers panel, console, scripts, and inspector. When using Google Earth Engine in a thesis, users should describe the platform, explain their methodology, use maps, charts, and visualizations to illustrate findings, cite properly, and comply with the platform's terms of service. The information provided is based on knowledge available up to early 2023, and users should refer to the official Google Earth Engine documentation for the most accurate and up-to-date information.

3.3 Method

3.3.1 Data Preparation

From this study, land use land cover (LULC) data has been processed using Google Earth Engine. By using Google Earth Engine, data preparation image data that has been used to run by using image collection from USGS Landsat 8 Collection 2 Tier 1 TOA Reflectance. From selected of Landsat 8, add marker to the region of interest (ROI) for Kelantan's area. The coordinate for map 2014, [102.22516666210474,6.115774698415912] meanwhile the coordinate for map 2023, [101.87635074413599,5.087549777013329].

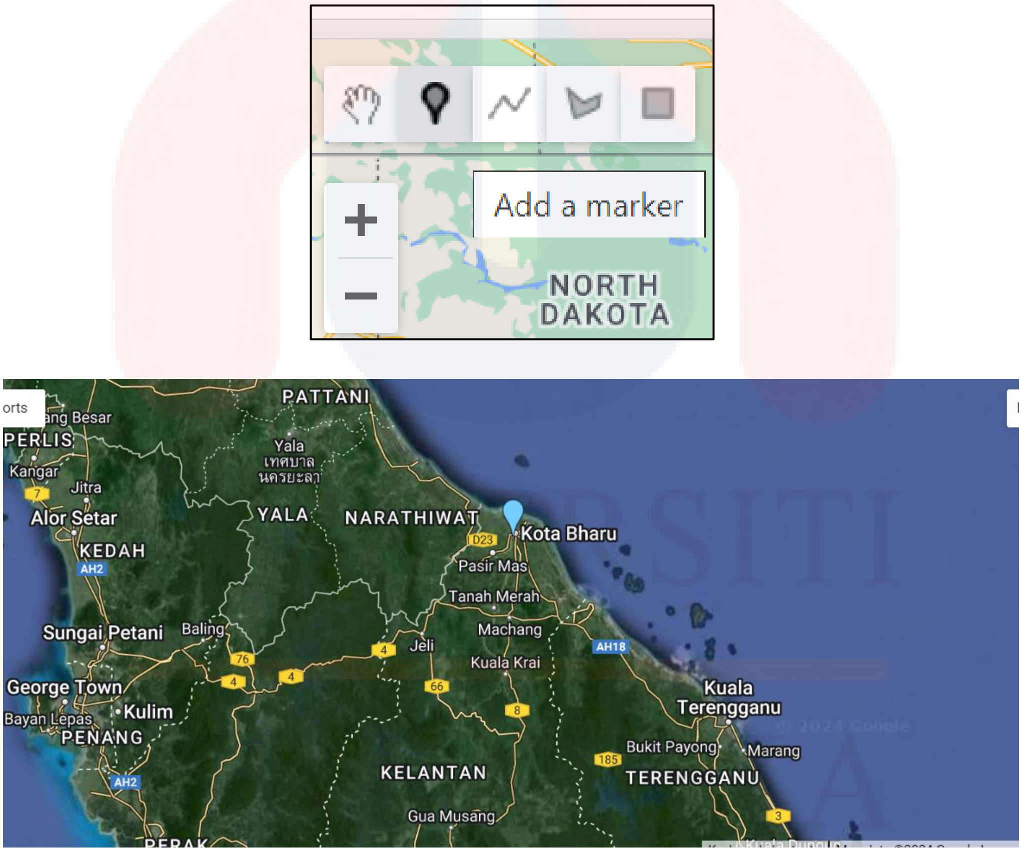

Figure 3.3: Add marker for the region of interest (ROI) for Kelantan's area.

3.3.2 Filter Time Image Data

For filter time image data, for map 2014 and 2023 generated the temporal data using filter time to visual the image data of Landsat 8, Kelantan's area of both years in Google Earth Engine. For map 2014, filter time map was ('2014-01-01','2014-12-31') and for map 2023 ('2023-01-01','2023-12-31'). After filter time has been placed in Google Earth Engine click run and the image was visualized.

```
// 1. Load Landsat 8 data
var image = ee.ImageCollection("LANDSAT/LC08/C02/T1_TOA")
.filterDate('2014-01-01', '2014-12-31')
.filterBounds(roi)
.sort('CLOUD_COVER')
.first();

// 2. Set visualization parameter
var visParamsTrue = {bands: ['B7', 'B5', 'B3'], min: 0, max: 0.3, gamma: 1.4};
Map.addLayer(image, visParamsTrue, "Landsat 2014");
Map.centerObject(roi, 8);
```

Figure 3.4: Coding in GEE for filter time map for year 2014 and year 2023.

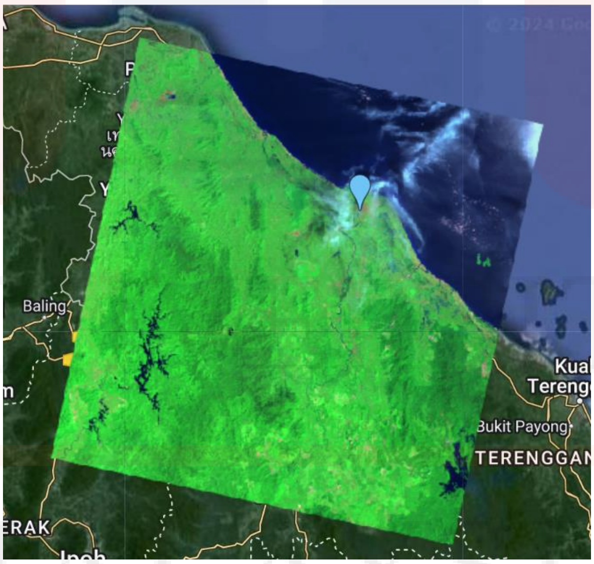

Figure 3.5: Image data for Landsat 8 for map year 2014.

3.3.3 Cloud Coverage

For more accuracy image data visualized, cloud coverage is important step based on (Schmitt et al., 2019), our workflow is based on Google Earth Engine, a web- and cloud-based platform for the analysis and visualization of large-scale geospatial data. Cloud coverage filter has been performed into both maps for the best view image data of Landsat 8.

```
print('Cloud coverage');
var cloudsorted = filtertime.sort('CLOUD_COVER');
print('Landsat8 Image based on cloud coverage ', cloudsorted);

print('Pick the best cloud coverage area');
var scene = cloudsorted.first();
var CloudCover = scene.get('CLOUD_COVER');
print('The best scene', scene);
print('Cloud Coverage: ', CloudCover);
```

Figure 3.6: Coding in GEE for filter cloud coverage for image data Landsat 8.

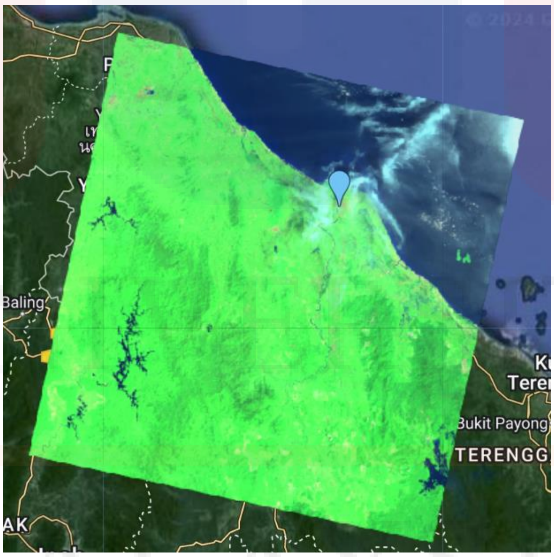

Figure 3.7: Image data for Landsat 8 after filtering cloud coverage.

3.3.4 Training Data Creation

Land use and land cover (LULC) maps have been categorized into four classes for feature collection, water, build-up, vegetation and barren. In feature collection for LULC maps in 2014 has been point by used add marker to pointed out for class of water (50), for build-up (106), vegetation (102) and barren (121). Meanwhile, for map in 2023 water (32), build-up (121), vegetation (103) and barren (77). For value class of each feature collection, the value for water is 0, build-up 1, vegetation 2 and barren is 3 for both maps. Bands has been used in training data band 1, 2, 3, 4, 5, 7. These bands are typically chosen based on their ability to differentiate between land cover types.

```
// 3. Create Training Data

var label = 'Class';
var bands = ['B1', 'B2', 'B3', 'B4', 'B5', 'B7'];
var input = image.select(bands);

var training = Vegetation.merge(Barren).merge(Water).merge(Buildup);
print(training);

// 4. Overlay the points on the image to get training
var trainImage = input.sampleRegions({
  collection: training,
  properties: [label],
  scale: 30
});
print(trainImage);

var trainingData = trainImage.randomColumn();
var trainSet = trainingData.filter(ee.Filter.lessThan('random', 0.8));  // Training
data
var testSet = trainingData.filter(ee.Filter.greaterThanOrEquals('random', 0.8));  //
Validation data
```

Figure 3.8: Coding in GEE for create training data (water, build-up, vegetation, and barren).

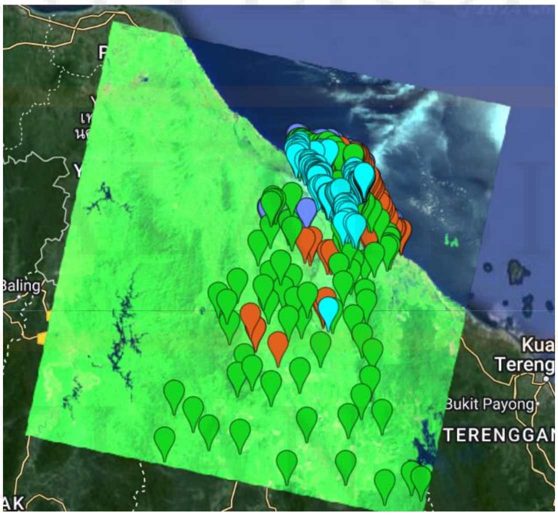

Figure 3.9: Feature collection water, vegetation, build-up and barren of maps

3.3.5 Classification

Google Earth Engine played a significant role in analyzing land use and land cover changes in Kelantan, with Google Earth serving as a crucial tool for enhancing the interpretation and communication of results. The analysis involved visualization methods to effectively showcase the observed changes in land use patterns. Utilizing Google Earth Engine's capabilities, researchers created visually compelling maps and graphics that depicted the changes in land cover over time. Techniques such as color-coded maps, overlays, and time-series animations were employed to dynamically represent the spatial and temporal aspects of land cover changes. These visual approaches greatly aided in the communication of complex information to various stakeholders, fostering a clearer understanding of the observed trends and supporting informed decision-making for sustainable land management practices in Kelantan, as discussed by Sui et al. (2013).

```
// 5. Classification Model
var classifier = ee.Classifier.smileCart().train(trainSet, label, bands);

// 6. Classify the image
var classified = input.classify(classifier);
print(classified.getInfo());

// 7. Define a palette for the classification.
var landcoverPalette = [
  '#113aff', //Water (0)
  '#cc3712', //Buildup (1)
  '#0fdc37', //Vegetation (2)
  '#dff01b', //Barren (3)

];
Map.addLayer(classified, {palette: landcoverPalette, min: 0, max:4 },
'classification');
```

Figure 3.10: Coding in GEE for classification for land cover palette.

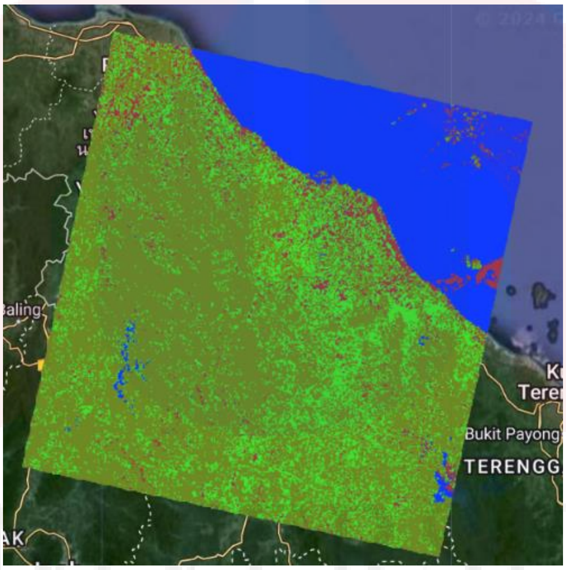

Figure 3.11: The classification of Land Use and Land Cover.

3.3.6 Accuracy Assessment

The script conducted an accuracy assessment of the land cover classification model by classifying an independent test dataset and generating a confusion matrix. This matrix, along with the calculated overall accuracy, provided a comprehensive evaluation of the model's performance, indicating how well it correctly identified different land cover classes. Although the script had the capability to calculate more detailed accuracy metrics, such as producers' and consumers' accuracy, these were not executed in the provided code. This assessment step was crucial for validating the reliability of the classification results. The resulting time series data provide valuable insights into the seasonality, cyclic patterns, and long-term trends of land cover changes in Kelantan, offering a comprehensive understanding of the evolving landscape over time (Turner et al., 2015).

```
// 8. Accuracy Assessment
//Classify the testSet and get a confusion matrix.
var confusionMatrix = ee.ConfusionMatrix(testSet.classify(classifier)
    .errorMatrix({
      actual: 'Class',
      predicted: 'classification'
    }));

print('Confusion matrix:', confusionMatrix);
print('Overall Accuracy:', confusionMatrix.accuracy());
//print('Producers Accuracy:', confusionMatrix.producersAccuracy());
//print('Consumers Accuracy:', confusionMatrix.consumersAccuracy());
```

Figure 3.12: Coding in GEE for accuracy assessment for image data for Landsat 8.

3.3.7 Export Results

For further research or reporting on the analysis of land use and land cover changes in Kelantan using Google Earth, the next step involved the exportation of results for further interpretation and dissemination. The generated land cover maps and associated change detection information were exported in formats suitable for visualization and analysis, such as GeoTIFF. These exported results served as valuable inputs for decision-making processes related to environmental conservation, resource allocation, and sustainable development in the region, as highlighted by Eastman (2009).

```
// Download Landsat 8 Images using Google Earth Engine?

// 1. Load Landsat 8
var image = ee.ImageCollection("LANDSAT/LC08/C02/T1_TOA")
.filterDate('2014-01-01', '2014-12-31')
.filterBounds(roi)
.sort('CLOUD_COVER')
.first();

// 2. Define the visualization parameter for the Landsat 8 image
var visPaaramsTrue = {bands: ['B4', 'B3', 'B2'], min: 0, max:3000, gamma: 1.4};
Map.addLayer(image, visPaaramsTrue, 'Landsat 2014');
Map.addLayer(image.clip(roi), visPaaramsTrue, 'Landsat 2014 SA');
Map.centerObject(roi, 10);

// 3. Export to Drive
Export.image.toDrive({
  image: image.int16(),
  description: 'Landsat 2014 Kelantan',
  scale: 30,
  region: roi,
  maxPixels: 1e13
});
```

Figure 3.13: Coding in GEE for exports result image to drive.

3.3.8 Statistical Analysis

The methodology involved calculating the Normalized Difference Vegetation Index (NDVI) from satellite imagery to identify and quantify vegetated areas within the region of interest (ROI). NDVI was computed by subtracting the red channel from the near-infrared channel and dividing by their sum, then visualized using specific parameters. A threshold of 0.3 was applied to distinguish vegetated areas (NDVI > 0.3). The percentage of vegetated area was determined by calculating the area of pixels above the threshold relative to the total area of the ROI. Results were normalized for visualization and presented in a feature collection and chart, providing a clear overview of the extent of vegetation within the study area. One commonly used formula for assessing the magnitude of land cover change is the Land Use Change Index (LUCI), which is calculated as the ratio of the changed area to the total study area (Lu, D., & Weng, Q., 2007).

```
// Calculate NDVI
var ndvi = nir.subtract(red).divide(nir.add(red)).rename('NDVI');

// Set visualization parameters
var ndviParams = {min: -1, max: 1, palette: ['blue', 'white', 'green']};

// Display the NDVI image
Map.centerObject(roi, 10);
Map.addLayer(ndvi, ndviParams, 'NDVI');

// Threshold for vegetated areas (NDVI > 0.3 is considered vegetated)
var ndviThreshold = 0.3;
var vegetated = ndvi.gt(ndviThreshold);

// Calculate the percentage of vegetated area
var areaImage = vegetated.multiply(ee.Image.pixelArea());
var areaStats = areaImage.reduceRegion({
  reducer: ee.Reducer.sum(),
  geometry: roi,
  scale: 30,
```

```
// Calculate total area
var totalArea = ee.Image.pixelArea().reduceRegion({
  reducer: ee.Reducer.sum(),
  geometry: roi,
  scale: 30,
  maxPixels: 1e9
});

var vegetatedArea = areaStats.get('NDVI');
var totalAreaValue = totalArea.get('area');

// Calculate percentage
var vegetatedPercentage =
ee.Number(vegetatedArea).divide(totalAreaValue).multiply(100);

// Print the results
print('Total Area (m^2):', totalAreaValue);
print('Vegetated Area (m^2):', vegetatedArea);
print('Percentage of Vegetated Area (%):', vegetatedPercentage);
```

```
// Normalize the percentage value for visualization
var normalizedVegetatedPercentage =
vegetatedPercentage.divide(100).multiply(totalAreaValue);

// Create a Feature Collection for the results
var results = ee.FeatureCollection([
  ee.Feature(null, {'Metric': 'Total Area (m^2)', 'Value': totalAreaValue}),
  ee.Feature(null, {'Metric': 'Vegetated Area (m^2)', 'Value':
vegetatedArea}),
  ee.Feature(null, {'Metric': 'Percentage of Vegetated Area (normalized)',
'Value': normalizedVegetatedPercentage})
]);

// Create a chart
var chart = ui.Chart.feature.byFeature(results, 'Metric', 'Value')
  .setChartType('ColumnChart')
  .setOptions({
    title: 'Vegetated Area Analysis',
    hAxis: {title: 'Metric'},
    vAxis: {title: 'Value'},
    legend: {position: 'none'}
```

Figure 3.14: Coding in GEE for statistical analysis vegetated areas in image data.

To calculate the percentage change in each land cover category between different time periods, 2014 and 2023 using the following formula:

$$\text{Percentage change} = \frac{(current\ value - previous\ value)}{previous\ value} \times 100 \qquad (3.1)$$

3.3.9 Report and Interpretation

Following the completion of the land use and land cover change analysis in Kelantan using Google Earth, the final step involved the preparation of a comprehensive report and the interpretation of the findings. The report included a detailed summary of the observed changes, highlighting the spatial distribution, magnitude, and trends in land use and land cover transformation over the designated time periods. Additionally, the report provided context for the identified changes, considering factors such as urbanization, deforestation, or agricultural expansion. The interpretation of these changes was crucial for understanding the socio-environmental implications and informing decision-making processes related to land management and sustainable development. Visual aids such as maps and graphs were incorporated to enhance the clarity of the report, facilitating effective communication of the results to stakeholders and policymakers, as discussed by Turner et al. (2015).

CHAPTER 4

RESULT AND DISCUSSSION

4.1 The Classification of LULC for Maps 2014 and 2023

Based on Figures 4.1 and 4.2, the map of land use and land cover (LULC) perform in Google Earth Engine. For land use and land cover map for 2014, the different of classification of class from feature collection, water, build-up, vegetation and barren with land use and land cover map 2023. The different of maps 2014 and 2023 it's from the class of vegetation. From map 2014, class of vegetation more than class of vegetation of map 2023. There is a close relationship between the growth and spread of vegetation and environmental elements including topography and climate (Piao et al., 2020). So, from the map 2014 compare to map 2023 the factors of class vegetation map 2014 more than map 2023 mostly related cause from topography and climate in Kelantan's area. At many spatiotemporal scales, recent research has examined the relationships between changes in vegetation and climatic variables (such as temperature and precipitation) (Deng et al., 2021). For class of barren, between map 2014 and 2023 the classification of barren's class showed that map in 2014 less than map 2023. As a result, climate influences are the main forces behind changes in land use. Changes in land use are mostly shaped by societal and economic reasons. Extensive research has indicated that substantial land deterioration is frequently caused by human activity (Mu et al., 2021). The overall accuracy between land use and land cover for map 2014 was 81% and for map 2023 was 70%. 30% of these points are used for validation and 70% are used for training in each iteration, determined by random selection. It's usual to find this 70/30 ratio in RF applications (Mueller et al., 2021).

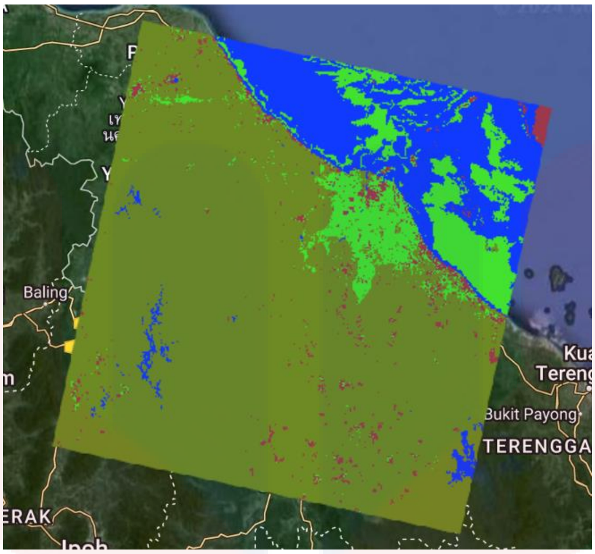

Figure 4.1: The classification land use and land cover (LULC) map of Landsat 8 2014.

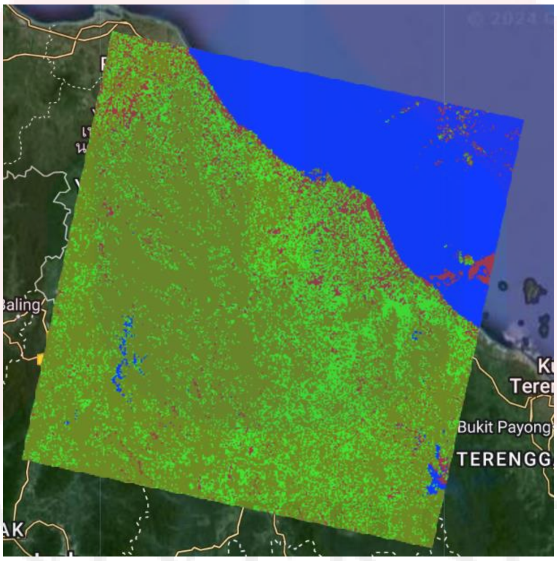

Figure 4.2: The classification land use and land cover (LULC) map of Landsat 8 2023.

Table 4.1: Feature Collection of different classification class for map 2014 and 2023.

Class	Point	
	2014	2023
Water	50	32
Build-up	106	121
Vegetation	102	103
Barren	121	77

Table 4.2: Overall accuracy between land use and land cover map 2014 and 2023.

Overall accuracy	Percentage (%)
2014	81%
2023	70%

4.2 Normalised Difference Vegetation Index (NDVI) and Value of Area

Based on Figure 4.3 and 4.4, NDVI map 2014 and 2023, overlayed on a geographic map, is a tool used to monitor plant growth, vegetation cover, and biomass production. The map distinguishes vegetated areas from non-vegetated areas using a threshold of 0.3. Green areas, marked by a NDVI value above 0.3, are likely to be densely vegetated, such as forests or crop fields. Non-vegetated areas, not shaded in green, are primarily urban or barren areas. The map is overlaid on a geographic map of Kelantan to identify the specific locations of vegetated and non-vegetated areas. This clear visual distinction is useful for ecological studies, land use planning, and environmental monitoring. The map's use of NDVI in this context is crucial for understanding and managing land use.

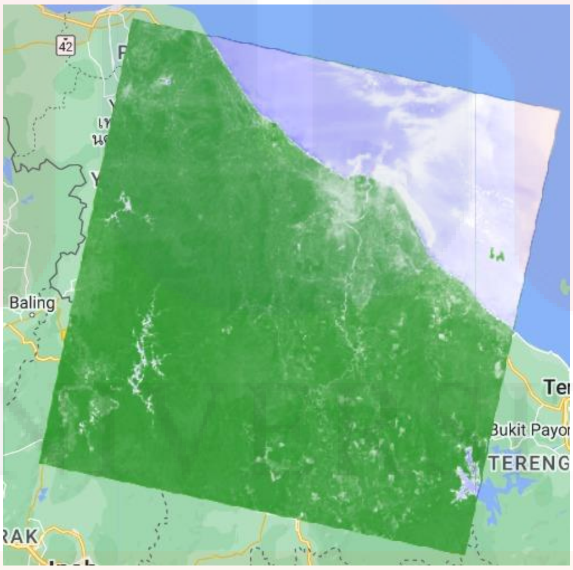

Figure 4.3: Normalised Difference Vegetation Index (NDVI) map of 2014.

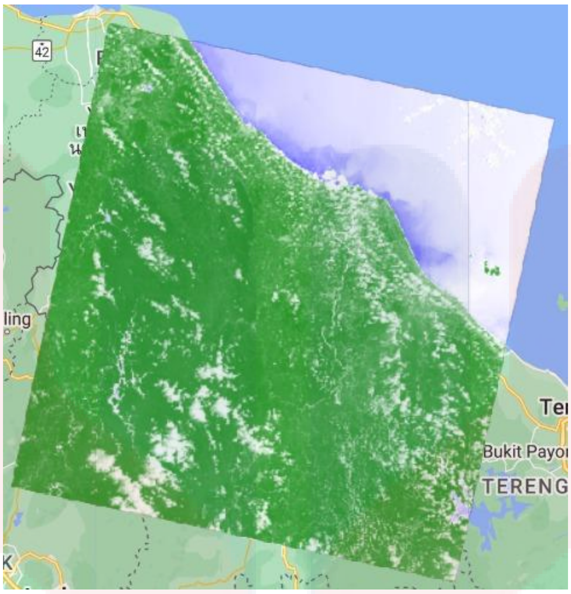

Figure 4.4: Normalised Difference Vegetation Index (NDVI) map of 2023.

Based on Figure 4.3, the bar chart provides a clear visual comparison between the total area of a plot of land and the portion of that area that is covered by vegetation. It reveals that the overall size of the land, measured in square meters and represented by the longer bar for Total Area (m^2), is considerably greater than the area occupied by vegetation, denoted by the shorter bar for Vegetated Area (m^2). This discrepancy suggests that a significant portion of the land is devoid of plant life, which could have various implications for land use planning, environmental analysis, real estate development, or agricultural assessment (Lam bin et al., 2001). For instance, urban planners might see an opportunity for green space development, while environmental scientists could be concerned with the ecological impact of the sparse vegetation (Chen et al., 2014). Overall, the chart is a useful tool for understanding the current state of the land and its potential for future use.

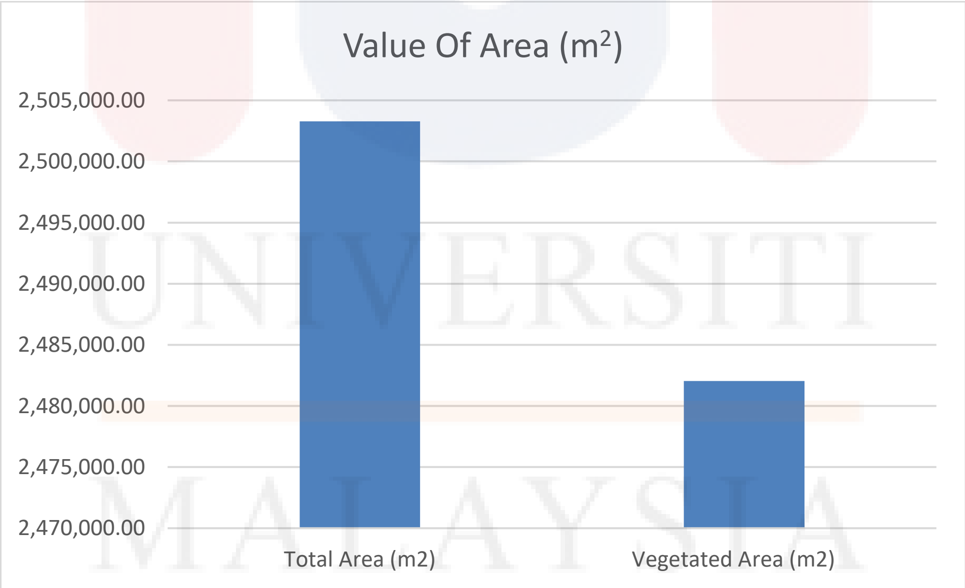

Figure 4.5: Value of area (m^2).

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The analysis of land cover and land use changes in Kelantan using Google Earth Engine has revealed significant transformations over the study period. The research has successfully mapped these changes, identified their primary drivers, and assessed their environmental impacts. The findings highlight the importance of sustainable land management practices to address the challenges posed by urbanization, agricultural expansion, and climate change. The study underscores the utility of GEE for timely and accurate monitoring of land cover dynamics, which is crucial for informed decision-making in environmental conservation and resource allocation. The research contributes valuable data for policymakers and stakeholders, enabling them to develop strategies that balance economic growth with environmental protection, ultimately ensuring the sustainable development of the region.

5.2 Recommendation

Based on observation, it is recommended to delve deeper into drivers such as climate change, urbanization, and agricultural growth, as well as use time-series analysis to track changes over time. The accuracy of the classification model should be assessed, and the findings should be compared with other data sources to validate the results. The ecological, economic, and social impacts of the observed changes should be assessed, and policy implications should be discussed. The visualization of the results should be improved, and a framework for ongoing monitoring should be proposed. An interdisciplinary approach should be employed, and the data should be made accessible to other researchers.

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