DUAL VEGETATION INDEX ANALYSIS AND SPATIAL ASSESSMENT IN KOTA BHARU, KELANTAN USING GIS AND REMOTE SENSING

by

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DECLARATION

I declare that this thesis entitled "Dual Vegetation Index Analysis and Spatial Assessment in Kota Bharu, Kelantan using GIS and Remote Sensing" 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.

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Date : 25 JULY 2024

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Dual Vegetation Index Analysis and Spatial Assessment in Kota Bharu, Kelantan using GIS and Remote Sensing

ABSTRACT

Kota Bharu is one of the districts in Kelantan and it is divided into several sub-districts. The rapid transformation of land use and environmental conditions in Kota Bharu presents significant obstacles to the implementation of sustainable land management practices. Furthermore, climate change caused by human activities affects the distribution of vegetation because the frequency of extreme weather events causes vegetation to feel stressed. This study is to identify the vegetation index using Normalized Difference Vegetation Index (NDVI) and Green Normalized Difference Vegetation Index (GNDVI) in Kota Bharu, Kelantan as well as evaluate the spatial analysis of vegetation in Kota Bharu, Kelantan using remote sensing and GIS for remote sensing images year 2008 and 2023. The data from earth explorer was presented through spatial maps and also bar graphs using Microsoft Word and ArcGIS version 10.3. The results of the study show that Kadok subdistrict experienced the most vegetation decline in high dense vegetation from 2008 to 2023 which is 4.31 km^2 where the NDVI range exceeds 0.4. For the GNDVI range that exceeds 0.4, Kok Lanas subdistrict shows the highest area of 21.84 km^2 in 2008 while the highest area in 2023 is 20.98 km^2 also in Kok Lanas subdistrict.

Analisis Dwi Indeks Tumbuhan dan Penilaian Spatial di Kota Bharu, Kelantan menggunakan GIS dan Penderiaan Jauh.

ABSTRAK

Kota Bharu merupakan salah satu daerah di Kelantan dan ia terbahagi kepada beberapa mukim. Transformasi pesat penggunaan tanah dan keadaan persekitaran di Kota Bharu memberikan halangan yang ketara kepada pelaksanaan amalan pengurusan tanah yang mampan. Tambahan pula, perubahan iklim yang disebabkan oleh aktiviti manusia menjejaskan taburan tumbuh-tumbuhan kerana kekerapan kejadian cuaca ekstrem menyebabkan tumbuh-tumbuhan berasa tertekan. Kajian ini adalah untuk mengenal pasti indeks tumbuhan menggunakan Indeks Tumbuhan Perbezaan Normal (NDVI) dan Indeks Tumbuhan Perbezaan Normalisasi Hijau (GNDVI) di Kota Bharu, Kelantan serta menilai analisis spatial tumbuh-tumbuhan di Kota Bharu, Kelantan menggunakan penderiaan jauh dan GIS untuk imej penderiaan jauh tahun 2008 dan 2023. Data daripada Earth explorer telah dipersembahkan melalui peta spatial dan juga graf bar menggunakan Microsoft Word dan ArcGIS versi 10.3. Hasil kajian menunjukkan bahawa mukim Kadok mengalami kemerosotan tumbuh-tumbuhan yang paling banyak dalam tumbuh-tumbuhan padat tinggi dari tahun 2008 hingga 2023 iaitu sepanjang 4.31 km^2 di mana julat NDVI melebihi 0.4. Bagi julat GNDVI yang melebihi 0.4, mukim Kok Lanas menunjukkan keluasan tertinggi iaitu 21.84 km^2 pada tahun 2008 manakala keluasan tertinggi pada tahun 2023 ialah 20.98 km^2 juga di mukim Kok Lanas.

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LIST OF ABBREVIATIONS

ArcGIS	Aeronautical Reconnaissance Coverage Geographic
GEP	Google Earth Pro
GIS	Geographic Information Systems
GNDVI	Green Normalized Difference Vegetation Index
NDVI	Normalized Difference Vegetation Index
OLI	Operational Land Imager
RS	Remote Sensing
TM	Thematic Mapper
USGS	United States Geological Survey

LIST OF SYMBOLS

km^2	Square kilometre
%	Percentage

CHAPTER 1

INTRODUCTION

1.1 Background of Study

This study is focused on comprehensively evaluating the vegetation cover and its spatial distribution within the state of Kelantan, Malaysia by using Geographic Information Systems (GIS) and Remote Sensing technologies. According to Fasolino et al., (2023) vegetation is very important for ecological balance and plays an important role in environmental health. Vegetation can be characterized as a collection of plants, ranging from one to many species that thrive in variously sized regions. The term "vegetation" refers to a heterogeneous distribution of plant species within a given terrain. The ecosystem comprises a diverse array of organisms, encompassing arboreal species, shrubs, grasses, forbs, and non-vascular plants including mosses. The distribution of various life forms throughout the land exhibits distinct patterns that contribute to the formation of vegetation structure (Schmid et al., 1996). According to Bannari et al., (1995) spatial-temporal variants in the atmosphere have an impact on the vegetation indices and more than 40 vegetation have been created in the previous 20 years to improve vegetation responsiveness.

Kelantan, which is in Malaysia includes an area that has significant environmental value with diverse ecosystem characteristics. In the Kelantan River basin, there 64% of the forested land in the southern region, 26% of agricultural land in the downstream region, and 10% of the developing area is mainly located in the northern downstream region (Che Ros et al., 2016).

Urban area growth frequently results in the loss of natural vegetation and green spaces, which are essential for preserving ecosystem services, biodiversity and general environmental health. The sustainability of urban ecosystems in Kota Bharu is threatened by the demands of urban growth combined with the effects of climate change. Conventional techniques for tracking vegetation changes such as mapping and ground surveys, take a lot of time, work, and frequently do not have the spatial and temporal precision needed to adequately record dynamic changes.

In addition, rubber plantations in Kelantan show a significant concentration between the regions of Gua Musang, Tanah Merah, Jeli and Machang. On the other hand, oil palm cultivation is mainly concentrated within the geographical boundaries of Gua Musang (Saadatkhah et al., 2016). Given the profound influence of plants on agricultural practices and overall environmental sustainability, it is important to implement a comprehensive assessment and monitoring initiative in the Kelantan region.

1.2 Problem Statement

The rapid transformations occurring in land use and environmental circumstances in the Kota Bharu district of Kelantan, Malaysia present significant obstacles to the implementation of sustainable land management practices. In addition, climate change caused by human activities also affects the distribution of vegetation because the frequency of extreme weather events causes vegetation to feel stressed. This study is to conduct a thorough evaluation of vegetation, specifically focusing on its spatial distribution in the Kota Bharu district of Kelantan, Malaysia. The application of advanced technologists such as Geographic Information System (GIS) and remote sensing offers a promising solution to these challenges. Remote sensing provides the capability to capture large-scale and high resolution imager, while GIS allows for sophisticated spatial analysis and visualization of this data. Vegetation indices derived from remote sensing data, such as Normalized Difference Vegetation Index (NDVI) and Green Normalized Difference Vegetation Index (GNDVI) are powerful tools for assessing vegetation health and changes over time.

1.3 Expected Outcome

The expected outcome of this research will provide valuable insights and implications for environmental conservation. Where it gives an overview of the health of plants in Kota Bharu district of Kelantan. This data is important to understand the balance of biodiversity in the area, such as areas with lush vegetation and vegetation that is in decline. Different environmental factors control different aspects of the vegetation pattern and it depends on the observational scale (Damman, 1979). Vegetation serves as an indicator of environmental conditions in ecological classifications. In addition, vegetation index analysis can also benefit farmers and agricultural planners by optimising crop selection and irrigation practices. The spatial distribution of healthy vegetation can increase agricultural productivity. This is because agricultural activities are highly dependent on the health and suitability of the soil.

This research can also provide an understanding of land cover changes in Kota Bharu district of Kelantan. This knowledge becomes the basis for an effective land-planning strategy. It can also help identify areas suitable for development and agriculture based on current vegetation conditions. Not only that, spatial analysis of vegetation also helps in disaster risk management because it identifies areas with dense vegetation that can act as a natural barrier against disasters. Changes in vegetation patterns may precede some disasters such as sparsely vegetated areas, which may be more prone to landslides. With this study, early action can be taken to prevent unwanted events from happening.

1.4 Objective

The objective of this study are:

i. To identify vegetation indices using Normalized Difference Vegetation Index (NDVI) and Green Normalized Difference Vegetation Index (GNDVI) in Kota Bharu, Kelantan.

ii. To assess the spatial analysis of vegetation in Kota Bharu, Kelantan using remote sensing and GIS for year 2008 and 2023.

1.5 Scope of Study

This study focuses on the Kota Bharu district in the state of Kelantan, Malaysia. This study aims to recognise the vegetation indices Normalized Difference Vegetation Index (NDVI) and Green Normalized Difference Vegetation Index (GNDVI). From the vegetation indices, the data will be used for spatial analysis of vegetation by using GIS and remote sensing technology. The output of the spatial analysis is based on the sub-district of Kota Bharu, Kelantan.

1.6 Significant of Study

The importance of this study is not only limited to the scientific community but also to the community and related parties involved in the management and conservation of land resources in Kota Bharu district of Kelantan. From this study, information about the health and distribution of plants can be produced. Vegetation cover change is one of the most important metrics for tracking environmental quality. It can represent climate variations and human activities correctly (Almalki et al., 2022). This can help stakeholders understand patterns and variations of vegetation cover in various areas found in Kota Bharu district of Kelantan. This understanding is important in assessing the health and density of vegetation in a place. In addition, the data obtained can also be used to monitor vegetation cover from time to time. With this, researchers can identify disturbances found in vegetation patterns and provide guidance to relevant parties regarding strategies for conserving the environment. This includes ways to reduce the negative effects of human activity. Not only that, but the concerned party can also assess how certain land uses affect vegetation and its long-term effects.

CHAPTER 2

LITERATURE REVIEW

2.1 Vegetation

A comprehensive examination of the correlation between vegetation and the environment necessitates a thorough comprehension of the environmental mechanisms that impact vegetation. This includes understanding the processes that connect rainfall to the accessibility of water for plants, as well as the physiological processes that regulate its utilization by various species. Within the field of ecology, a common distinction arises between experimental investigations and observational inquiries. There is a scarcity of studies that integrate meticulous observational analysis with comprehensive manipulative experiments pertaining to vegetation composition.

In the field of plant ecology, two commonly employed phrases are community and continuum. The term "community" has variability in its definitions. Plant communities exhibit a stable floristic composition, displaying a uniform physiognomy, and are typically found in specific environmental conditions. Furthermore, these communities tend to appear in multiple geographical regions. The term implies that the presence of consistent composition and homogeneous physiognomy can be attributed to biotic interactions among species, with a special emphasis on competition. The concept of the individualistic continuum is characterized by the recognition that each species exhibits unique responses to both abiotic and biotic factors. This is particularly evident when examining plants in relation to environmental variables, as there is a continuous diversity in floristic composition and structure (Maarel et al., 2014).

2.2 Spatial Analysis

Spatial analysis is the process of investigating and understanding the relationships between objects and their placement in geographic space. To analyze, interpret and visualize geographic data, it uses geographic information systems (GIS) as well as several other tools and techniques. The use of spatial analysis can be used in solving environmental problems and urban planning. Spatial analysis is important for vegetation research where it can determine the amount of vegetation cover in each area (Mahmood & Al-Rawe, 2023). In addition, spatial analysis is used in various domains such as crime rate investigation, public health research, environmental science, geology, marketing and decision making for complex spatial problems (Charles et al., 2024).

Spatial analysis examines correlations, patterns, and trends related to geography or space. Spatial analysis involves studying phenomena, their patterns, and observable trends. GIS and associated technologies are used to explore geographical phenomena in social, biological, and physical sciences. This definition emphasises spatial analysis, which focuses on the geographic features of data rather than statistical aspects (Fotheringham, et al., 2000).

Spatial analysis involves assessing, evaluating, and modelling spatial data features such as location, attributes, and interrelationships, as well as displaying geometric properties. Geospatial analysis involves analysing and evaluating geographic location data, spatial qualities, and their relationships through various methodologies. Spatial analysis distinguishes itself from non-spatial analysis by analysing relationships based on geographic location (Hao, 2019). According to Goodchild & Longley (1999), this idea refers to how the findings of an analytical approach can alter according on the location of the object. This description emphasises the importance of location when conducting spatial analysis. This suggests that spatial analysis is highly dependent on location. Spatial analysis can lead to different conclusions or decisions based on geographical variances.

2.3 Vegetation Indices

Vegetation indices are quantitative measures that offer insights into the condition, abundance, or vitality of vegetation coverage on the earths land surface. The indices discussed herein are derived from remote sensing data commonly acquired from satellites or aerial platforms and serve the purpose of monitoring and analyzing diverse attributes pertaining to plant development and health (Xue & Su, 2017). Vegetation indices are quantitative measures that offer insights into the condition, abundance, or vitality of vegetation coverage on the earths land surface. The indices discussed herein are derived from remote sensing data commonly acquired from satellites or aerial platforms and serve the purpose of monitoring and analyzing diverse attributes pertaining to plant development and health (Jiang, 2007).

The values of Normalised Difference Vegetation Index (NDVI) and Green Normalised Difference Vegetation Index (GNDVI), together with the corresponding formulas used for calculating these vegetation indices, are discussed in this research. The purpose of Normalised Difference Vegetation Index (NDVI) is for assessing the level of greenness in vegetation. The process of identifying and evaluating the quality of living green plants involves the utilisation of NDVI analyses, which assess the reflected visible and near-infrared light. The measurement of vegetation density and health in a satellite picture is conducted by analysing the individual pixels through the use of Normalised Difference Vegetation Index (NDVI) (James et al., 2023).

The Green Normalised Difference Vegetation Index (GNDVI) exhibits more sensitivity to variations in chlorophyll levels inside the crop compared to the Normalised Difference Vegetation Index (NDVI), and it also possesses a higher saturation threshold. This technique is applicable in agricultural settings where crops possess dense canopies or have reached more advanced phases of development.

2.4 Remote Sensing

Remote sensing is the data collection about an object without direct physical contact. The medium through which the distant object and the sensor are connected is electromagnetic radiation. Remote sensing technology has been the main driver of improvement in aerial photography techniques. A wide range of sensor types deployed on different platforms, such as satellites, balloons, and aeroplanes, can supply data for remote sensing. Field data is needed for the interpretation of remote sensing images to be confirmed (Gupta, 2017).

Remote sensing has the capability to offer regular and reliable data, enabling the monitoring of wetlands at various scales ranging from regional to national. This, in turn, aids in the conservation and management of wetlands by providing valuable support for their adaption strategies. Wetlands encompass a variety of plant species, including mangrove trees, nipah trees, and the aquatic trees that coexist within the area (Taddeo et al., 2019).

Other than that, the subject of agricultural monitoring using remote sensing (RS) encompasses a wide range of topics, and numerous studies have conducted comprehensive evaluations of Remote Sensing methods and their utilization in agriculture from diverse perspectives, occasionally focusing on specific applications. Some examples of applications in the field of agriculture include the assessment of soil parameters, monitoring soil moisture levels, forecasting crop yields, managing diseases and pests, and detecting and managing weeds (Khanal et al., 2020).

According to Kolarik et al., (2020) remote sensing can be employed as a tool to analyze alterations in vegetation structure, hence facilitating the monitoring of changes that may contribute to land degradation. The Remote Sensing approaches described in both applications have the capability to offer reliable and timely images, which is essential for mitigating the impact of destructive changes.

2.5 Geographic Information System (GIS)

Geographic information systems (GIS) encompass computer-based technology that can capture, store, analyse, and present data with geographical references. The word GIS is commonly employed to denote methodologies that integrate geographical location into analytical processes. The utilisation of GIS has experienced substantial growth in recent years, coinciding with the rising availability of digital data and advancements in computer hardware and software technologies (Montana, 2008). GIS enables the examination of intricate connections and patterns across distinct terrains by incorporating several forms of data, including maps, satellite photos, and statistical information. This technology is essential in areas such as urban planning and environmental management. The software that will be used for this study is ArcGIS.

CHAPTER 3

MATERIAL AND METHODS

3.1 Study Area

Kelantan is one of the states in Malaysia and it is known for the diverse geographical features. It is the eighth largest state in the country, meaning it ranks as the eighth largest among all the states in terms of land area (Afar, J. N. et al., 2013). The study area centered in Kota Bharu (6.1254°N , 102.2405°E) is in the northeastern state of Kelantan, Malaysia. The state is in the Kelantan River valley and has a bit of coastline facing the South China Sea. Northern region of the country. The Golok River serves as the border between Narathiwat Province and the international border that separates Malaysia and Thailand (Syahidah et al., 2020). Kota Bharu is also located in a strategic location near the mouth of the Kelantan River and is the state capital of the state of Kelantan (Madzlan et al., 2015).

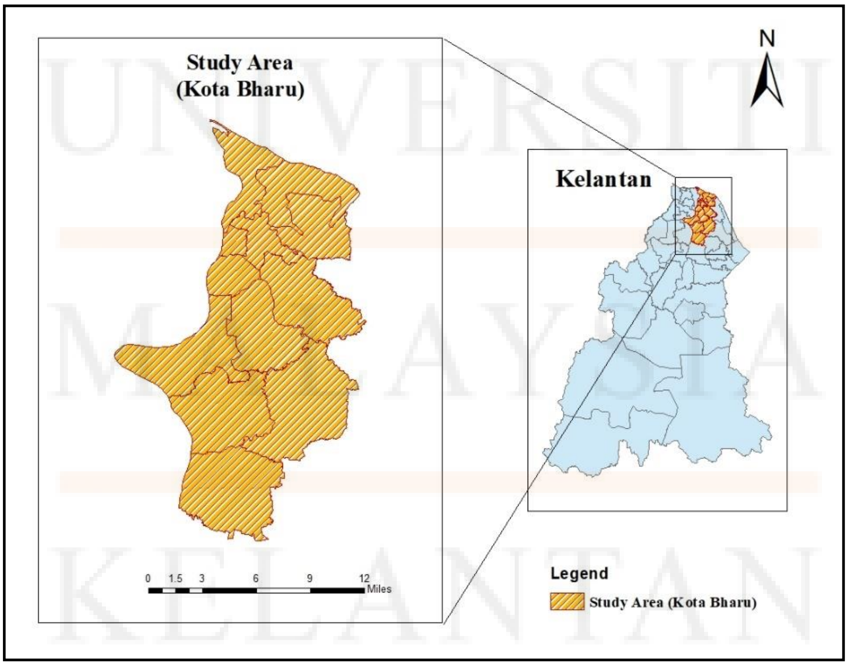


Figure 3.1: Kota Bharu District map in Kelantan

3.2 Material

3.2.1 Earth Explorer

The data will be acquired via the United States Geological Survey (USGS) Earth Explorer platform. The United States Geological Survey (USGS) is the preeminent public institution dedicated to cartography and the study of earth sciences within the United States. The system gathers, monitors, analyses, and provides scientific information pertaining to issues, complexities, and considerations associated with natural resources. According to USGS data, a raster can be characterised as distinct from the geoprocessing tool in that although the geoprocessing tool generates a new raster, the raster function employs direct processing of image pixels and raster datasets. In addition to this, the proposed formula offers a user interface that is designed to be easily comprehensible, along with straightforward tools that provide efficient visualisation and examination of images. Formulas can be employed for the purpose of examining extensive datasets and information, facilitating visual comparisons of images, generating robust 3D visualisations, constructing scatter plots, analysing pixel signatures, and performing several other tasks.

3.2.2 Google Earth Pro (GEP)

The data will be obtained through the Google Earth Pro platform. Google Earth Pro is a software tool created by Google that allows users to explore the earths surface using detailed satellite images and 3D terrain models (Suharini et al., 2020). Data is used in KML format. Google Earth Pro (GEP) also a powerful application that enables the evaluation of archaeoastronomical and landscape archaeological aspects (Romain, 2023).

3.2.3 ArcGIS

The selection of ArcGIS as the primary programme for this study has been made. The version of ArcGIS that will be used is 10.3. The softwares properties enable users to assume the role of an editor, facilitating the creation of new data and the generation of geospatial data. This work focuses on the integration of remote sensing and GIS, particularly utilising the ArcGIS programme, to analyse satellite imagery and GPS data. This study employed ArcGIS as a tool to investigate spatial patterns, evaluate data interactions, and assess data trends, specifically focusing on the distribution of vegetation types (James et al., 2023).

3.2.4 Landsat 5

Landsat 5 carried two sensors which are the Multispectral Scanner (MSS) and the Thematic Mapper (TM). MSS data acquisitions in the United States halted in 1992, while global acquisitions ended in 1999. In November 2011, the TM sensor failed, and the MSS instrument was brought back online. From June 2012 to January 2013, more than 15,000 MSS scenes were gathered. There are four spectral bands for Multispectral Scanner (MSS) which are Band 4 Visible Green (turned off owing to high current in August 1995), Band 5 Visible Red, Band 6 Near-Infrared, and Band 7 Near-infrared. Thematic Mapper (TM) provides seven spectral bands, including thermal bands which are Band 1 Visible Blue, Band 2 Visible Green, Band 3 Visible Red, Band 4 Near Infrared, Band 5 Near Infrared, Band 6 Terms, and Band 7 Mid-Infrared (U.S. Geological Survey., 2018).

Landsat 5 offered several improvements in spectral, radiometric, and geometric capabilities compared to previous Landsat sensors. In order to further ensure the consistency of images taken by different satellites throughout time, the USGS and

NASA personnel were entrusted with the same duties for the regular radiometric and geometric calibration of Landsat 5 (Chander, et al, 2005).

3.2.5 Landsat 9

The launch of Landsat 9 (L9) and its two sensors, Operational Land Imager-2 (OLI-2) and Thermal Infrared Sensor-2 (TIRS-2), on September 27, 2021, enables the Landsat Mission to continue providing high-tech. quality science data to the remote sensing user community (U.S. Geological Survey, 2019).The geometric component of the L9 commissioning work is similar to that performed during the Landsat 8 (L8) commissioning period for its two instruments, Operational Land Imager-1 (OLI-1) and Thermal Infrared Sensor-1 (TIRS-1) together with the L8 satellite. The L8 and L9 missions used the same method and phase geometry to perform calibration and characterization. The only variations are the initial prelaunch values for both sensors and the degree of change between the prelaunch and postlaunch calibration parameters (Choate et al., 2023).

3.2.6 Vegetation Index

The Normalised Difference Vegetation Index (NDVI) is a quantitative metric employed in the fields of remote sensing and geographic information systems (GIS) to evaluate and track the condition, abundance, and vitality of plant life within a specific geographical region. The calculation of this parameter is derived from data obtained by remote sensing techniques, typically utilising satellite or aerial imagery. Its application is prevalent within various disciplines, including agricultural and environmental research (Wilson & Norman, 2018). The formula is:

$$NDVI = (NIR – RED) / (NIR + RED) \quad (3.1)$$

The Green Normalised Difference Vegetation Index (GNDVI) is a widely employed vegetation index in the fields of vegetation study and remote sensing. The focus of this study pertains to the green segment of the electromagnetic spectrum, which bears similarities to the Normalised Difference Vegetation Index (NDVI) (Wilson & Norman, 2018). The formula is:

$$GNDVI = (NIR – GREEN) / (NIR + GREEN) \quad (3.2)$$

3.3 Method

3.3.1 Image Acquisition

The acquisition of Landsat 9 (OLI / TIRS C2 L2) and Landsat 5 (TM C2 L1) images using the USGS Earth Explorer platform enables the acquisition of significant datasets for vegetation research conducted in the Kota Bharu district of Kelantan.

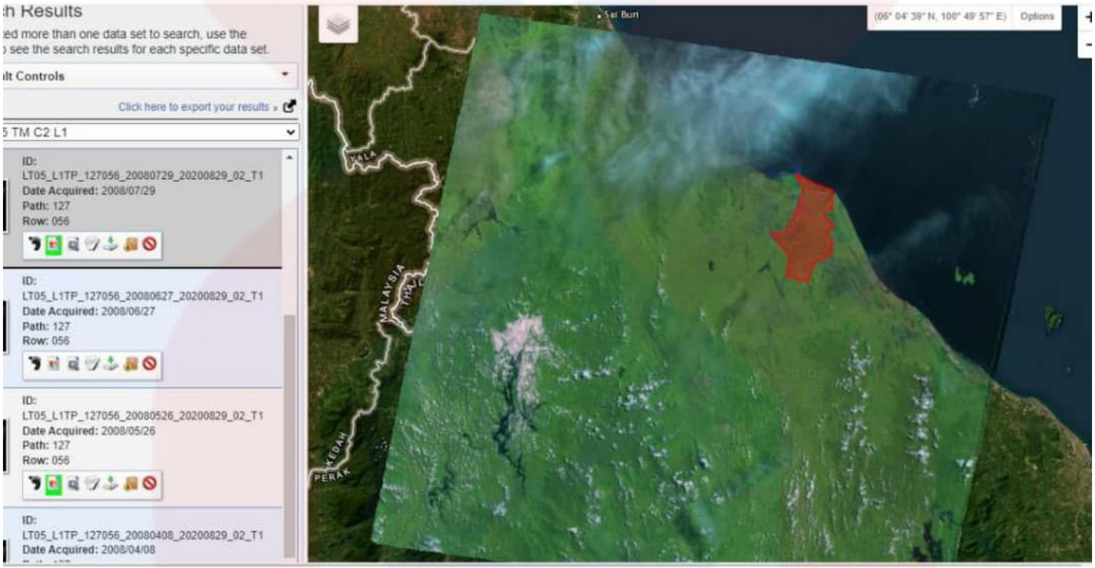


Figure 3.2: The acquisition of Landsat 5 images

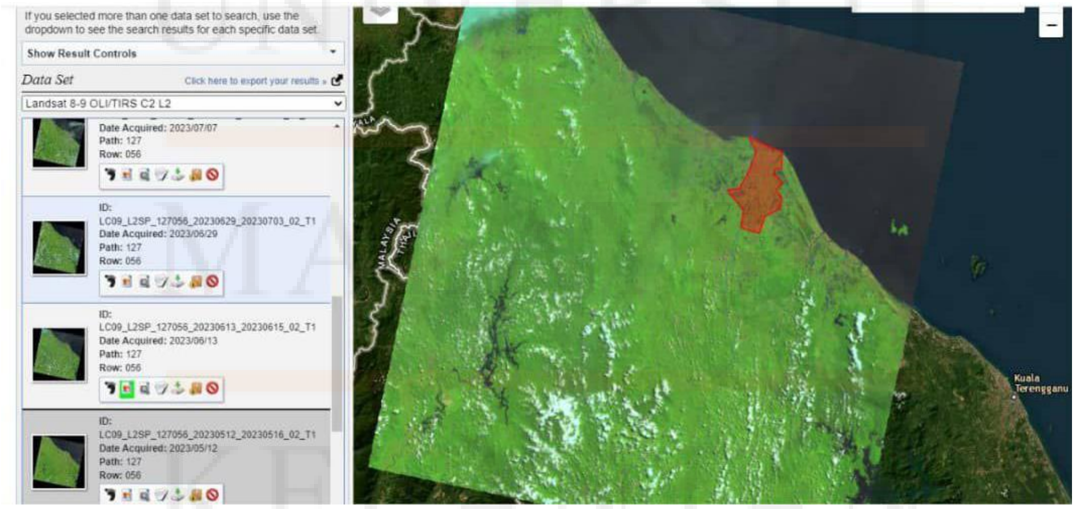


Figure 3.3: The acquisition of Landsat 9 images

3.3.2 Image Preprocessing

The preprocessing of satellite images before vegetation extraction is crucial for the elimination of noise and enhancement of the interpretability of the image data. This is particularly true when employing a time series of imagery or when dealing with a region that is covered by numerous photos, as it is of utmost importance to ensure spatial and spectral compatibility among these images (Yichun et al., 2008).

Clipping is a technique employed in image editing whereby a specific region of a picture is isolated and extracted through the utilisation of a cropping tool and the subsequent selection of a subset. This practise aids in guaranteeing the precision of the findings, so contributing to the total validity of the inquiry (James et al., 2023). Add all layers and enter the shapefile study area (Kota Bharu). Click windows on the main menu and click Image Analysis to apply the Clip function to the raster in ArcMap by selecting all the layers in the Image Analysis window.

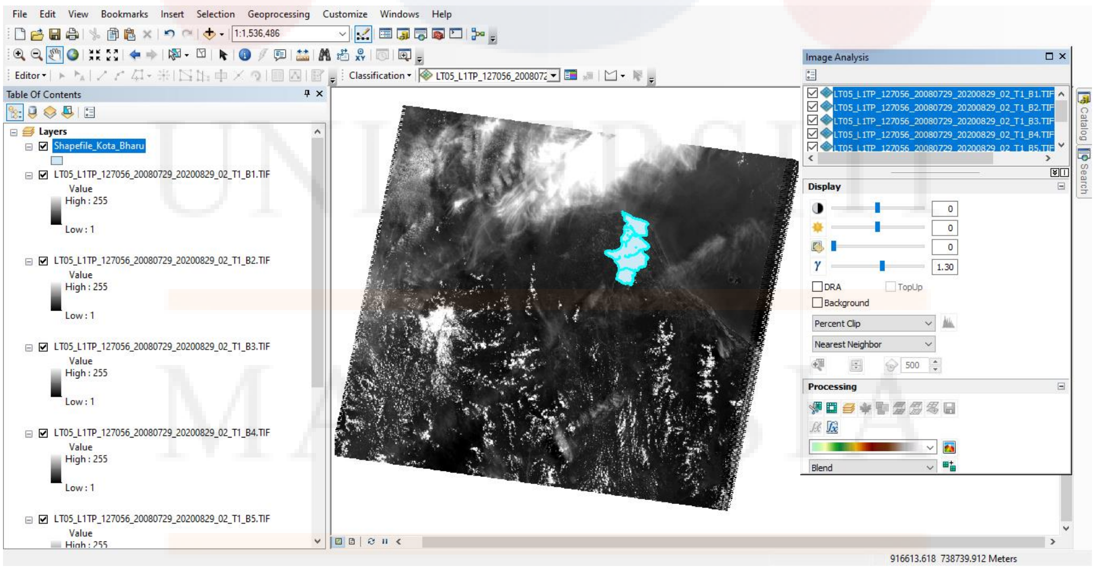


Figure 3.4: Clipping Image 2008

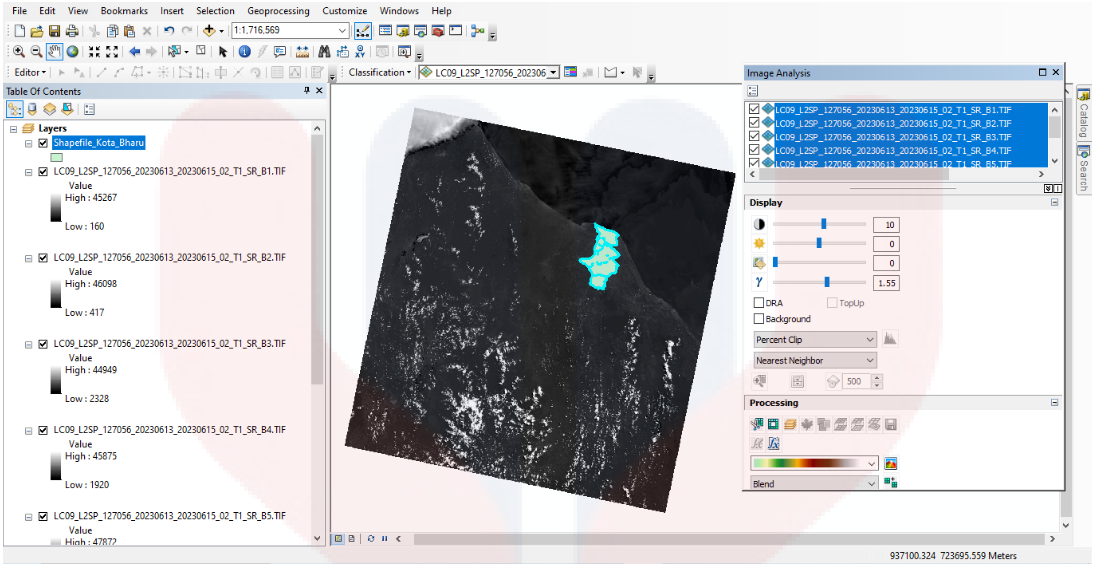


Figure 3.5: Clipping Image 2023

3.3.3 Image Processing

Before conducting any analysis, it is important to perform an initial examination of the chosen image. This entails importing the image into the ArcGIS application, hence facilitating the analysis of the data encapsulated inside the image. This enables the data contained in the image to be subjected to analysis. This enables the conduction of inquiries pertaining to the data included inside the image itself. The image to be examined can be selected due to its selectable nature. As a consequence of this fact, there is potential for an enhanced comprehension of the total issue. The procedure of enhancing photographs through the utilisation of software to guarantee a superior degree of image quality, as well as the process of georeferencing and registering using software to assure the consistency of map projections. All of these enhancements can be implemented through the utilisation of software (Mohd Aris et al., 2023).

3.3.3.1 Radiometric Correction

The digital number (DN) of the satellite image was translated to spectral radiance (at the sensor) and reflectance using radiometric correction (Suyarso et al., 2023). Even though this approach provides a clear indicator of the image matching quality, the evaluation is subjective and qualitative. When the outcomes match what is sought rather than necessarily what is correct, the radiometric correction approach is considered accurate (Janzen et al., 2006).

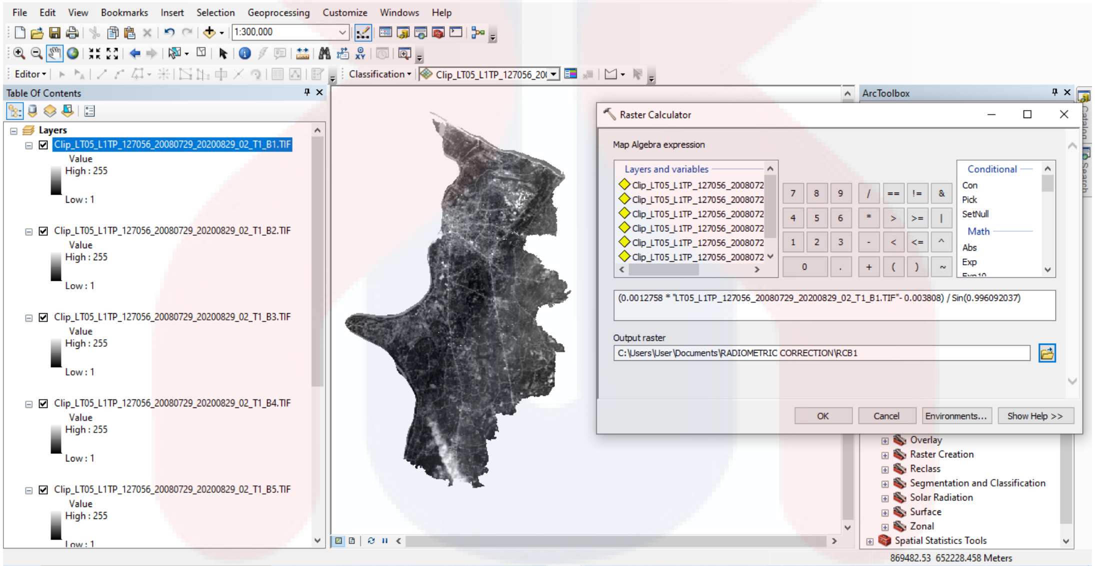


Figure 3.6: Radiometric correction (2008)

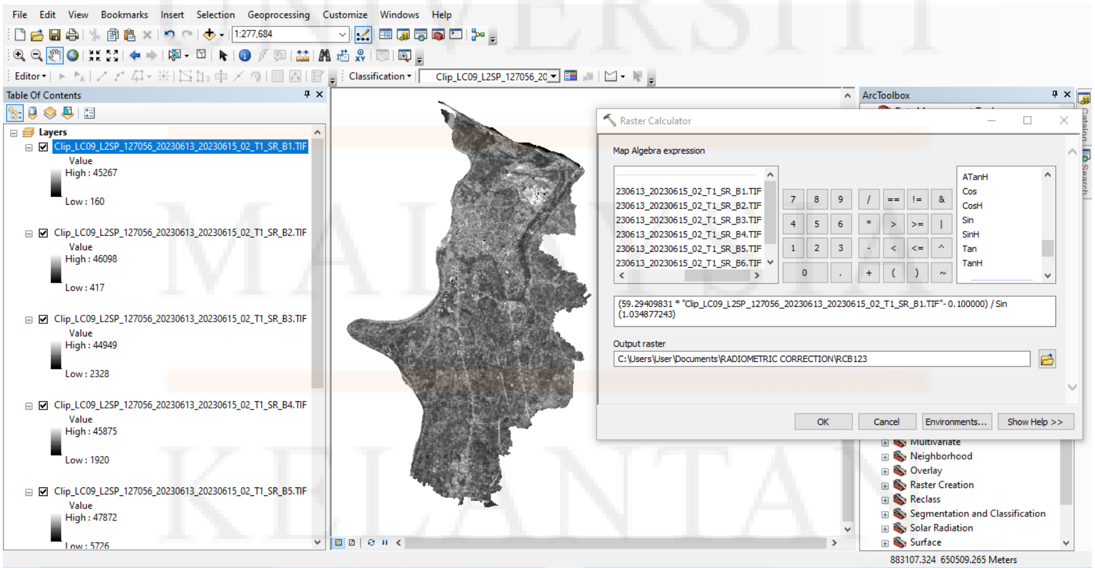


Figure 3.7: Radiometric correction (2023)

3.3.3.2 Composite Band

Composite band is accomplished by merging three bands into a colour composite band in order to facilitate visual interpretation in relation to the spectral reflectance characteristic (Melati, 2012). Three bands are used to organise compositions, which are represented by the colours Red, Green, and Blue (RGB). The false colour composite of band 543 was selected for Landsat 5 TM (2008). This combination offers the user with a wealth of information and colour contrast. Healthy plants are bright green, and the soil is mauve while band 654 for Landsat 9 OLI (2023), because of its many benefits for vegetation research (Quinn, 2001). Band 5 is designated as Middle Infrared (MIR) for Red guns, band 4 as Near Infrared (NIR) for Green guns, and band 3 as Red for Blue guns. Creating colour Composites has been done using the Arc Toolbox menu of the ArcGIS.

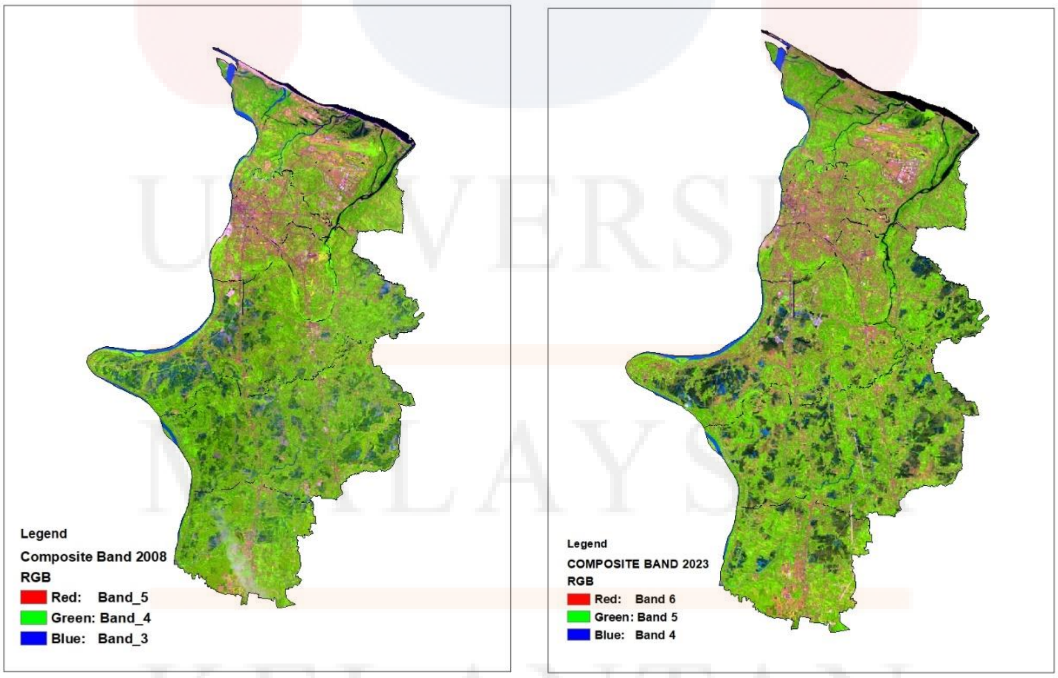


Figure 3.8: Composite band image for 2008 & 2023

3.3.4 Data Analysis

NDVI analysis measures reflected visible and near-infrared light to identify and evaluate living green plants. NDVI is used to estimate vegetation density and health in satellite images by examining pixels (James et al., 2023). The Green Normalized Difference Vegetation Index (GNDVI) has a higher saturation threshold and is more sensitive to plant chlorophyll levels than NDVI. This approach works in agricultural environments with dense canopies or advanced crop development. The following formula represents the vegetation index employed:

NDVI = (NIR – RED) / (NIR + RED)

GNDVI = (NIR – GREEN) / (NIR + GREEN)

Type of Landsat	NDVI Formula: NDVI = (NIR – RED) / (NIR + RED)	GNDVI Formula: GNDVI = (NIR – GREEN) / (NIR + GREEN)
Landsat 5	(Band 4 – Band 3) / (Band 4 + Band 3)	(Band 4 – Band 2) / (Band 4 + Band 2)
Landsat 8	(Band 5 – Band 4) / (Band 5 + Band 4)	(Band 5 – Band 3) / (Band 5 + Band 3)

NIR = Band 4/Band 5

RED = Band 3/Band 4

GREEN= Band 2/Band 3

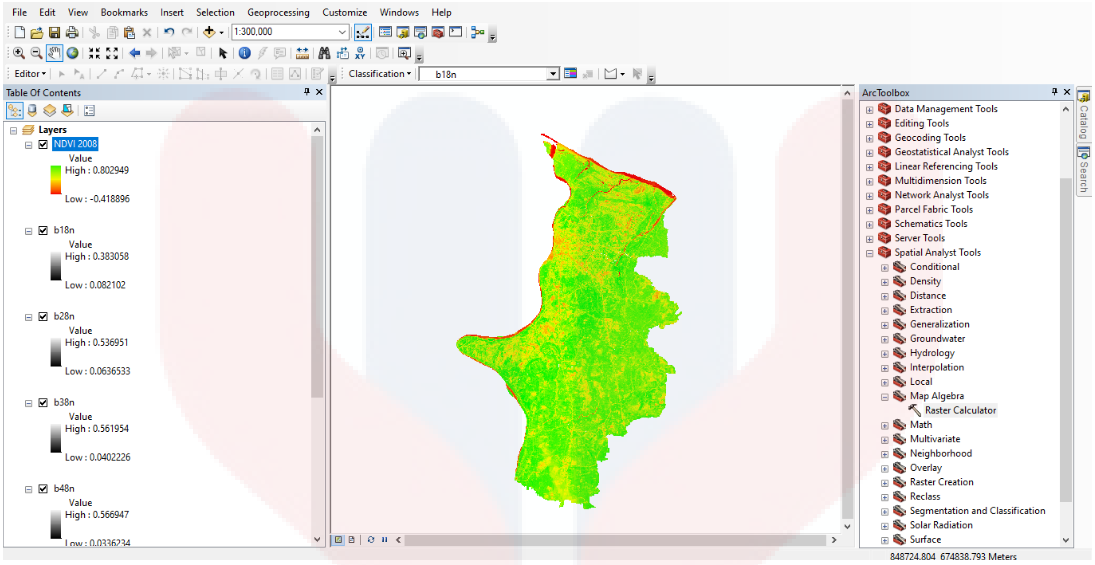


Figure 3.9: NDVI 2008

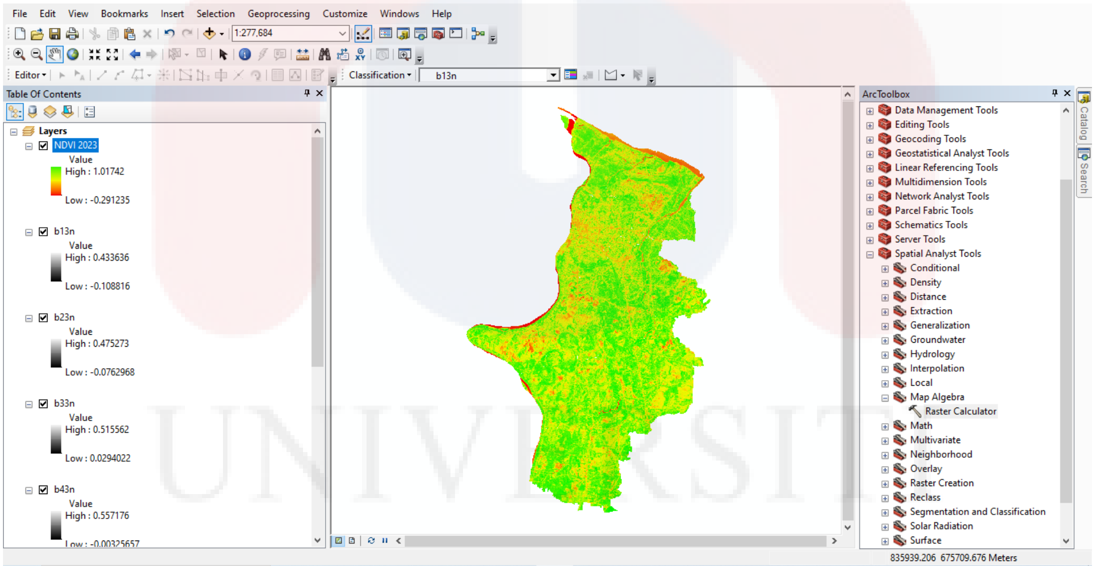


Figure 3.10: NDVI 2023

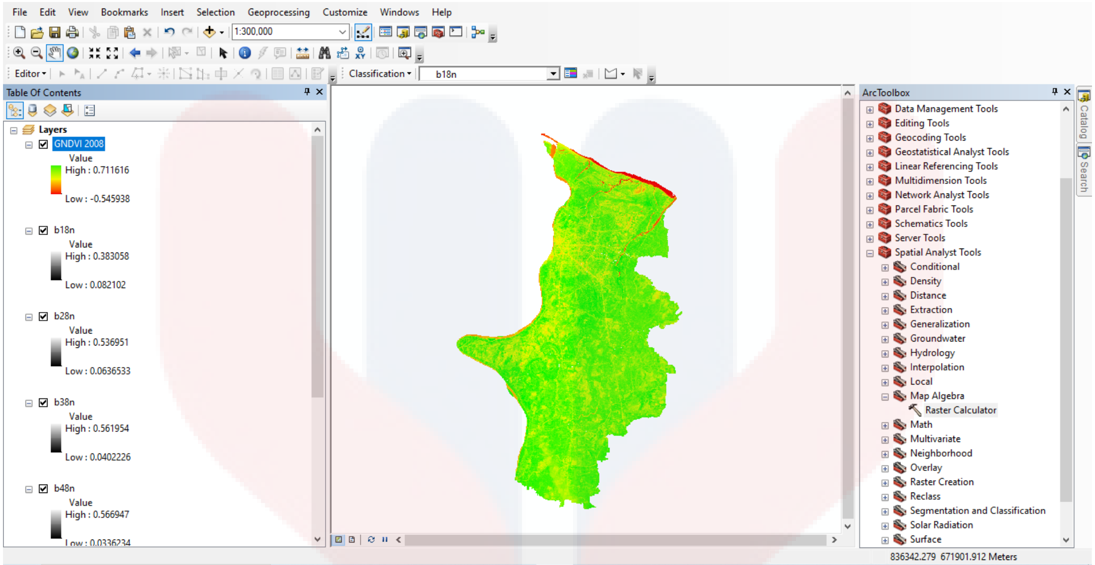


Figure 3.11: GNDVI 2008

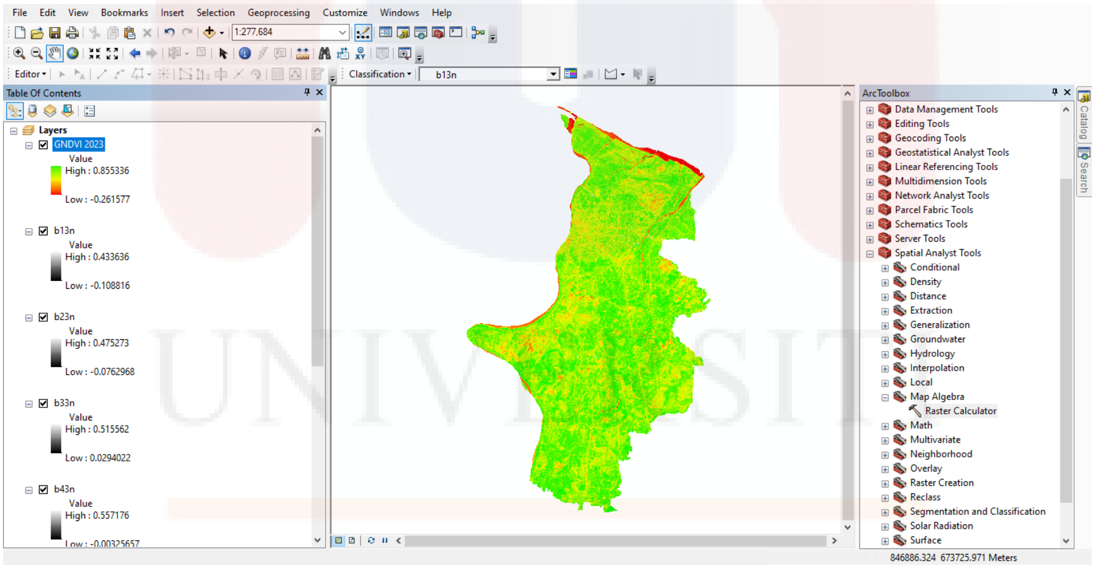


Figure 3.12: GNDVI 2023

3.3.5 Statistical Techniques

Cohen's Kappa coefficient, which is often used to measure inter-rater reliability, may also be applied to test-retest data. The Kappa coefficient in test-retest analysis represents the degree of agreement between the frequencies of two sets of data taken on two separate dates (Yu, 2005). The significance of rater dependability stems from the fact that it indicates the degree to which the data obtained in the study are accurate representations of the variables examined. Interrater reliability is a measure of how many data collectors (raters) assign the same score to the same variable. While there have been other approaches for measuring inter-rater reliability, it has generally been expressed as percent agreement, which is determined as the number of agreement scores divided by the total number of scores (ML McHugh, 2012). The formula of Kappa coefficient is as follows:

$$\text{Ka} = \frac{N\sum_{i=1}^{r} xii - \sum_{i=1}^{r}(x_{i+} * x_{+i})}{N^2 - \sum_{i=1}^{r}(x_{i+} * x_{+i})} \qquad (3.3)$$

RESEARCH FLOW

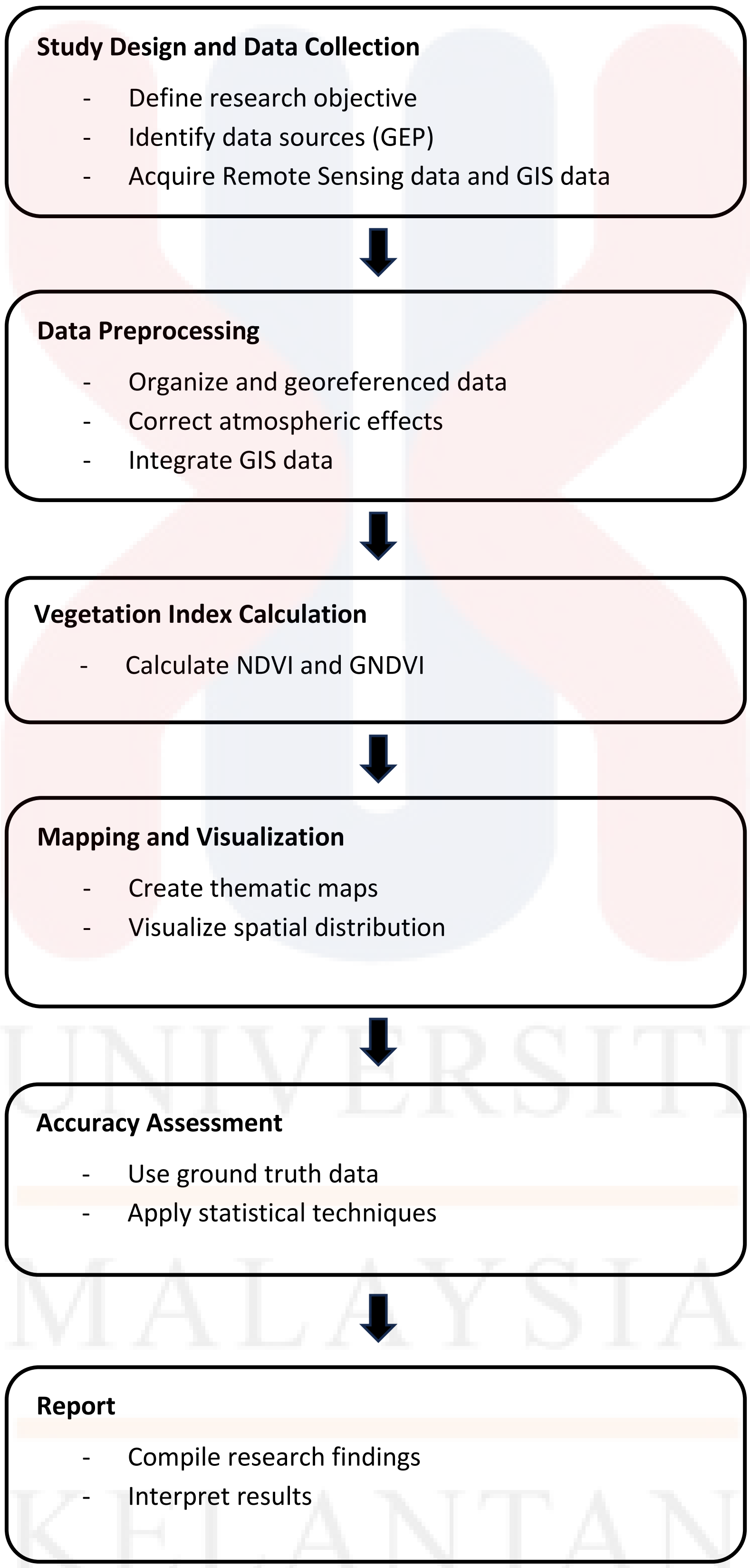


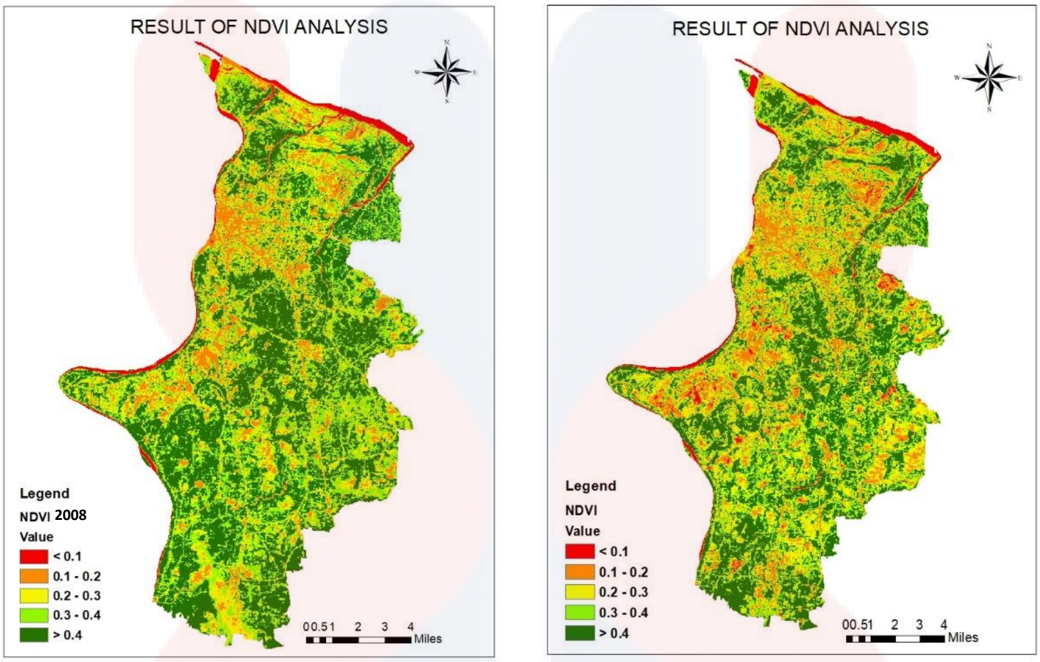
Figure 3.13: Research Flow

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Calculation of Vegetation Cover for The Study Area by Using NDVI

In this study, classification of NDVI value was adopted from (Zaitunah et al., 2021). Sparse vegetation ranged from 0.1 to 0.2, moderate vegetation ranged from 0.2 to 0.3, dense vegetation ranged from 0.3 to 0.4. While, for the NDVI range was less than 0.1, it indicated non vegetation area and more than 0.4 indicates high dense vegetation. Where the NDVI range less than 0.1 shows a non-vegetation increase of 4.40 km^2 and will be 24.16 km^2 in 2023. The increase in population growth has caused an increase in built up areas and settlements as well as a reduction in vegetation land. The reduction of vegetation area will have a negative impact on the quality of the environment such as flooding due to the decrease in water in the absorption area. Most of the vegetation land has been converted to housing and buildings. In addition, converted to roads and public facilities. Based on Table 4.1.2 and 4.1.3, Kadok is a subdistrict that has experienced a lot of decline in high dense vegetation from 2008 to 2023 which is 4.31 km^2 where the NDVI range exceeds 0.4. Meanwhile, Kok Lanas subdistrict showed a drastic increase from 2008 (0.31 km^2) to 2023 (3.33 km^2) which is 3.02 km^2 for the NDVI range of less than 0.1 (Non-vegetation).



(a) Year 2008 (b) Year 2023

Figure 4.1: Map of NDVI

Table 4.1: NDVI Range & Class

No.	NDVI Range	Class
1	< 0.1	Non-Vegetation
2	0.1 – 0.2	Sparse Vegetation
3	0.2 – 0.3	Moderate Vegetation
4	0.3 – 0.4	Dense Vegetation
5	> 0.4	High Dense Vegetation

Table 4.2: Vegetation cover in 2008 (NDVI)

Sub-District	Vegetation cover (km^2) NDVI 2008				
	(< 0.1)	(0.1 – 0.2)	(0.2 – 0.3)	(0.3 – 0.4)	(> 0.4)
1 Kuang	2.69	1.82	4.13	5.89	9.19
2 Chempaka	3.04	2.89	5.85	7.95	9.35
3 Panchor	0.92	3.65	4.97	8.29	10.21
4 Bunut Payon	0.11	1.76	3.18	3.64	4.53
5 Kadok	0.49	4.50	8.15	13.90	20.30
6 Melor	3.73	7.12	13.15	17.40	19.45
7 Pasir Tumboh	2.81	4.35	7.20	10.40	12.32
8 Salor	2.03	7.21	10.61	12.04	13.52
9 Demit	2.26	5.00	7.85	12.11	15.34
10 Kota Lama	0.13	1.52	1.70	1.23	0.62
11 Tanjong Mas	1.24	2.72	3.37	3.48	3.45
12 Kok Lanas	0.31	6.29	10.89	14.44	23.73
Total	19.76	48.83	81.05	110.77	142.01

Table 4.3: Vegetation cover in 2023 (NDVI)

Sub-District	Vegetation cover (km^2) NDVI 2023				
	(< 0.1)	(0.1 – 0.2)	(0.2 – 0.3)	(0.3 – 0.4)	(> 0.4)
1 Kuang	1.36	1.75	4.43	6.17	10.01
2 Chempaka	3.83	4.38	6.44	6.80	7.61
3 Panchor	1.82	4.61	5.71	7.20	8.70
4 Bunut Payon	0.09	2.75	4.14	3.20	3.02
5 Kadok	0.96	6.37	12.00	12.02	15.99
6 Melor	3.31	12.86	12.42	13.66	18.60
7 Pasir Tumboh	2.41	5.97	7.17	8.62	12.91
8 Salor	2.12	6.39	13.90	10.78	12.23
9 Demit	3.09	8.32	9.11	9.65	12.38
10 Kota Lama	0.06	1.59	1.76	1.15	0.62
11 Tanjong Mas	1.78	3.44	3.51	3.03	2.50
12 Kok Lanas	3.33	9.30	10.29	11.52	21.22
Total	24.16	67.73	90.88	93.8	125.79

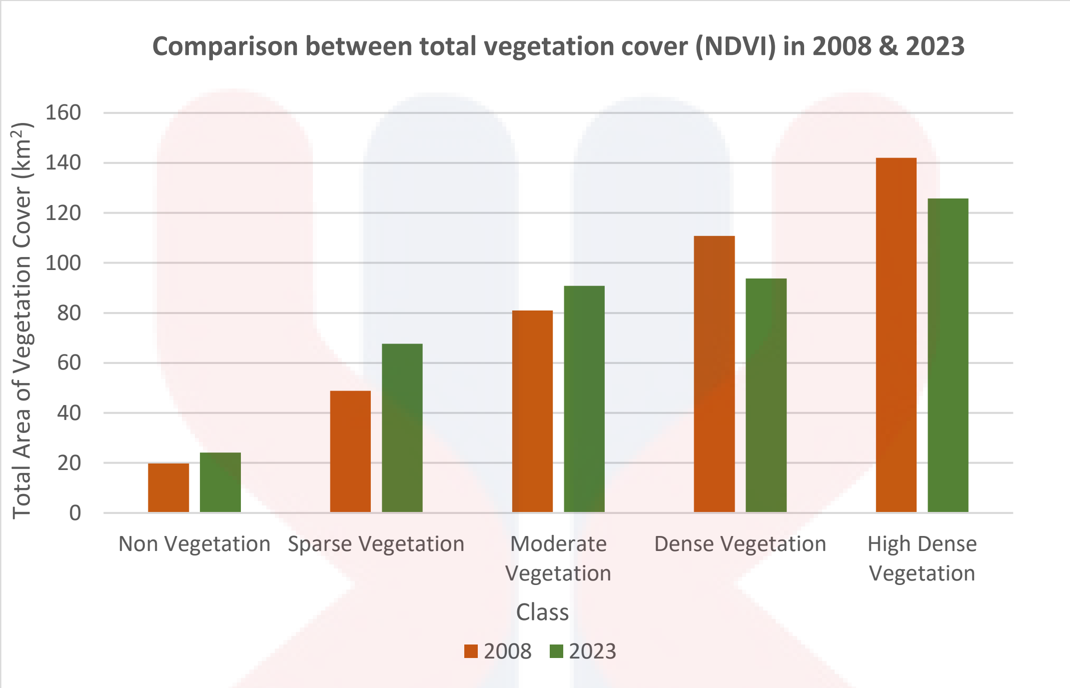


Figure 4.2: Comparison between total vegetation cover (NDVI) in 2008 & 2023

4.2 Calculation of Vegetation Cover for The Study Area by Using GNDVI

According to Gwihwan Moon (2024), the value given for this index also vary between -1 and 1. Sparse vegetation ranged from 0.1 to 0.2, moderate vegetation ranged from 0.2 to 0.3, dense vegetation ranged from 0.3 to 0.4. While, for the GNDVI range was less than 0.1, it indicated non vegetation area and more than 0.4 indicates high dense vegetation. Based on figure 4.4, the total of non vegetation cover from 2008 to 2023 shows an increase from 16.91 km^2 to 20.23 km^2 which is an increase of 3.32 km^2. This is due to the development of the district which is Kota Bharu from year to year. Table 4.2.2 and 4.2.3 show that subdistrict of Kok Lanas shows vegetation cover (high dense vegetation) GNDVI range above 0.4 is the highest area which is 21.84 km^2 in 2008 and likewise in 2023 which is 20.98 km^2. Meanwhile, Panchor subdistrict showed the most decrease among all subdistricts in Kota Bharu from 2008 to 2023 for high dense vegetation class (> 0.4) which is 2.82 km^2 where it decreased from 12.23 km^2 to 9.39 km^2. But for GNDVI, the density of vegetation in an area shows that a high vegetation cover is not necessarily in a healthy condition because GNDVI is more sensitive to the chlorophyll content in the leaves.

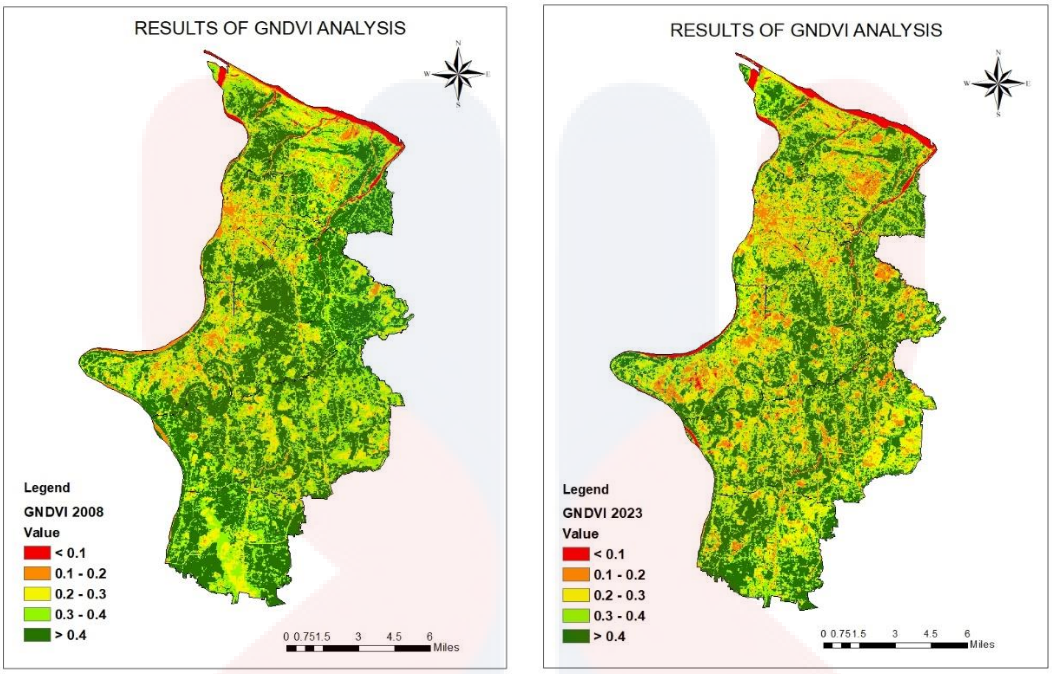


Figure 4.3: Map of GNDVI

Table 4.4: GNDVI Range & Class

No.	GNDVI Range	Class
1	< 0.1	Non-Vegetation
2	0.1 – 0.2	Sparse Vegetation
3	0.2 – 0.3	Moderate Vegetation
4	0.4 – 0.4	Dense Vegetation
5	> 0.4	High Dense Vegetation

Table 4.5: Vegetation cover in 2008 (GNDVI)

Sub-District	Vegetation cover (km^2) GNDVI 2008				
	(< 0.1)	(0.1 – 0.2)	(0.2 – 0.3)	(0.3 – 0.4)	(> 0.4)
1 Kuang	0.94	1.99	3.15	6.49	11.16
2 Chempaka	2.98	2.04	5.31	8.89	9.87
3 Panchor	0.50	2.12	4.82	8.36	12.23
4 Bunut Payon	0.89	1.99	3.10	3.31	3.92
5 Kadok	0.59	5.14	9.19	14.48	17.94
6 Melor	4.14	7.82	13.96	17.31	17.64
7 Pasir Tumboh	2.40	4.49	7.37	10.91	11.91
8 Salor	2.19	7.58	10.84	11.60	13.19
9 Demit	1.48	5.08	7.56	13.65	14.78
10 Kota Lama	0.14	1.27	1.68	1.38	0.71
11 Tanjong Mas	0.07	1.92	3.64	4.54	4.08
12 Kok Lanas	0.59	7.19	10.93	15.11	21.84
Total	16.91	48.63	81.55	116.03	139.27

Table 4.6: Vegetation cover in 2023 (GNDVI)

Sub-District	Vegetation cover (km^2) GNDVI 2023				
	(< 0.1)	(0.1 – 0.2)	(0.2 – 0.3)	(0.3 – 0.4)	(> 0.4)
1 Kuang	2.34	0.87	4.29	6.25	9.98
2 Chempaka	3.33	1.87	6.37	8.44	9.06
3 Panchor	1.05	3.58	5.98	8.03	9.39
4 Bunut Payon	0.53	2.41	3.92	3.30	3.04
5 Kadok	0.98	5.26	12.36	12.64	16.09
6 Melor	2.79	11.40	13.20	14.47	19.00
7 Pasir Tumboh	1.50	4.94	7.52	9.68	13.43
8 Salor	2.54	6.53	13.27	10.89	12.18
9 Demit	2.02	6.91	9.55	10.91	13.16
10 Kota Lama	0.09	1.33	1.86	1.25	0.66
11 Tanjong Mas	0.57	2.81	4.09	3.81	2.98
12 Kok Lanas	2.49	8.86	10.59	12.74	20.98
Total	20.23	56.77	93.00	102.41	129.95

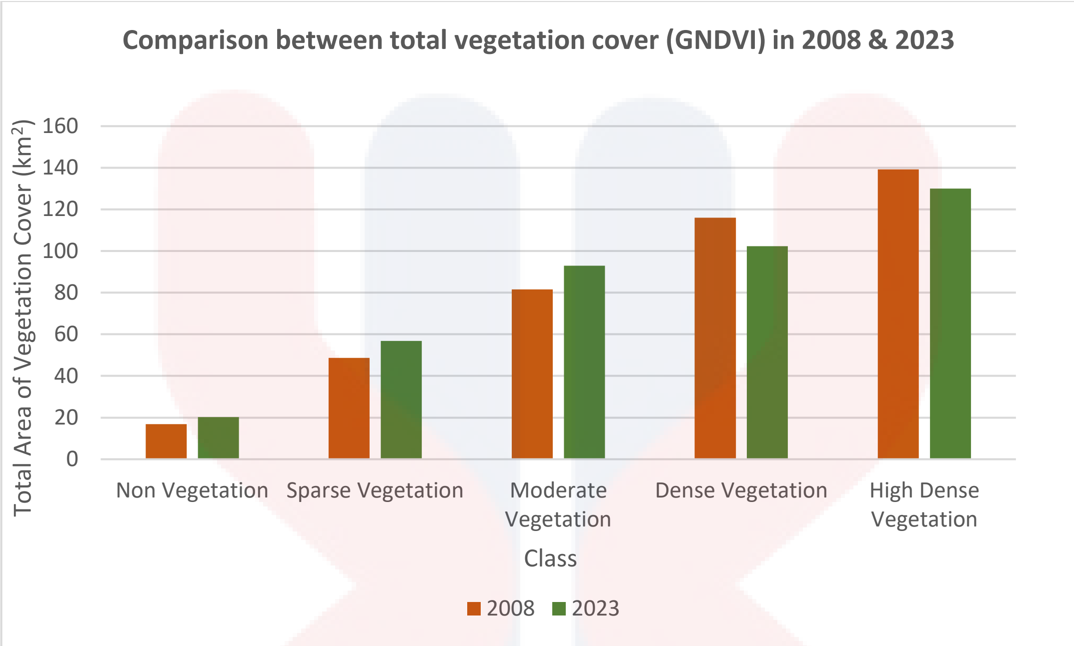


Figure 4.4: Comparison between total vegetation cover (GNDVI) 2008 & 2023

4.3 Accuracy Assessment

An essential component of every project involving spatial data is accuracy assessment (Congalton, 2001). An image classification is not completed unless its accuracy has been assessed. To ensure the validity of the accuracy assessment it is recommended to use the most recent ground truth data available. This is important because the accuracy of classified data can change over time due to changes in the environment or air quality. Overall accuracy is defined as the total number of correctly classified pixels divided by the total number of referenced pixels (Rogan et al., 2002). To assess the accuracy of the NDVI results, they were compared with Google Earth Pro images. 50 reference points are taken randomly where they represent 10 points for each class and digitized. The same goes for evaluating the results of GNDVI. The average accuracy level for NDVI 2023 is 78% while the average accuracy level for GNDVI 2023 is 76%. According to Congalton (1991), accuracy value greater than 70% is considered to be acceptable and the Kappa value ranging from 0.40 to 0.85 represents the good correspondence. The value of kappa coefficient for NDVI and GNDVI for 2023 respectively are 0.73 and 0.72. Kappa coefficient can be calculated using the formula of Kappa coeffiecient.

Table 4.7: Accuracy assessment for NDVI 2023 & GNDVI 2023

	No. of taken sample	No. of sample match with Google earth Pro	Average accuracy level in %	Kappa Coefficient
NDVI 2023	50	39	78%	0.73
GNDVI 2023	50	38	76%	0.72

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In conclusion, the integration of GIS and remote sensing could help in providing valuable insights and implications for environmental conservation as well as providing an overview of vegetation health and vegetation density in the Kota Bharu district of Kelantan. Through the spatial analysis of vegetation, this study shows that non-vegetated areas that have a range of less than 0.1 show an increase from 2008 to 2023 for both vegetation indices, namely NDVI and GNDVI. Where NDVI shows an increase of 4.4 km while GNDVI shows an increase of 3.32 km. However, for areas with high dense vegetation that has a range of over 0.4 shows a decreasing pattern from 2008 to 2023. Where NDVI shows a decrease of 16.22 km while GNDVI shows a decrease of 9.32 km. The non-vegetated area shows an increasing trend while the vegetated area shows an overall decrease.

5.1 Recommendations

Studies on vegetation index analysis and spatial evaluation play an important role in vegetation density to provide the status of vegetation health for each area. In order to improve this study, it is suggested to use a platform that has a clear picture like Planets Labs because it provides data in various formats and has a very high update frequency compared to Landsat and Sentinel. This aims to produce more accurate and clear results. In addition, in order to improve this study it is recommended to read more references in order to produce a better study and it is also recommended to develop a deeper understanding of the use of GIS in order to be able to use the tools provided correctly.

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