



**WATER BODIES DELINEATION AND CHANGE
DETECTION USING GIS AND REMOTE
SENSING: A CASE STUDY IN TUMPAT,
KELANTAN**

by

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DECLARATION

I declare that this thesis entitled “Water Bodies Delineation and Change Detection Using GIS and Remote Sensing: A Study Case in Tumpat, 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.

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The study has indeed helped me to explore more knowledgeable avenues related to my topic and I am sure it will help me in my future.

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**Water Bodies Delineation and Change Detection Using GIS and Remote Sensing
: A Study Case in Tumpat, Kelantan**

ABSTRACT

Mapping the water surface is a significant aspect of identifying the extension or shrinkage of any water body. It is a beneficial technique for a region, experiencing gradual river shifting, erosion, or frequent flood events. Climate change often causes excessive rainfall or drought conditions in a riverine region, significantly impacting water over-spilling or shrinkage and sedimentation of a river. The spatio-temporal study of delineation and mapping of extracting and delineating water bodies and estimating changes during 2014 to 2023 in Tumpat, Kelantan, to detect and delineate water bodies in Tumpat, Kelantan for year 2014 and year 2023, to identify change detection of water bodies in Tumpat, Kelantan between 2014 to 2023. This study aims to delineate water bodies of Tumpat, Kelantan using Geographic Information System (GIS) and remote sensing over a temporal scale of ten years from 2014 to 2023. Normalized Difference Water Index (NDWI) are used in this study to map and estimate the changes and extension of water bodies of the region. It is observed that there is a decrease of 10.75% in water bodies in the district from 2014 to 2023.

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**Sempadan Badan Air dan Pengesanan Perubahan Menggunakan GIS dan
Penderiaan Jauh
: Satu Kes Kajian di Tumpat, Kelantan**

ABSTRAK

Pemetaan permukaan air merupakan aspek penting dalam mengenal pasti lanjutan atau pengecutan mana-mana badan air. Ia merupakan teknik yang berfaedah untuk sesuatu wilayah, mengalami peralihan sungai secara beransur-ansur, hakisan atau kejadian banjir yang kerap. Perubahan iklim selalunya menyebabkan hujan yang berlebihan atau keadaan kemarau di kawasan sungai, yang memberi kesan ketara kepada tumpahan air yang berlebihan atau pengecutan dan pempadapan sungai. Kajian spatio-temporal mengenai persempadanan dan pemetaan mengekstrak dan delineasi badan air dan menganggarkan perubahan sepanjang 2014 hingga 2023 di Tumpat, Kelantan, untuk mengesan dan membuat delineasi badan air di Tumpat, Kelantan bagi tahun 2014 dan tahun 2023, untuk mengenal pasti pengesanan perubahan badan air di Tumpat, Kelantan antara tahun 2014 hingga 2023. Kajian ini bertujuan untuk membuat delineasi badan air Tumpat, Kelantan menggunakan Sistem Maklumat Geografi (GIS) dan penderiaan jauh dalam skala temporal selama sepuluh tahun dari 2014 hingga 2023. Indeks Air Perbezaan Ternormal (NDWI) digunakan dalam kajian ini untuk memetakan dan menganggarkan perubahan dan lanjutan badan air di rantau ini. Adalah diperhatikan bahawa terdapat penurunan sebanyak 12% dalam badan air di Tumpat, Kelantan ini dari tahun 2014 hingga 2023.

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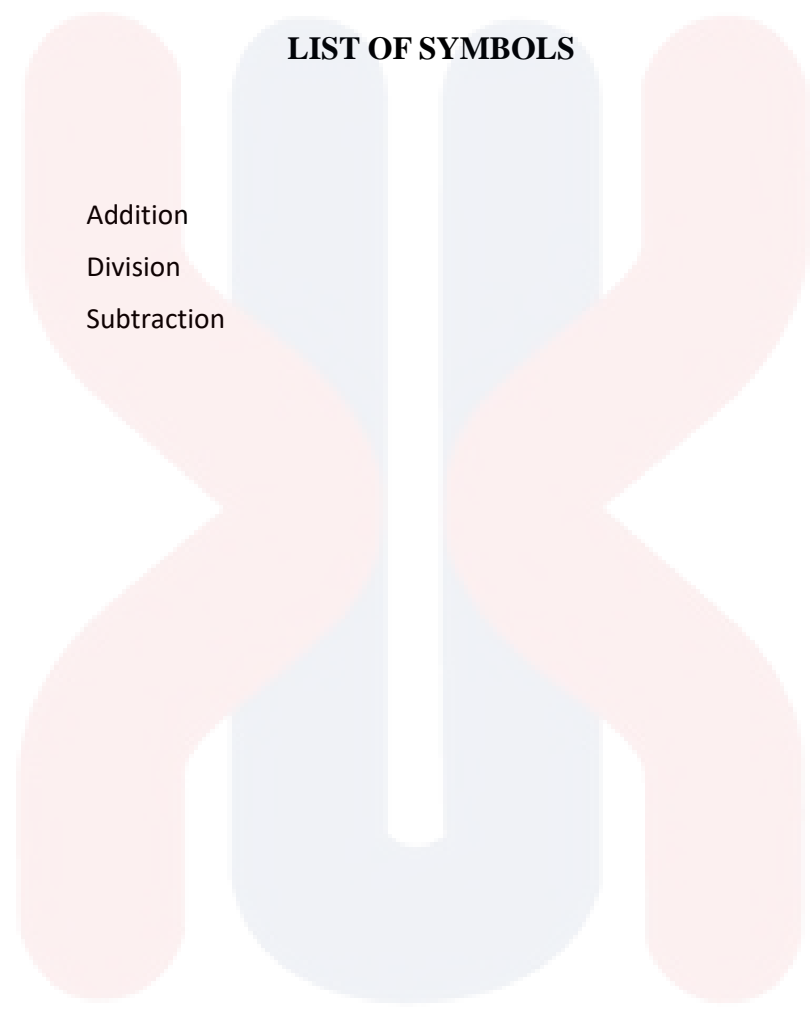
LIST OF ABBREVIATIONS

DEM	Digital Elevation Model
GIS	Geographic Information System
GloVis	The Global Visualization Viewer
GPS	Global Positioning System
NDVI	Normalised Difference Vegetation Index
NDWI	Normalised Difference Water Index
NIR	Near-infrared
OLI	Operation Land Imager
SWIR	Shortwave infrared
TIRS	Thermal Infrared Sensor
USGS	United States Geological Survey

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LIST OF SYMBOLS

+	Addition
/	Division
-	Subtraction



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CHAPTER 1

INTRODUCTION

1.1 Background of Study

In Malaysia, water source quality is an important factor in maintaining the availability of safe and clean water for a variety of applications, including drinking, agriculture, industry, and enjoyment. Malaysia has a broad range of water resources, including rivers, lakes, reservoirs, and groundwater. These sources are critical in providing water to both urban and rural populations (Huang et al., 2015).

Kelantan has a land area of 15,099 km² and is located in the northeastern section of Peninsular Malaysia, bordering to the north by parts of southern Thailand, to the west by Perak, to the south by Pahang, and to the east by Terengganu. Kota Bharu, Tumpat, Machang, Pasir Puteh, Bachok, Jeli, Tanah Merah, Pasir Mas, Kuala Krai, and Gua Musang are its administrative districts (Razak, 2010).

The southern regions of the state have hilly terrains separated by the Titiwangsa Mountain Range, with lush coastal plains downstream defining the region's geography. Paddy farming, timber, rubber, oil palm, and tropical fruits predominate in the river valley. The woodlands provide habitat for a diverse range of terrestrial and aquatic plants and fauna. Sungai Nenggiri, Sungai Lebir, Sungai Galas, Sungai Pergau, Sungai Kelantan, Sungai Golok, Sungai Kemasin, Sungai Pengkalan Chepa, Sungai Pengkalan Datu, and Sungai Semerak are among the major rivers.

Various aspects of water resource management in the state will be discussed in order to meet diverse demands based on water resource availability. The economy, demography, surface water hydrology, ground water availability, potable water

demand, irrigated paddy water demand, non-paddy agriculture water demand, alternative sources of water, other irrigation water demand, hydropower, and limiting factors such as sewerage, flood mitigation, river sedimentation, river navigation, and water pollution are all factors to consider in water resource management. Water quality, land usage, forestry, environmental fluxes, fisheries, livestock, and solid wastes are all specifically related to environmental and engineering concerns. All of this is examined and studied, ending in suggestions for water resource projects in the state, particularly potable water supply.

1.2 Problem Statement

Kelantan's significant water bodies are delineated by mapping and delineating their limits. Some famous examples include the Kelantan River, which requires mapping its course and identifying its tributaries. This is critical for determining the river's drainage basin and managing water resources. The Galas River, like the Kelantan River, is delineated by tracing its path and tributaries. This helps to provide a full grasp of the region's hydrology.

Additionally, there is a large waterfall area. Delineation at Sungai Stong State Park will entail charting the region around Stong Waterfall and documenting the boundaries of this important natural feature and its surrounding scenery. Then come reservoirs and wetlands. Kelantan's smaller reservoirs and wetlands help with water management and biodiversity. Delineating these water bodies entails defining their borders and comprehending their ecological significance.

Kelantan's monsoon season can have a considerable impact on the demarcation of water bodies. Heavy rainfall and flooding may cause current bodies of water to expand, new ones to form, or river and stream courses to change. This dynamic process

has the potential to transform the landscape, impacting the accuracy with which water bodies are delineated in mapping and geographical information systems. Due to severe rainfall and flooding, the monsoon season in Kelantan can result in the formation of temporary water bodies such as ponds and small lakes. However, it is critical to handle the possible dangers connected with floods during this time.

Kelantan's dry season normally runs from May to September. During this time, the region receives less rain, higher temperatures, and reduced humidity. During Kelantan's dry season, the potential impact on water supply, agriculture, and the environment must all be considered. During Kelantan's dry season, decreased rainfall and lower water levels in rivers and lakes can change the appearance and size of bodies of water. Smaller bodies of water may temporarily shrink or dry out. Water bodies' boundaries may alter, which can affect how they are represented in maps and geographic information systems. Water bodies must be monitored and updated on a regular basis during the dry season in order to accurately reflect seasonal changes.

1.3 Objective

The study has objectives as follow:

1. To detect and delineate water bodies in Tumpat, Kelantan for year 2014 and year 2023.
2. To identify change detection of water bodies in Tumpat, Kelantan between 2014 to 2023.

1.4 Scope Study

Water bodies delineation and change detection using GIS and Remote Sensing will be conduct at Tumpat, Kelantan. ArcGIS application will be used in this research to

detect the changes of water bodies delineation and the change of water bodies size. NDWI been used in this research to get cleared image of the water bodies.

1.5 Significant of Study

In this research of water bodies delineation and change detection using GIS and Remote Sensing in Tumpat, Kelantan hold significant importance of changes of water bodies delineation. The changes of water bodies delineation are influence by climate change of rain and dry season. The water bodies delineation can be less or big due to season. If raining, the water bodies will be big and if dry season, the water bodies will be small than normal. Another factor that will change water bodies delineation in Tumpat, Kelantan is urban expansion.

There are two years that will be used in this research which to detect changes of water bodies delineation using GIS and Remote Sensing in 2014 and 2023. The water bodies in 2014 in this research will be compared to water bodies delineation in 2023. The objective of this research is to detect and delineate water surface in Tumpat, Kelantan between 2014 to 2023 and to identify and detect the change of water surface in Tumpat, Kelantan between 2014 to 2023.

Water bodies, such as lakes, rivers, ponds, marshes, and seas, play an important role in the environment and provide several benefits to both natural ecosystems and human culture. Conservation of biodiversity, many endangered and vulnerable species rely on certain bodies of water for existence. The protection of these ecosystems is critical for the survival of these species. A vast spectrum of aquatic and terrestrial organisms relies on water bodies for survival. They provide habitat for a wide variety of plants, fish, amphibians, reptiles, birds, and mammals. Many species rely on these habitats for reproduction and feeding. Water bodies give several advantages to the

environment and human well-being. As a result, their preservation and long-term management are critical for ensuring healthy ecosystems and a prosperous future.



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CHAPTER 2

LITERATURE REVIEW

2.1 Kelantan Water Bodies

Kelantan, a Malaysian state, is known for its many water bodies such as river, ocean, lake and so on, which are important to its environment, economics, and culture. In Kelantan, rivers and the ocean (South China Sea) play critical roles in supporting numerous areas of life and the environment. Water bodies, such as rivers, are also employed in agricultural operations known as irrigation systems in the agricultural sector, which is one aspect in generating revenue for local communities and may also assist to prevent calamities such as floods. In terms of economic activity, the sector is the fishing industry. The ocean is a vital resource for Kelantan's fishing sector, delivering fish and shellfish that sustain local lives and commerce. can also be observed in the trade and transportation industries. The coastline area promotes trade and marine transit, linking Kelantan to both local and international markets. In Kelantan, locals utilize river water for domestic purposes. Rivers provide a vital supply of fresh water for drinking, cooking, sanitation, and other home purposes. They are also utilized for washing and bathing, as well as contributing to everyday hygiene activities.

2.1.1 Kelantan's Water Bodies: Biodiversity, Sustainability, and Dynamic

Ecosystems

Kelantan is a Malaysian state known for its rich cultural heritage, natural beauty, and unique traditions. Kelantan, located on the Malay Peninsula, is one of the

country's 13 states and is known as the "Land of Lightning" due to its frequent thunderstorms.

Tumpat does include water bodies, such as rivers and estuaries, which are important characteristics of the terrain. The Golok River, which forms part of Malaysia's border with Thailand, is a notable water body in the area. It runs through Tumpat before spilling into the South China Sea.

Furthermore, as a coastal district, Tumpat is likely to include coastal areas with beaches and mangrove forests, which add to the richness of its aquatic habitats. Water bodies in Tumpat, Kelantan are important to both the ecosystem and the local populations for a variety of reasons. First, consider biodiversity and ecosystem support. Kelantan's water bodies, which include rivers, lakes, and wetlands, are home to a diverse array of aquatic flora and fauna. Many species rely on these ecosystems for breeding grounds, shelter, and food. They contribute to the region's overall biodiversity and are necessary for the health of terrestrial and aquatic ecosystems (Mahirah Kama1udin1, 2013).

Following that, water bodies are a primary source of freshwater for both rural and urban communities in Kelantan. They provide drinking water, irrigation for agriculture, and support a variety of industrial processes. The availability of clean and plentiful water is critical for sustaining livelihoods and economic activities (Fresh Water, 2023).

Water bodies, such as rivers, lakes, and seas, change throughout time due to natural processes and human activity. Climate change can cause rising sea levels, changing precipitation patterns, and increasing water temperatures, all of which can have an impact on the health and stability of water bodies. Seasonal changes in water

bodies include swings in water levels, temperature, and flow rates. These are frequently related with weather patterns and have the potential to have an impact on aquatic ecosystems (Fecht, 2019).

Furthermore, erosion and sedimentation. Natural processes such as erosion and sedimentation constantly modify riverbanks and lakebeds. Human activities such as construction and deforestation can aggravate erosion. Kelantan, is blessed with a variety of water bodies that contribute to its natural beauty and ecological diversity. Kelantan is crisscrossed by numerous rivers, some of which are quite large. The Kelantan River, named after the state, is one of the largest and most important. These rivers are important for irrigation, transportation, and are often the focal point of local communities.

There are several lakes in Kelantan, both natural and man-made. Natural lakes, such as Silver Jubilee Lake, provide scenic views and recreational opportunities. Additionally, reservoirs formed by damming rivers, such as the Air Chabang Dam, serve as sources of water supply and may include recreational facilities.

Next, wetlands in Kelantan are important for biodiversity and ecological balance. These areas include freshwater swamps, marshes, and peatlands. Kelantan has internationally recognized wetlands, such as the Pulau Suri Mangrove Forest Reserve, which supports a variety of wildlife and bird species Why Are Wetlands Important? - Wetlands (U.S. National Park Service)).

Furthermore, the state of Kelantan has a coastline along the South China Sea. Coastal areas include beaches, estuaries, and mangrove forests. Tourists flock to the beaches, such as Pantai Cahaya Bulan. Estuaries are critical to the health of coastal ecosystems and frequently support fishing communities.

2.1.2 The Importance of Water Bodies

A body of water, often known as a waterbody, is a considerable collection of water on the surface of the Earth or another planet. The phrase is most used to describe oceans, seas, and lakes, but it may also apply to smaller bodies of water such as ponds, marshes, and, less frequently, puddles. A body of water does not have to be still or enclosed; rivers, streams, canals, and other geological features that transport water from one location to another are also considered bodies of water.

Waterbody biodiversity offers a variety of services that have an impact on human health and well-being, both directly and indirectly. For people, aquatic ecosystems provide water, food, and materials, as well as a space for enjoyment, commercial fishing, and tourism. Another important aspect of water bodies is the presence of aquatic plants and animals, as well as their ecological functions for our existence. A body of water also acts as a barrier to emerging illnesses, generates work possibilities in tourist-friendly areas, and serves as a source of medication (Ogoyi, 2022).

Oceans, in particular, play a crucial role. Their size enables them to retain and transfer heat over extended periods of time, influencing weather patterns and climate. Ocean currents also transport warm or cold water from one area to another, allowing temperature dispersion. Comprehending how water bodies control temperature is crucial for comprehending Earth's climatic systems. It emphasises how land, air, and water interact to shape our planet's weather conditions. Water bodies such as lakes, rivers, and seas shape precipitation and influence weather patterns. Water bodies are crucial components of the water cycle. When the sun's heat reaches these bodies, it evaporates into the atmosphere as water vapour. As the air rises, it cools, causing the water vapour to condense into small droplets that create clouds. These clouds are

crucial in establishing weather patterns. They discharge moisture in the form of rain or other kinds of precipitation, replenishing our freshwater supplies and promoting plant and ecosystem health. Waterbodies have an impact on the area's climate as well. Coastal places, for example, benefit from the moderating impact of adjacent oceans, while huge lakes can develop local weather patterns. Understanding the significance of water bodies in rainfall and weather allows us to better understand how Earth's systems interact. This emphasises the need to preserve these valuable resources in order to preserve a balanced and sustainable ecosystem (*Krishvision, 2023*).

Water bodies are an important source of drinking water for both people and animals. They also supply water for irrigation, which is critical in agriculture. Water bodies are also important for food production. Water bodies provide a diverse range of fish and other aquatic species that provide people with sustenance. They also promote the growth of algae and other plants that fish and other animals consume. Water bodies can be used to move people and products. Revertant is a component of the worldwide transportation network. Rails and canals have been used for millennia to move products, and they are now an important (Raj, 2023).

Thus, water bodies are crucial to human existence and civilisation because they provide needed resources, support economic activity, and improve our quality of life in a variety of ways. Protecting and managing water resources in a sustainable manner is critical for future generations' well-being and the overall health of the planet.

2.1.3 Water Bodies Monitoring

The most direct effect of water body quality monitoring is to provide information about water body quality to related stakeholders so that they can understand the status of the water bodies around them, as well as to raise public awareness of water

environment preservation so that people feel water bodies are accessible and safe to use. Furthermore, scheduled water body quality monitoring may aid in the development of a database of water quality changes over time as well as the evaluation of the consequences of water pollution clean-up operations, which can be used as a valuable reference for developing water pollution management plans. Water quality monitoring is classified into two groups based on the type of water body: river water and reservoir water (Water Quality Monitoring, 2019).

Water body monitoring can help preserve human health. Water bodies provide drinking water for millions of people across the world. Monitoring ensures that water quality satisfies safety criteria and is free of contaminants that may endanger human health, such as pathogens, heavy metals, and pollutants.

Next, ensure environmental health. Water bodies sustain a variety of ecosystems, including aquatic plants, animals, and microbes. Monitoring allows us to assess the health of these ecosystems, detect changes in biodiversity, and identify stresses like pollution, habitat loss, and invasive species (Levallois & Villanueva, 2019).

Effective water resource management requires reliable data on water quantity and quality. Monitoring reports on water levels, flow rates, sediment movement, and groundwater recharge rates. This data helps to inform water distribution choices, drought management methods, and sustainable usage practices (Cosgrove & Loucks, 2015).

Monitoring the effects of climate change is also an option. Water bodies are sensitive indicators of climate change effects such as shifting precipitation patterns, rising temperatures, and sea level rise. Monitoring tracks changes in water temperature, chemistry, and hydrology, providing critical information regarding the

effects of climate change on aquatic ecosystems and water supplies (How Do We Observe and Monitor the Climate? | NIWA)

Water body monitoring is the systematic observation, evaluation, and measurement of many parameters and situations in aquatic settings. This technique is critical for understanding the health, quality, and dynamics of water bodies, as well as for developing effective management and conservation policies.



2.2 Water Bodies Delineation and Change Detection

Water Body Delineation and Change Detection are critical procedures in hydrology, environmental management, and city planning. These methods aid in the knowledge and management of water resources, environmental monitoring, and infrastructure design. Water body delineation and change detection are critical procedures in hydrology, environmental management, and city planning. These methods aid in the knowledge and management of water resources, environmental monitoring, and infrastructure design. Water body delineation is the act of defining and charting the borders of water bodies such as rivers, lakes, ponds, and reservoirs. Remote Sensing such as Satellite Images and GIS technologies are used to locate and map water features, distinguishing between water and land, and creating detailed maps of aquatic bodies, enabling investigation of properties like area and form. Change detection tracks and analyses changes in water bodies over time to better understand their dynamics and implications. This technique is important to monitor changes in the environment of water bodies such as rivers, oceans, lakes, etc. to determine the implications and manage resources.

2.2.1 GIS and Remote Sensing for Water Bodies Detection

Geographic Information Systems (GIS) serve a wide range of functions and applications in a variety of fields. Here are some of GIS's key functions is to collect, manage, and stores spatial data, which includes information tied to specific geographic locations. Surveys, remote sensing, GPS devices, and other methods can

be used to collect this data. GIS allows for the analysis data of spatial data to reveal patterns, relationships, and trends. It assists in making informed decisions by processing and interpreting data (Geographic Information System, 2023).

Geographic information systems (GIS) are widely used to create maps and visual representations of geographic information. These maps can be used to effectively communicate complex spatial data as well as to display them. Next, Natural Resource Management. GIS is critical for the management of natural resources such as forestry, mining, and fisheries. It promotes sustainable resource utilization and conservation (Geographic Information System, 2023).

Moreover, remote sensing technology plays an important role in the delineation and mapping of water resource, assisting in the identification of their extent, characteristics, and changes over time. The following are the key functions of remote sensing in water body delineation, first is boundary mapping. Remote sensing aids in the mapping of water bodies such as rivers, lakes, and reservoirs. It delineates where the water ends and the surrounding land begins (Halder & Bandyopadhyay, 2022).

The next one is change detection. Remote sensing data can reveal changes in the size and shape of water resources over time. This is critical for tracking the effects of factors such as urbanization, land use changes, and climate variations. Remote sensing assists in calculating the surface area of water bodies, which is critical for hydrological and environmental assessments (Wang et al., 2019).

Moreover, GIS and Remote Sensing also can be used to detect wetland delineation. Although wetland delineation can be difficult on the ground, remote sensing can identify and delineate these important ecosystems. This is critical for conservation efforts as well as understanding the ecological significance of the species.

Last but not least, identification of water bodies. Remote sensing aids in the identification and classification of various types of water bodies, such as lakes, rivers, and reservoirs. It helps to comprehend the distribution and characteristics of these features (Gholizadeh et al., 2016).

2.2.2 Vegetation Indices for Water Bodies

Vegetation indices are often used to analyse and monitor terrestrial vegetation health and dynamics via satellite or aerial remote sensing data. Traditional vegetation indices, such as the NDVI (Normalised Difference Vegetation Index), may not immediately apply to aquatic bodies, particularly freshwater and marine habitats, due to changes in reflectance qualities and the absence of terrestrial vegetation.

Water quality indicators are used to evaluate the water quality of lakes, rivers, and coastal waters using remote sensing data. They frequently use measurements of water colour, turbidity, chlorophyll-a concentration, and suspended particles to determine water quality characteristics. Water temperature indices are an important characteristic that influences aquatic ecosystems and may be evaluated using remote sensing data. Indices may use thermal infrared bands to monitor surface temperature fluctuations in bodies of water (Zhonghua, 2019).

Water Depth and Bathymetric Indices are used to measure water depth and bathymetry using remote sensing data, which frequently includes the penetration depth of light into the water column and the reflectance properties of the bottom substrate.

Vegetation Water Content Indices While generally employed for terrestrial vegetation, water content-sensitive indices (e.g., NDWI, or Normalised Difference Water Index) can be used to analyse aquatic bodies, particularly in situations where water content fluctuations are large (Jackson, 2004).

These indices and approaches are critical instruments for monitoring and analysing the health, dynamics, and environmental aspects of water bodies using remote sensing technologies. They give significant information on water quality, aquatic habitat conditions, and ecosystem health, which aids successful management and conservation activities.

2.2.3 Water Bodies Delineation Using Vegetation Indices

Delineating water bodies with vegetation indices entails taking use of their capacity to distinguish between vegetated and non-vegetated surfaces, such as water. While vegetation indices are primarily intended to highlight vegetation, they may also be used to help detect and define water bodies by understanding their spectral properties and how they differ from both vegetation and other land use categories.

Vegetation Indices are used to identify vegetation from water bodies by measuring the difference between the near infrared (NIR) and red bands of the electromagnetic spectrum. Vegetation reflects more NIR light and absorbs more red light than water. Thus, high NDVI values imply dense vegetation, whereas low values are generally associated with water bodies or barren land. Furthermore, water bodies have relatively low NDVI values because they do not reflect NIR light well and reflect red light in a totally different way than vegetation. These indexes make it reasonably straightforward to discriminate between water and vegetation (Dodd et al., 2023).

Mapping and Classification Suitable NDVI value thresholds enable the classification of pixels in remote sensing imaging into various categories, including water bodies, vegetation, and bare soil. For example, NDVI values below

a specific threshold can be used to locate water bodies. Next, change detection in vegetation indices may be used to track changes over time. A reduction in NDVI in a formerly vegetated region, for example, may indicate invasion or extension of a water body (Hashim et al., 2019).

Accuracy and limitations in seasonal variations, Seasonal variations in vegetation can modify vegetation indices, potentially influencing water body identification. It is critical to consider the timing of satellite pictures and any seasonal effects. Furthermore, surface reflectance for factors such as sediment load, water turbidity, and algal blooms can modify the reflectance qualities of aquatic bodies, influencing how effectively vegetation indices identify them (Huang et al., 2020).

Vegetation indices such as NDVI are important tools in remote sensing for identifying water bodies. Their spectral features serve as a foundation for discriminating between water and plants, making land cover categorization and mapping more efficient. However, to obtain the most accurate findings, these indices are frequently coupled with additional data sources and indices.

CHAPTER 3

MATERIAL AND METHOD

3.1 Study Area

Kelantan is one of Malaysia's thirteen states. It is situated in the northeastern portion of Peninsular Malaysia, on the western side of the Malay Peninsula. Kelantan is well-known for its own culture, strong Malay traditions, and natural beauty (Khadizan, 2023).

Kelantan, being a state with a considerable coastline region and multiple rivers, has a variety of water bodies, including rivers, lakes, and coastal areas. Kelantan's noteworthy bodies of water include Sungai Galas. Sungai Galas is a significant tributary of the Kelantan River. It runs through the picturesque region of Gua Musang. The river is utilised for leisure purposes such as tubing and river cruises (Abasteraster, 2023).

Tumpat is the name for both a town and a district in Kelantan, Malaysia. Tumpat is located near the terminus of Malayan Railways' East Coast railway line. This railway connects Kelantan to the western parts of Peninsular Malaysia. Tumpat, because to its strategic position, has become Kelantan's transportation centre. The settlement is around 15 km from the state capital, Kota Bharu (Ibrahim Ali, 2014).

Tumpat is also located on Peninsular Malaysia's eastern coast, and its bounds may include several minor rivers, streams, and estuaries. These bodies of water serve a significant role in the surrounding environment by providing habitat for wildlife, supporting agriculture, and serving as transit channels (Z.Zamri, 2024).

Pantai Cahaya Bulan is located in Kota Bharu, this beach offers a gorgeous coast along the South China Sea and is a popular site for picnics, swimming, and water sports. Belau Lake, located in the Tumpat area, is a freshwater lake. It is a tranquil area for picnics and enjoying the natural environment, surrounded by thick flora. Jubakar Lake is a freshwater lake in the Tumpat district of Kelantan (map shows in Figure 3.2). It has beautiful vistas and a tranquil atmosphere (Diana Bocco. 2023).

The Tumpat River runs through Tumpat, and its mangrove regions are vital to the local environment. The river is utilised for a variety of aquatic activities. Pantai Senok is located in the Bachok district, this beach is recognized for its peaceful and relaxing atmosphere. It is a popular beach and relaxing resort. Pantai Irama is located near Kota Bharu, this beach offers a more tranquil and less crowded alternative to PCB Beach. It is well-known for its calm environment. More importance is Kelantan River is the state's longest river, beginning in the Titiwangsa Mountains and passing through Kelantan until emptying into the South China Sea. It is vital to the region's agriculture and transportation (Diana Bocco. 2023).

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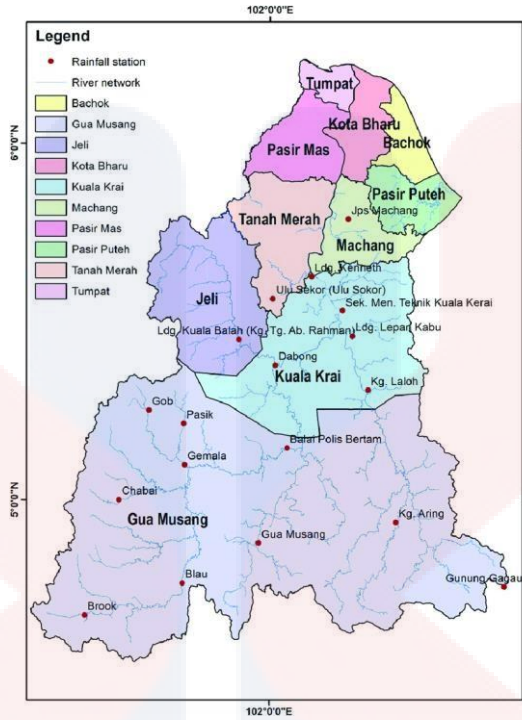


Figure 3.1: Kelantan District

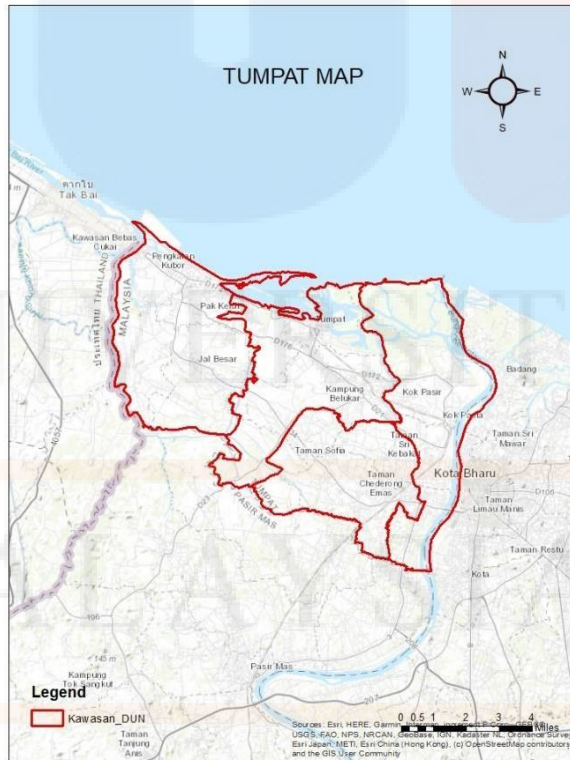


Figure 3.2: Tumpat Map

3.2 Materials

3.2.1 ArcGIS

In this research of Water Bodies Delineation and change detection using GIS and Remote Sensing in Kelantan. This research used ArcGIS application to get image of the water surface or water bodies landscape. Geographic Information Systems (GIS) are an excellent tool for learning Earth and environmental science topics and developing scientific problem-solving abilities. GIS was previously restricted to professionals with access to high-end computer workstations, but it is now available to all students, from elementary to graduate level. When utilized as a teaching tool, GIS offers several advantages over traditional resources.

GIS-based studies enable you to find and characterize links by altering various visual representations of data, such as dynamic and configurable maps, tables, charts, and animations. Data examination Using database functions, statistical analysis, and geographical overlay operations, analytical tools allow you to quantify relationships inside and across spatial data sets.

3.2.2 Remote Sensing Data

Remote sensing is the process of acquiring information about an item, location, or phenomena from a distance, usually utilizing sensors that detect and quantify electromagnetic radiation (such as visible light, infrared, or microwave radiation). This technology allows us to monitor and study the Earth's surface and atmosphere without making direct physical touch.

Satellite imaging is a sort of remote sensing data used to track changes in aquatic bodies. Optical imaging is the use of visible and near-infrared wavelengths to detect aquatic bodies using their spectral signature. Water absorbs and reflects light

differently than land, allowing for differences. Multispectral and hyperspectral imaging provide more complete information by combining data from many spectral bands, allowing for greater separation between water quality parameters and aquatic vegetation.

Remote sensing data may offer information about the size and behavior of water bodies such as lakes, reservoirs, rivers, lake, ponds, and coastal areas. This information is crucial for determining water level variations, coastline erosion, and land-water interactions.

Spectral bands are Landsat 8 is outfitted with the Operational Land Imager (OLI), which has multiple spectral bands that are quite good at detecting water bodies. Visible and near-infrared bands may differentiate between ocean and land surfaces based on their reflectance properties. Water bodies absorb more visible light and reflect less near-infrared light than land, making them distinguishable in satellite imagery. Short-wave infrared bands may detect suspended particles and turbidity in aquatic environments. Landsat 8 has a spatial resolution of 30 meters for most spectral bands and 15 meters for panchromatic bands. This resolution is appropriate for identifying and mapping water bodies such as lakes, reservoirs, rivers, and coastal areas.

3.3 Methods

3.3.1 Remote Sensing

The study's goal is to detect and delineated the changes in water bodies in Kelantan between 2014 and 2023. To achieve the goals and objectives, the following tasks were completed: First, Landsat satellite data have been collected from USGS

GloVis' Landsat 9 OLI-TIRS sensors. The specifications of the Landsat images are presented.

Second, the collected data was extracted, and image layers were stacked using 2014 data. Third, ArcGIS was used to perform image preprocessing function radiometric correction such as haze reduction, noise reduction, and histogram equalization.

Fourth, the images were used to extract the area of interest, the collected base map of Kelantan according to the district administrator. NDWI is the examples of band techniques used in water extraction.

Finally, ArcGIS Image Analysis were used to analyze the images. In this regard, the NDWI was calculated and Landsat 9 OLI images to delineate and extract Tumpat surface water. Water features were extracted using the ArcGIS raster calculator. The accuracy was then evaluated using an image and other high-resolution platforms.

3.3.2 Normalized Difference Water Index (NDWI)

NDWI stands for "Normalized Difference Water Index." It is a remote sensing index used to analyze and monitor water content or the presence of water in diverse environmental contexts. NDWI is particularly useful for activities such as monitoring changes in water bodies, detecting drought conditions, and measuring vegetation stress. The formula for calculating NDWI commonly entails utilizing reflectance values in the near-infrared (NIR) and shortwave infrared (SWIR) bands from remote sensing data, such as satellite or aerial photos.

It is a remote sensing index that is used to evaluate and monitor water content or the presence of water in a variety of environmental scenarios. NDWI is very effective for monitoring changes in water bodies, identifying drought conditions, and evaluating vegetation stress. The formula that will be used is as below:

$$\frac{\text{Band 3 (GREEN)} - \text{Band 5 (NIR)}}{\text{Band 3 (GREEN)} + \text{Band 5 (NIR)}} \quad \text{Equation 3.1}$$

RESEARCH FLOW

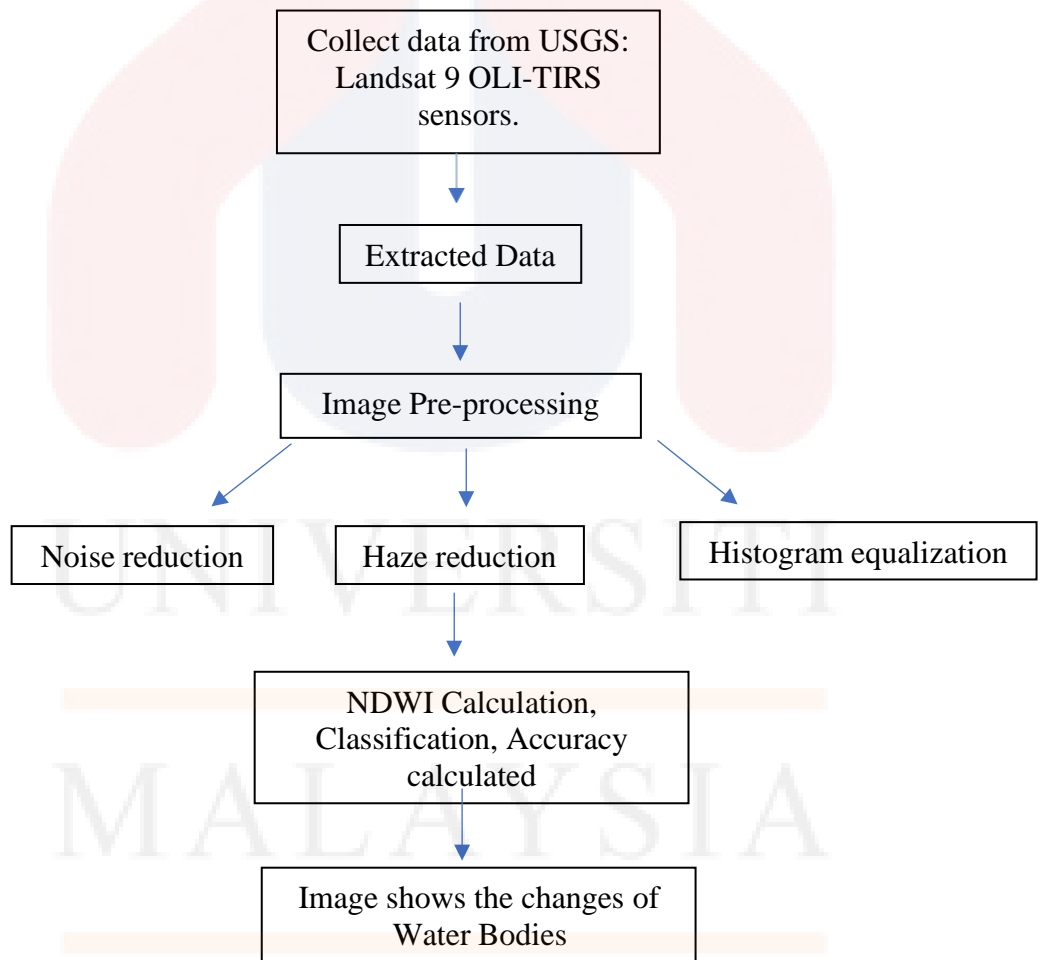


Figure 3.3: Flow Chart

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Result NDWI using GIS

This shows the step and results of water bodies delineation using GIS and Remote Sensing in (a) 2014 and (b) 2023. First of all, add the shapefile data for the study case, which is Tumpat in Kelantan. Only the necessary research area should be in ArcGIS. While the shape files for other locations in Kelantan must be removed because they are no longer needed. This method will be used in (a) and (b).

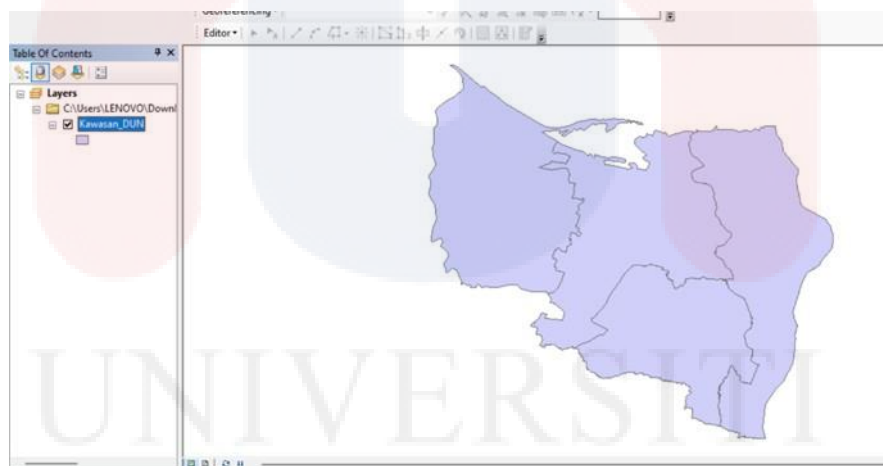


Figure 4.1: Add Data Shapefile

Then, add the downloaded and extracted data to ArcGIS. The data has to be entered into ArcGIS are Band 1, Band 2, Band 3, Band 4, Band 5, and Band 7. Image will be shown by layers from Band 1 to Band 7. Band 6 will not be used in this methods because there will be NDWI calculate. The same method will be used in 2014 and 2023.

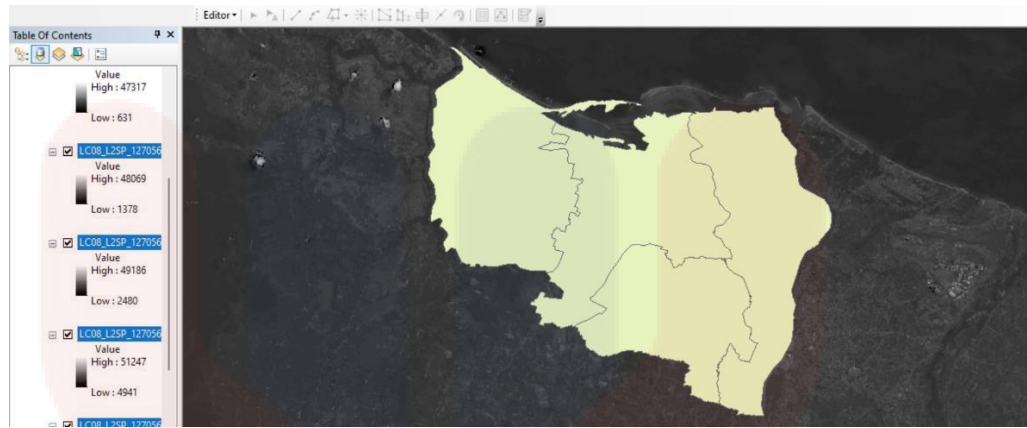
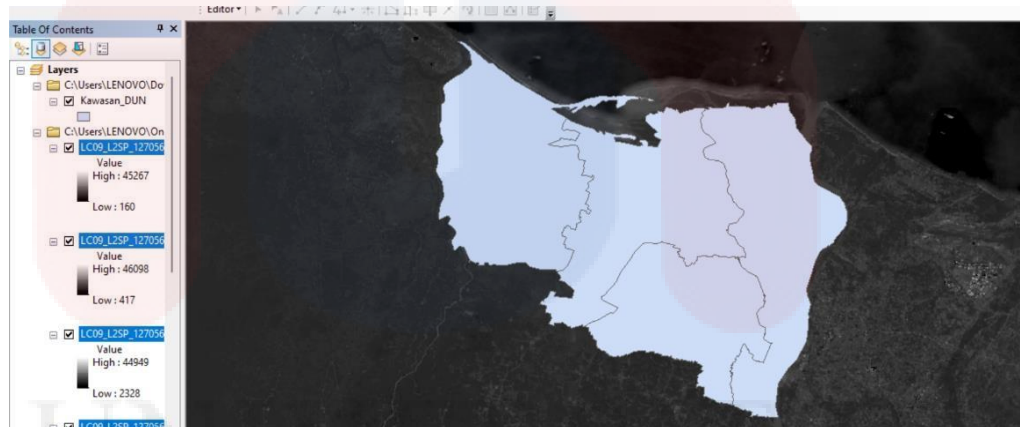


Figure 4.2: Add Band 1 until Band 7

This is the result after adds the Band 1 to Band 7 will be shows as layer. This can be found in table of contents in ArcMap 10.8 software.



4.3: Data Layers

The Normalized Difference Water Index (NDWI) is calculated using the near infrared NIR (Band 3) and Green (Band 5). This formula emphasizes the amount of water present in water bodies. Used Raster Calculator to calculate NDWI.

The formula to be used in (a) and (b) is Equation 3.1:

$$\frac{\text{Band 3 (GREEN)} - \text{Band 5 (NIR)}}{\text{Band 3 (GREEN)} + \text{Band 5 (NIR)}}$$

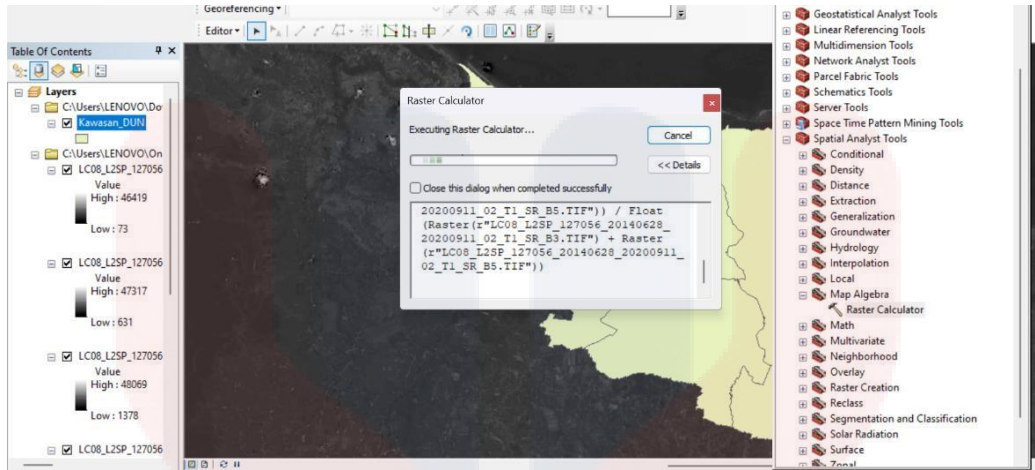


Figure 4.4: Result NDWI Calculated

The Extract, "Clip" tool extracts or clips a piece of a raster dataset for 'kawasan dun' based on the geographic extent given by another dataset. This enables you to concentrate your investigation on the important part of the image. Especially when dealing with raster datasets and focusing on specific regions of interest within greater geographic extents.

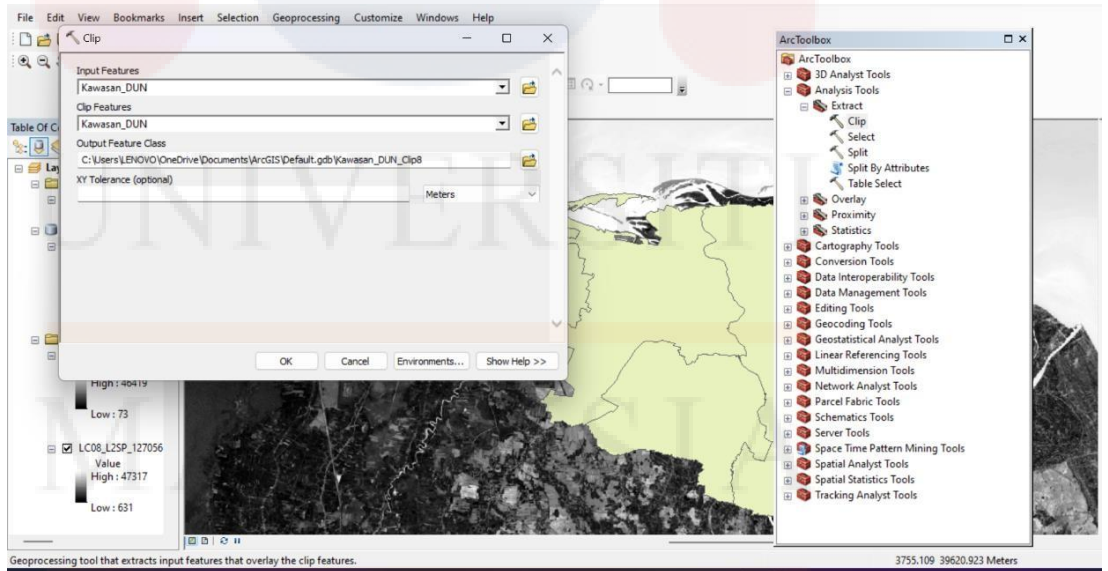


Figure 4.5: Result Clip

A Digital Elevation Model (DEM) spanning a broad region is used to analyze a specific watershed. The "Extract by Mask" function extracts elevation data from within the watershed's boundary. Overall, ArcGIS's "Extract by Mask" feature is a

useful tool for geographic data processing and analysis, especially when dealing with raster datasets and focusing on specific areas of interest within greater spatial extents.

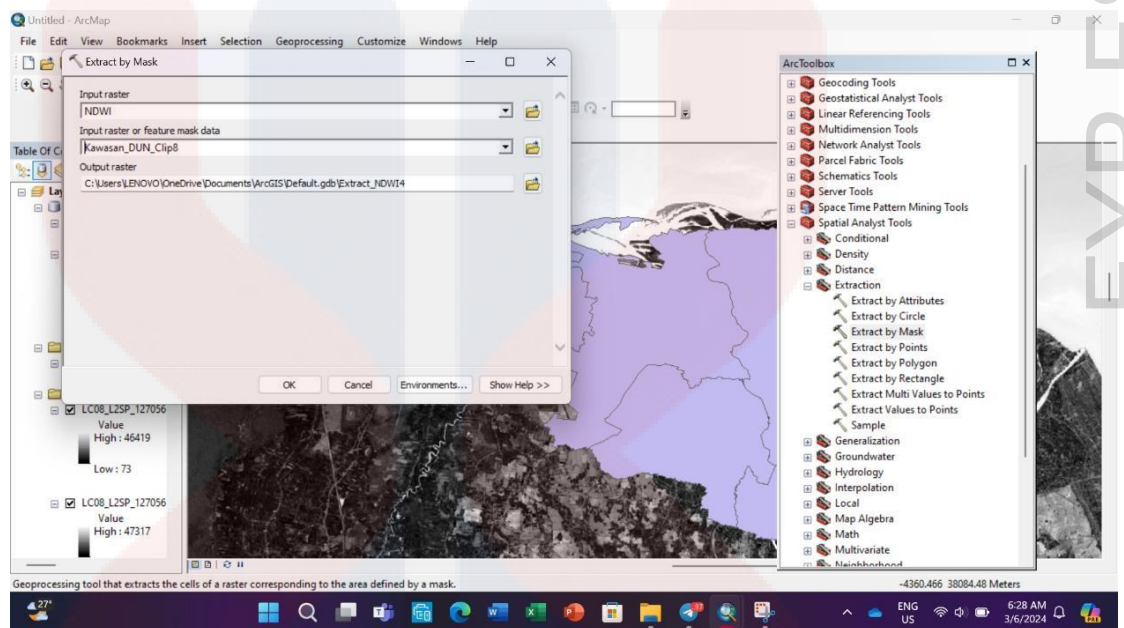


Figure 4.6: Result by Mask

The next step is to export the data from the raster calculator, NDWI. Export data is used to evaluate the NDWI and extracted data so that it may be seen more clearly and will have extract NDWI.

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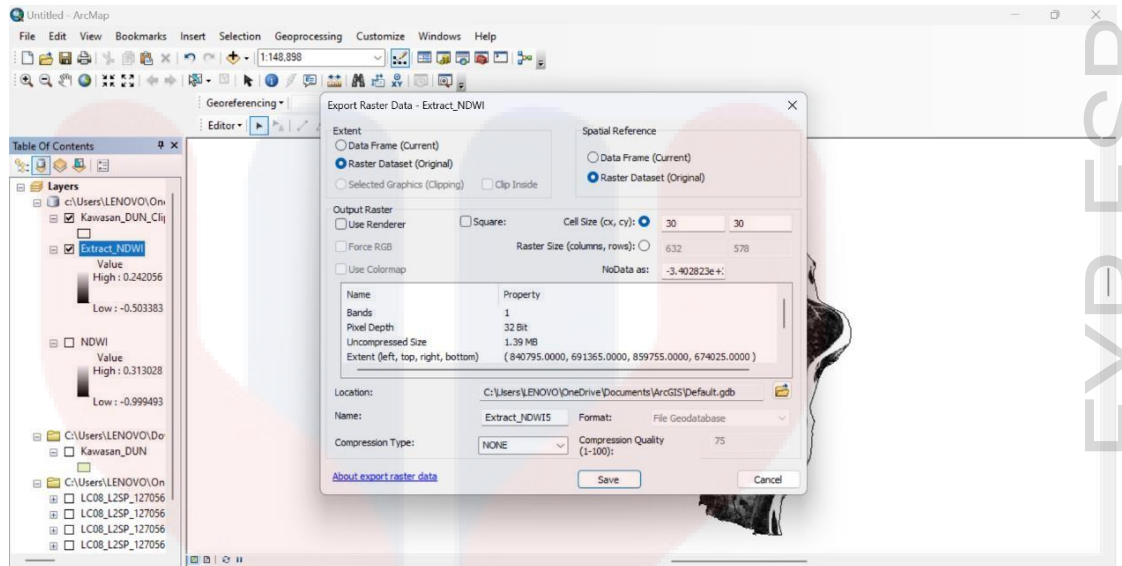


Figure 4.7: Extract Data NDWI

Figure 4.8 shows the result of Water Bodies in (a) 2014. Classifying NDWI data in ArcGIS allows you to convert continuous NDWI values into meaningful categories or classes, making it easier to read and analyze water-related data in GIS and remote sensing applications.

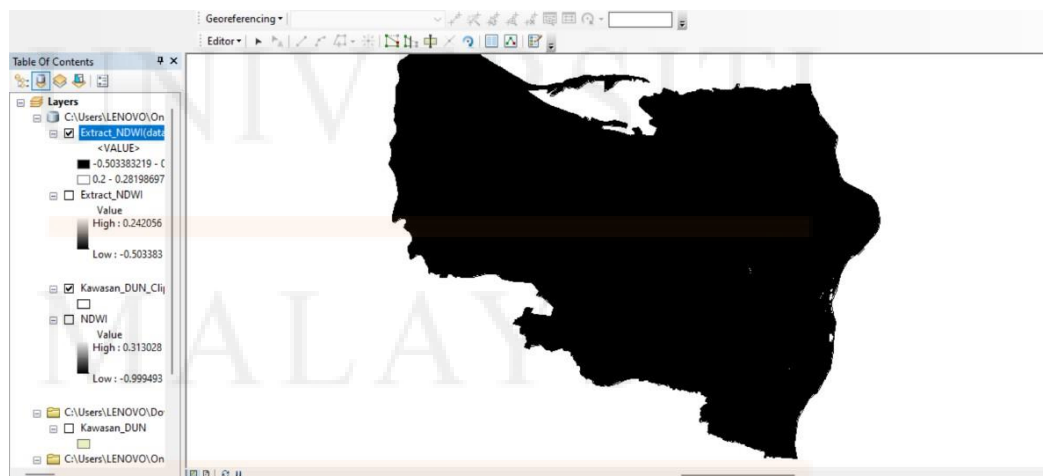


Figure 4.8: Classify 0.8 (a)

Lastly, after extract and export the data just same in 2014. Next, classify the data NDWI and the result shows the image of 2023 water bodies delineation detection.

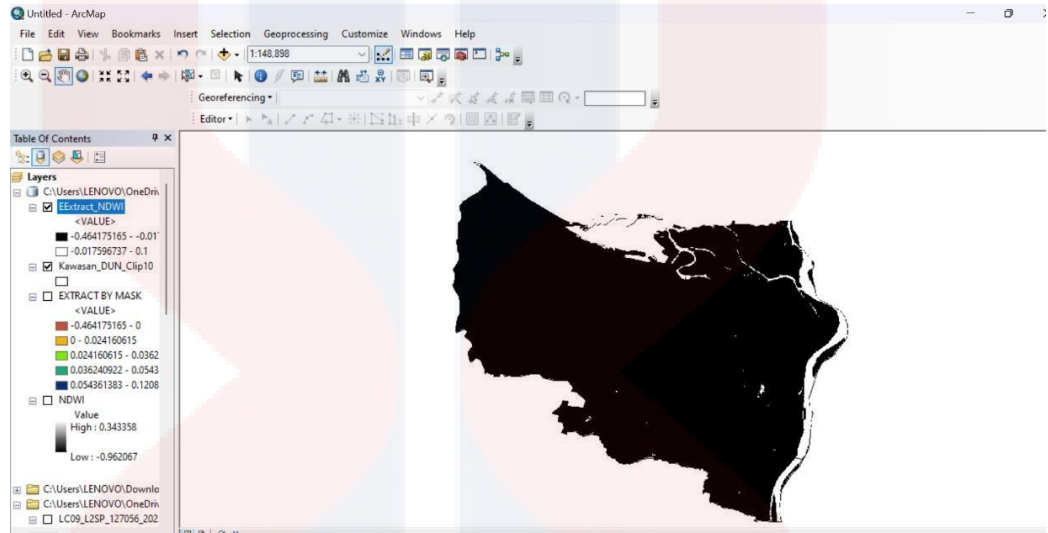


Figure 4.9: result of classify (b)

4.2 Result of Water Bodies change detection using GIS and Remote Sensing

This table (4.2) shows the different water bodies or water surface in (a) 2014 and (b) 2023.

NDWI Classification Map Year for 2014 and 2023

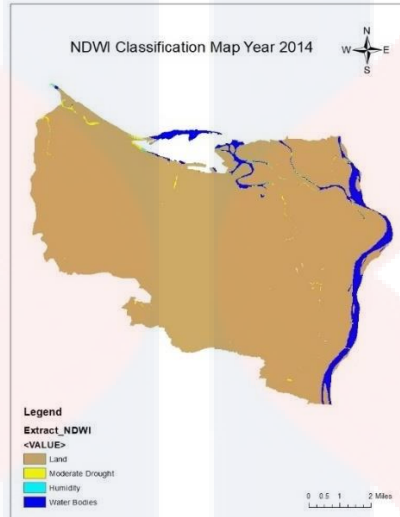


Figure 4.10: NDWI Classification Map Year for 2014

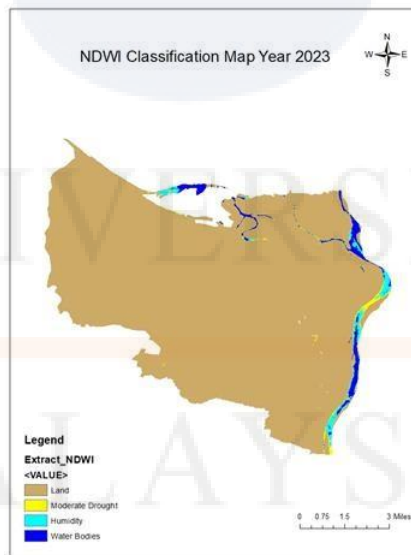


Figure 4.11: NDWI Classification Map Year for 2023

Water Bodies Delineation Map Year for 2014 and 2023

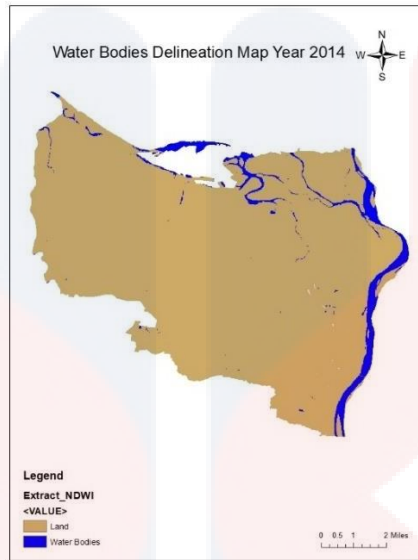


Figure 4.12: Water Bodies Delineation Map Year for 2014

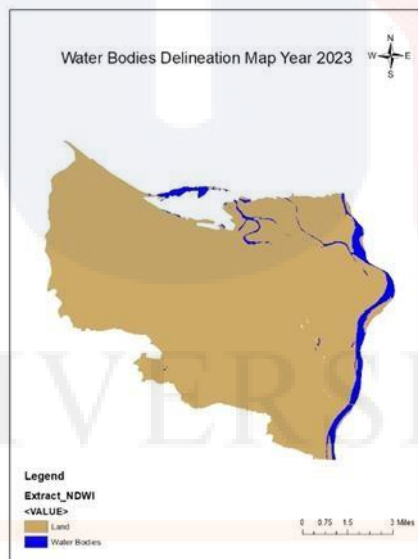


Figure 4.13: Water Bodies Delineation Map Year for 2023

Table 4.1: Water Bodies List in Tumpat, Kelantan.

WATER BODIES IN TUMPAT, KELANTAN	
Ocean	Pantai Sri Tujuh
Ocean	Pantai Geting
Ocean	Pantai Ndo
River	Sungai Kelantan
River	Sungai golok
River	Sungai Mak Nelarang
River	Sungai Selehong
River	Sungai Peng Nangka
River	Bang Nara
River	Sungai Geting
River	Sungai Pinang

Table 4.2: Water Bodies percentage in 2014 and 2023

TYPE	LEGEND	YEARS	% AREA CHANGES
Water Bodies (River, Ocean)	0.072616795- 0.242055982	2014	24%
Water Bodies (River, Ocean)	0.036240922- 0.120803073	2023	12%

The result of Extract by mask will be extract by mask, the result must be classified into 4 classify. This image shows the result after the classify into 4 classify which contain different color of water bodies and land use. The dark blue, turquoise and yellow color shows humidity, moderate drought and water bodies details such as ocean, river, lake, ponds and wet land. While the soft brown shows the land in Tumpat,

Kelantan from 2014. This image can be justified in Figure 4.10 which is NDWI Classification Map Year 2014.

Figure 4.11 shows the NDWI in 2023. As we can see the different in 2023 between 2014. Same as 2014, after extract by mask did, classified it into 4 classify which contain soft brown, dark blue, turquoise and yellow. Dark blue color explains different types of water bodies which is shows ocean, river, pond, lake and wet land.

The accompanying figure depicts the changes in water bodies between 2014 and 2023. Changes in water bodies can be identified using this technique. Figure 4.12 depicts the water bodies delineation area in 2014, which included numerous water bodies such as oceans, rivers, marshes, lakes, and so on. Meanwhile, the area of water bodies is expected to decrease in densely populated regions by 2023. This is most likely caused by temperature or climatic change in the area. However, a variety of factors influence the change in the water body, whether it grows or decreases. As we can see in the Figure 4.13 the image shows the water surface of 2023 become smaller than 2014 which is decrease from 24% to 12%.

Table 4.3: Accuracy Assessment Table for NDWI 2014

	Land	Moderate Drought	Humidity	Water Bodies	Total (User)
Land	6	0	0	0	6
Moderate Drought	0	7	0	0	7
Humidity	0	0	5	0	5
Water Bodies	0	0	0	12	12
Total (Producer)	6	7	5	12	30

$$\text{Overall Accuracy} = \frac{\text{Total Number of Correctly Classified Pixels (Diagonal)}}{\text{Total Number of Reference Pixels}} \times 100$$

$$\text{Overall Accuracy} = \frac{30}{30} \times 100 = 100\%$$

$$\text{Kappa Coefficient (Total)} = \frac{(TS \times TCS) - \sum(\text{Column Total} \times \text{Row Total})}{TS^2 - \sum(\text{Column Total} - \text{Row Total})} \times 100$$

$$\frac{(30 \times 30) - \sum(6 \times 6) + (7 \times 7) + (5 \times 5) + (12 \times 12)}{900 - \sum(6 \times 6) + (7 \times 7) + (5 \times 5) + (12 \times 12)} \times 100$$

$$\frac{900 - 254}{900 - 254} \times 100 = 100\%$$

Table 4.4: Accuracy Assessment Table for NDWI 2023

	Land	Moderate Drought	Humidity	Water Bodies	Total (User)
Land	10	0	0	1	11
Moderate Drought	0	7	0	2	9
Humidity	0	0	3	1	4
Water Bodies	0	0	0	6	6
Total (Producer)	10	7	3	10	30

$$\text{Overall Accuracy} = \frac{\text{Total Number of Correctly Classified Pixels (Diagonal)}}{\text{Total Number of Reference Pixels}} \times 100$$

$$\text{Overall Accuracy} = \frac{26}{30} \times 100 = 87\%$$

$$\text{Kappa Coefficient (Total)} = \frac{(TS \times TCS) - \sum(\text{Column Total} \times \text{Row Total})}{TS^2 - \sum(\text{Column Total} - \text{Row Total})} \times 100$$

$$\frac{(30 \times 26) - \sum(11 \times 10) + (9 \times 7) + (4 \times 3) + (6 \times 10)}{1600 - \sum(11 \times 10) + (9 \times 7) + (4 \times 5) + (6 \times 10)} \times 100$$

$$\frac{700-245}{1600-245} \times 100 = 61\%$$

According to the analysis In 2014, there was 0 percent absolute error at 100 percent accuracy and a 100% Kappa coefficient. In 2023, the absolute error is 0.13 percent, with an accuracy of 87 percent and a Kappa value of 61%. Accuracy assessment analysis revealed that the NDWI approach can be used to describe surface water and detect changes in Tumpat, Kelantan.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The study attempted to simulate the spatiotemporal changes in the water surface of Tumpat, Kelantan, between 2014 and 2023. The goal was achieved by utilizing NDWI. The findings show that there is a substantial reduction in surface water in Tumpat, Kelantan, with water surface or water body area decreasing between 2014 and 2023 which from 24% to 12 %. If this tendency continues, Tumpat, Kelantan, will most likely run out of water in the future. It is significant because the Tumpat plays a vital role in fish production by serving as the country's 'mother fishery'.

5.2 Recommendation

The results of community-based sustainable management of Tumpat should benefit the natural cover, particularly the water surface. Otherwise, the habitats' freshwater reserves would be depleted, and Tumpat will lose its significance as a freshwater habitat. Furthermore, institution-wide surface water monitoring is required

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