



**ASSESSING THE POTENTIAL OF WATER  
RESERVOIR IN TANAH MERAH, KELANTAN  
USING GIS AND REMOTE SENSING**

by

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A report submitted in fulfillment of the requirements for the degree of  
Bachelor of Applied Science (Nature Resources Science) with Honours

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**FACULTY OF EARTH SCIENCE  
UNIVERSITI MALAYSIA KELANTAN**

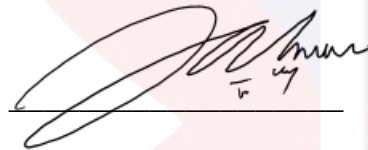
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2024

## DECLARATION

I declare that this thesis entitled “Assessing The Potential Water Reservoirs in Tanah Merah, 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.

Signature :



Name : ZAHIRAH BINTI HUZAIRI

Date : 4 August 2024

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## **Assessing The Potential Water Reservoirs in Tanah Merah, Kelantan Using GIS and Remote Sensing**

### **ABSTRACT**

Natural watered resources in Malaysia are well-endowed in abundance, which means many catchment areas can be used as storage or reservoirs. Environmental factors cause higher demand for watered users & supply. Many reservoir establishments ensure a dependable & sustainable watered supply for the next generation. This studied aims to find the potential watered reservoirs in Tanah Merah, Kelantan by used GIS & remote sensing by used ArcGIS 10.8 software. The objective of this research was to determine the environmental factors for identifying water reservoirs in Tanah Merah, Kelantan & to assess the potential of watered reservoirs in Tanah Merah, Kelantan. The data would process used Landsat-9 & analyzed in four locations Bukit Bunga, Bukit Panau, Kemahang also Gual Lipor. The main criteria selected for this research are slope, land use, river, river distance & elevation extracted from the Digital Elevation Model. The Weighted Overlay (WO) used to scale parameters for decision-making. From the analysis, could be identified had three locations or areas found that have a high potential for new water reservoirs. Therefore, it could be concluded that Weighted Overlay (WO) was a useful tool for analyze watered reservoir site selection in the studied area using ArcGIS.

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## Menilai Potensi Takungan Air di Tanah Merah, Kelantan Menggunakan GIS dan Penderiaan Jauh

### ABSTRAK

Sumber air asli di Malaysia dikurniakan dengan jumlah air yang banyak, memberikan kawasan tadahan air yang luas boleh dijadikan simpanan atau takungan. Faktor persekitaran yang menyebabkan permintaan air lebih tinggi untuk pengguna & bekalan air. Terdapat beberapa pembinaan takungan ini dapat memastikan bekalan air yang boleh terjamin & mampan untuk generasi akan datang. Kajian ini bertujuan untuk mencari takungan air yang berpotensi di kawasan Tanah Merah, Kelantan dengan menggunakan sistem maklumat geografi (GIS) & penderiaan jauh melalui penggunaan perisian ArcGIS 10.8. Objektif bagi kajian ini adalah untuk menentukan faktor persekitaran bagi mengenal pasti takungan air di Tanah Merah, Kelantan & untuk menilai potensi takungan air di Tanah Merah, Kelantan. Data ini akan diproses menggunakan Landsat-9 & dianalisis di empat lokasi Bukit Bunga, Bukit Panau, Kemahang juga Gual Lipor. Kriteria utama yang dipilih untuk penyelidikan ini ialah cerun, guna tanah, sungai, jarak sungai & ketinggian (DEM). Tindakan berwajaran (WO) digunakan untuk menskalakan parameter bagi membuat keputusan. Daripada analisis, dapat dikenalpasti mempunyai tiga lokasi atau kawasan yang didapati mempunyai potensi tinggi untuk takungan air baharu. Oleh itu, dapat dirumuskan bahawa WO adalah teknik yang berguna untuk menganalisis pemilihan tapak takungan air di kawasan kajian menggunakan ArcGIS.

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## LIST OF ABBREVIATIONS

DEM	Digital Elevation Model
DN	Digital Number
GIS	Geographic Information System
KTM	Malaysia Railway Limited
LiDAR	Light Detection and Ranging
LULC	Land Use Land Cover
OLI	Operational Land Imager
SHP	Shape File
USGS	United States Geological Survey
WO	Weighted Overlay

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## CHAPTER 1

### INTRODUCTION

#### 1.1 Background of Study

Freshwater was an essential resource for the ecosystem to human endemic & sensitive biota, which are also precious & growing increasingly limited resources. There had been an increase over the past century when human demanded & the population for watered supplies are intensifying (Dudgeon et al. 2006). Freshwater was specifically, important to shaping landscapes, maintaining living on earth & nourishing ecosystems because data covers 71% of the planet's surface & 2.5 % of water that was available to society. The main source provides reservoir freshwater that could accessed. The reservoir serves the water supply & vital to the main activities, society, & daily needs in various sectors (Gaupp et al., 2015). A watered reservoir was the natural storage or management of water for various purposes such as agriculture, domestic & environmental. Reservoirs play the main role of watered storage management supply, providing watered while decreasing mitigating effects such as floods or droughts.

The dam was the main component of management & creating of a water reservoir as a hydrological environment of a limited area at a small scale (Biggs et al., 2016). A dam was a structure that spans rivers & raises watered levels by controlling or preventing the flow of watered. Dams also helped to supply water reservoirs when

the dry season ends, but when the wet season was expected to overflow, the dam has to released watered, which could cause floods or limited watered delivery. Economic values had significant roles in regulating the distribution of watered resources & balancing watered systems & ecosystems (Jozaghi et al., 2018). Water resources from a dam could been used to protected from watered disasters such as floods or fair & adequate distribution of water.

GIS been used effectively for this purpose to combine different themes objectively & analyze those systematically to identify suitable locations (Shahid et al., 2000). Data spectrum & spatial could analyze the can influencing reservoir suitability. New areas appeared by used location data & parameters in Tanah Merah, Kelantan. Geographic Information System (GIS) was based on a computer system that processes attribute data such as spatial data, decision making & remote sensing. GIS methods used to quantify volume assessment by creating watered depth maps based on spatial characteristics from the reservoir bottom DEM (Weis & Kubinský, 2014). DEM was a method for measured the geodetic profile of the reservoir's bottom or analyzing the acquired cross-section. Geographic information was a critical characteristic that is being used. GIS was a function for processing data, modeling, visualization & managing the data. Remote sensing was the used of GIS data to combine high resolution with high spatial resolution & critical source data that support spatial analysis in an important role in the management & allocation of watered reservoirs (Alaibakhsh et al., 2013).

## 1.2 Problem Statement

Optimized water reservoir system management faces growing water challenges due to climate change when increased temperature precipitation patterns could lead to decreased water availability in many sectors, the increase in population because demand for water increases & agriculture expansion that happens (Schill et al., 2019) widely by year. That could result in changes in the ecosystem, society, or economy (Rolls et al., 2012) & a reduction in inflow from the main tributary river. Existing water supplies are now under less pressure & present reservoir management practices in water storage are unsustainable & lack data. Water scarcity harms limited water distribution, flooding, water quality & inefficient resource allocation for water storage. The accurate data on water availability or land use, & monitoring water quality prevent water reservoir management from being optimal (Yu et al., 2015).

This problem requires a few solutions to keep water storage stable, such as improved water management & efficiency involved with a government agency or disaster department earlier warning or optimizing release schedule & reduce leakage to water management (Schlüter et al. 2019). This might increase the water fairly distributed to various sectors. Improve resilience to climate change involves adapting to changing rainfall patterns & managing dry seasons, wet or flood seasons used to utilize renewable energy sources to maintain water storage.

The benefits of a stable water reservoir in condition, water supply & water could be stored during the wet seasons could store water for preparation for dry seasons ensuring consistent supply. Supplying domestic household demands allows the industry to process the water & flood control by regulating river flow levels. Hydropower was a renewable energy source in which dams generate electricity to keep water storage when demand periods & also, to stabilize the ability grid. Water

quality improves because the water reservoir was a filter & increases the downstream water quality.

### **1.3 Objectives**

- i. To determine the environmental factors for identifying water reservoirs in Tanah Merah, Kelantan.
- ii. To assess the potential area of a water reservoir in Tanah Merah, Kelantan.

### **1.4 Scope of Study**

This research aims to investigate the potential for water reservoirs, considered the factors that this happens liked environmental, also develop watered storage in new specific areas, to identified & determine the area affected needing water storage capacity. Geographic Information Systems (GIS) was useful in assessing the factors to identified suitable location areas for watered reservoirs. The study area was chosen located in Tanah Merah, Kelantan. The river to river is reclassified also, & the slope layer the important selection of reservoir-like slope was classified into two classes high & low suitability followed by the darker & was high at the optimum site area. Landsat-8 (2023) data from the USGS were utilized to count watered parameters. The data was the Data Elevation Model (DEM) year 2023, river network map, also contour map & land used map that have been converted to shapefile (shp) format to input the datasets in ArcGIS software. The environmental factors considered elevation where lowered elevation was favorable such as the river layer that, shows the distance of river to river in reclassified also, the slope layer the important selection of reservoir-like slope was classified into two classes high & low suitability followed which color was darker represent to higher at optimum site area.

Weighted Overlay (WO) to solve the problem of finding the suitable area by elevation scale 1 to 10, where scale 1 denotes the least preferable & 10 the most preferable scores & set the scale valued for each input raster. Overlay maps were characterized by 5 sections that follow low or high values to each location. In the ArcGIS process, the data was each raster needs to be multiplied by the weight value & the result shows the ideal site water reservoir was darker than the other colors in the map. Land use was to generate maps to show the distribution of various land uses around the reservoir area, & an image map that visualizes land use patterns analyzes the factors watershed affects. Land use generates maps to showed the distribution of various land used around the reservoir area & an image map that visualizes land use patterns & analyzes the factors watershed affects. This stepped could created a susceptibility river map & also mapped the site selection for the water reservoir.

### **1.5 Significant of Study**

The purpose of this research was to provide important information also knowledge that could be contributed by the researcher, & the government department regarding being in charge of the watered & natural disaster department. The findings of this research allow the department to utilize water reservoir data that could enhance preparedness for disaster before it happens, mitigation efforts & the response. Knowledge for researchers was monitoring watered levels to expect the potential & took proactive measures that can accurately flood forecasting for the area. Researchers could analyze & determine watered reservoir data to be proper to manage also store capacity, & trend use of the watered resource. This research could help society, balance competing watered needed with the sector & optimize water allocation. This studied gave benefits to the government in terms of environmental impact that could

been to assess watered quality & flowed patterns to inform protection measures. The department could used the data to help build strategies for climate changed.



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## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Background of Geographic Information System (GIS)

This system refers to producing, acquiring, interpreting, & presenting spatial data for geography. GIS had made major contributions to mainstream geographic research & applications, mainstream geographic research & applications, as well as demonstrated prospective benefits to several allied fields (such as Earth System Science) (Goodchild, 2018). The system had two main categories of data: raster data & vector model data, which are used to source spatial data. GIS shows spatial data & analyzes it to disseminate spatial data (Markert et al., 2020). Spatial data are landscapes of features that could be represented on a map in three forms such as lines, polygons & points in GIS. Thus, focused on acquiring geographic information, studying objects & their interactions & exploring advanced geographic rules to determine spatiotemporal behaviour (Lin et al. 2013). Mapping used GIS was the basis of providing visual or digital images of dimensions such as 2D or 3D. Spatial analysis had pushed GIS well beyond basic mapping applications to provide users with logic for understanding spatiotemporal distributions & relationships (Burke & Khan 2006; Shaw et al. 2008). GIS facilitates was exploration & explanation of geographic patterns, simulates geographic processes, & predicts geographic phenomena.

## 2.2 Introduction of Remote Sensing

Remote Sensing offers a wealth of data for a variety of applications. The reviews focus on the rate at which data was generated & how different sensors contribute to big data in remote sensing. This technique was important to collect data & update their location-based service (U.C. et al., 2004) (T. Blaschke, 2010). The development of earth observation technology, especially satellite remote sensing, had made massive remotely sensed data available for research & various applications (Liu 2015;) (Chi et al. 2016). The sensor captures images of the Earth's surface at infinite spatial resolution & huge volumes of remotely sensed images was available in many countries & international agencies with the amount growing every day, hour & second (Rosenqvist et al., 2003).

## 2.3 Water Reservoirs and Their Potential

Water reservoirs were important to management as a water resource development. The reservoir could replaced segments of the river, & influence impounded reaches of the river both upstream & downstream. Reservoirs played an important role in providing watered during the dry season to store watered & the regulation excessive flows during the wet season (Donchyts et al., 2016). Dam-sufficient tanks to sucked up watered demanded been increasing & needed to measured reservoir lake storage. The delivery system was a network that delivered watered from storage to the user. Flood watered flows could been reduced & risk was low if dry seasons come. The effect of excess watered could caused overflow could disasters such as flooding giving unclean watered quality & lakes might lead to overflow & flooding in the downstream area during wet seasons (Vanthof et al., 2019), (Guo et al., 2017). During dried seasons river flow was low & watered regime

could managed low flowed also flood watered. Watered storage was to protected the reservoir & river maintained watered quality from a dam.

#### **2.4 Digital Elevation Model (DEM)**

The Digital Elevation Model (DEM) was used in hydrology, & remote sensing to map data producers. In generic terms digital cartographic, topographic & ground surface in 3D (Manune, 2007). DEM was used in GIS to survey & plan to applications depending on accuracy such as geomatics, geological, environmental, or mapping applications. (Manune, 2007). DEM spatial resolution grid model is 10 x 10 physical land meter.

#### **2.5 Methodologies for Evaluating the Potential of Water Reservoir**

In macro basins, GIS & multicriteria decision analysis were commonly used in the process of analytical hierarchy to prioritize areas where hydraulic structures been located depending on the study area, the main features to be taken into account were determined, such as runoff coefficient, drainage network, & slope (Bunn, 2002) & GIS, remote sensing, & hierarchical weighting also multicriteria analysis are important to facilitate decision making for government entities, since through them, runoff capacity is determined, planned, & evaluated for the potential use of rainwater in an area (Zhang et al., 2016). Five water-use strategies were macro basins, micro-watersheds, aquifer recharge, micro & macro basins, & reserve tillage. The way to store the watered reservoir in that area is to used the system rainwater harvesting systems (RWHS) to got data processing needs to used the GIS of the parameter.

## 2.6 Introduction of Landsat-8 and 9

The higher the Landsat or the resolution, the more cleared or accurate the captured of information on the Landsat. USGS (United States Geological Survey) started the first reprocessing of the US Landsat achieve to radiometric adjustment and geolocation information (Dwyer et al., 2018). This Landsat satellite started 50 years ago when Landsat-1 started an earth observation to ensure that another Landsat data would be processed consistently. Landsat-9 launched in orbit in September 2021 with on board OLI-2 will captured 14-bit radiometric data. Before Landsat-9 launched, it depended on Landsat-8 with a resolution radiometric 12-bit that in 2016. Pre-launch for Landsat-8 & 9 which is on-orbit to monitor instrument or stability. From Landsat-1 until 9 radiometric calibration & precise geolocations was function stepped pre-processing & undergone pr-launch recorded data could been geolocated accurately (Barsi et al., 2014; Markham). Landsat surface reflected & surface temperature was generated systematically on a global used combined radiative transfer & content image (Vermote et al., 2015). This system was Earth observation, important to Landsat 9 & 8 because combined work together reduces the period from 16 days to only 8 days. This could helped to compare & validate the data from both satellites to ensure reliability or consistency in the synergistic data in the long term.

## 2.7 Land Use and Land Cover

Land use & land cover (LULC) were important to Earth's system related to numerous human & physical surroundings also very sensitive systems had been damaged by any factors like climate change or humans (Aune-Lundberg et al., 2014). This was important because LULC was the main component across multiple fields that leverage Earth such as urban or regional that measured the environment like

climate change (Talukdar et al., 2020). This changed played the main role in environmental stability was had a linkage with global climate & carbon cycle (Meer MS et al., 2020). Characteristics for LULC like forestry wasteland & watered bodies increase Earth's surface. LULC would change followed by a trend with significant implications for natural resources or loss of ecosystem service. Remote sensing images were the main data source for monitoring LULC changes because pixel-based could classify each individually based on spectral data used in software GIS. GIS had been used for mapping or image processing that could increase satellite imageries such as Landsat. Remote sensing technology provides new wide coverage, assessing large amounts of information and monitoring (Zhang et al., 2020).

## **2.8 Reservoir Improving Flood**

Frequent floods was caused by climate changed, reservoirs was one of the most effective infrastructures to controlled floods which large basins. Global warming or the construction of watered conservancy could change watered cycle speed & will reduce system stability, this change leads to global also characteristics (Wang et al., 2022). This situation increased the water level & surface & also leads to the intensity. The reservoir its function was to manage & balance flood risk also the economic benefits of irrigation & solved water storage (Emerton et al., 2016). Almost around the world thousands of large reservoirs would alter the watershed natural conditions also change the watered cycle structure (Song et al., 2017). The change in watered level possibility of drought & flood events would cause damage to agriculture, ecology, or weather (Wei et al., 2021).

## 2.9 The Influence of the Dam Reservoirs on Water Quality

Reservoirs main element of watered management & source water like drinking because the dams or lakes contribute to improved watered conditions & reduced flooding risk. The depth, & size lake or reservoir would showed the flowed cleanliness of the river the watered because key to protecting the environment or ecosystem (Krengel et al., 2018). Low watered levels would usually occur when the dry seasons (Górski et al., 2019) lakes or reservoirs, & high-water flow happens only in the wet season & also an increased watered supply from the catchment. When dry seasons showed the temperature below the reservoir was higher than above caused water flow would slowly in a shallow channel & more heats much faster. The reservoirs on the river were built through water damming limiting the load of pollutants flowing through it also analyzed the retention reservoir.

## 2.10 Environmental Affect to Water Reservoir

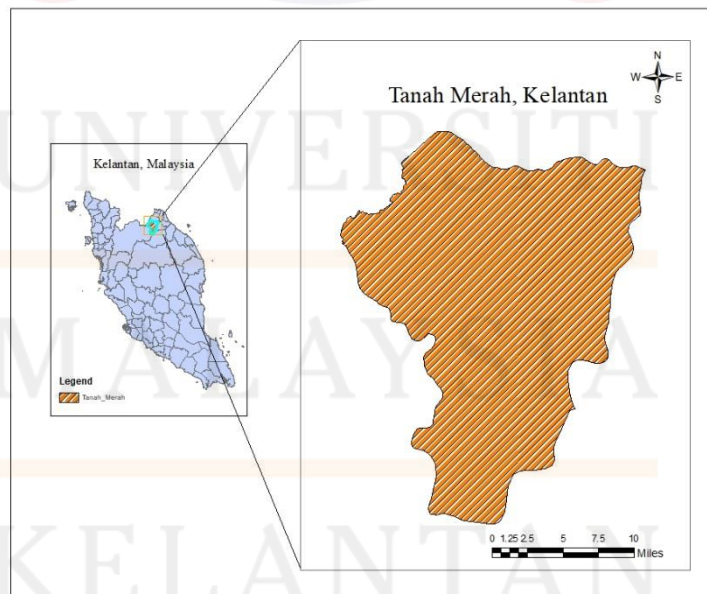
The majority of agriculture, industrial, or urban was carried out with land used that could be affected by rivers & this management will changed the quality & quantity of surface watered area (Zeinalzadeh et al., 2017). The nutrient increase in the watered like nitrogen & phosphorus affects the aquatic ecosystem downstream river. Because of the construction of dam retention phosphorus fraction or climate changed would be pollution to the water surface. Dry seasons affect water pollution because dilution happens, wet seasons pollutants flow which affects water quality also quantity. The reservoir acts as a controlled water quality to avoid river pollution because important to watered resources (Koçer et al., 2014).

## CHAPTER 3

### MATERIAL AND METHOD

#### 3.1 Study Area

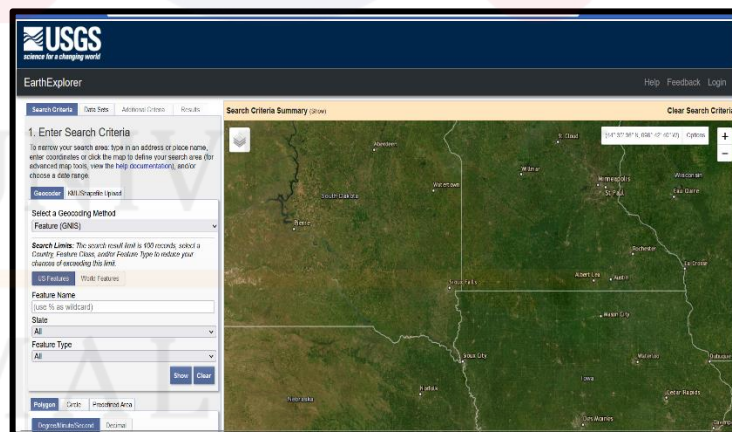
The study area was located in Tanah Merah, Kelantan districts (Figure 3.1). It lied at a latitude between  $5^{\circ} 49' 07''$  N & longitude between  $102^{\circ} 02' 48''$  E also, Tanah Merah covers an area of approximately  $880 \text{ km}^2$ . Tanah Merah was a large urban region that stretches for  $11900 \text{ km}^2$  along the Kelantan River. Tanah Merah was a small town that was the center of administration & possesses main of the main railway train station inside the town, for KTM (Malayan Railways Limited).



**Figure 3.1:** Map of Study in Tanah Merah Distric, Kelantan.

### 3.2 Material

Data for images Landsat-8 (2023) had been downloaded from the US Geological Survey (USGS) (Figure 3.2) known as a satellite, used to monitor the Earth's surface through multispectral images & this Landsat had a high resolution (12-bit), which gave improvement to detect the changes of Earth surface (Roy et al., 2014). Remote sensing methods had been used to extract DEM from satellite images of any concerning coordinate system, the digital topographic surface that could be used to determined detentions & uplands of any pointed-on Earth to get the result of Earth's surface, hydrology, or geological analysis creating in 3D (K. Khasonov et al., 2019). Remote sensing had been used to add high temporal & spatial resolution (N. Al-Mutairi et al., 2019). DEM obtains morphometric data for the elevation or slopes layer that created the determined watered bodies & calculates the volume of watered in the area.

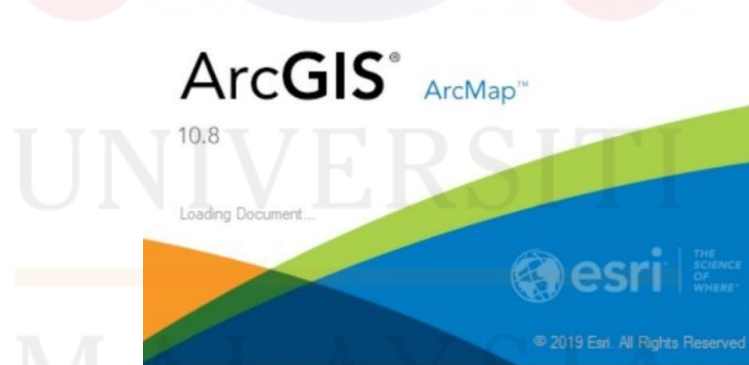


**Figure 3.2:** USGS Earth Explored Website (Source; USGS website)

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### 3.2.1 Software

Arc Map 10.8 software (Figure 3.3) was the primary tool for creating mapping applications, querying attributes, analyzing spatial data, & managing databases (Maguire & D.J., 2008). The software used a water reservoir to collect data, observe, & analyze irrigation systems in a raster. This program used the hemispherical viewshed algorithm (Fu & Rich, 2002) to compute potential solar radiation over a given geographic area. ArcGIS (Figure 3.3) was a remote sensing software that converted raw data into relevant information, such as identifying land covered types for watered & tracking changes over time (Fan et al., 2014). The process of detecting & monitoring the physical properties of an area by measuring reflected & emitted radiation from a distance. To found a suitable site important need used ArcGIS (Figure 3.3) as a weight overlay to process & analyze each raster layer also the value based on the suitability scale (Yu et al., 2011).



**Figure 3.3:** Software ArcGIS 10.8 in 2019 was used to collect & examine Water Source Data.

### 3.3 Method

#### 3.3.1 Selection Area

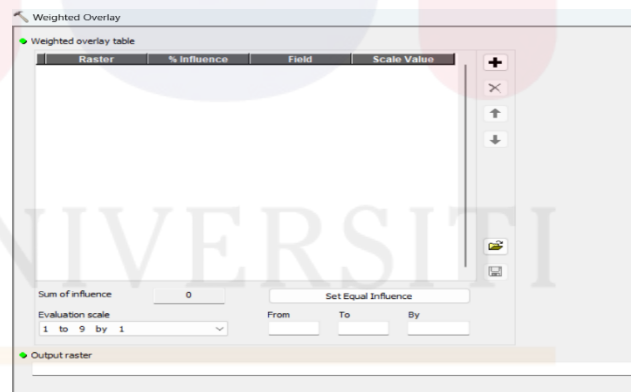
To run the ArcGIS software (Figure 3.3), Landsat-9 data had been downloaded from the USGS Earth Explore website (Figure 3.2) which specifically takes data from the area in Tanah Merah, Kelantan within a year from now (2023). Landsat-9 data had been obtained from satellite imaging with multi-spectral sensors where it can see the Earth's surface (Feyisa et al., 2014) where Landsat-9 in ArcGIS (GIS) processes & analyzes data & extracts about watered bodies in the area.

Import the data from the single band watered index into the software then added the downloaded Landsat-9 as a raster data set (Firozjaei et al., 2019). Acquired a high-resolution Landsat-9 (30 meters) DEM dataset of the same area & self-collected data used GPS surveys. Landsat-8 would propose data to used radiometric calibration to converted digital numbers (DN) to reflectance values. Used atmospheric correction to remove the effect. After that, the DEM would process the data to analyze the hydro flowed & create artificial watered bodies.

Import the data from the single band watered index into the software then added the downloaded Landsat-9 as a raster data set (Firozjaei et al., 2019). Acquired a high-resolution Landsat-8 (30 meters) DEM dataset of the same area & self-collected data using GPS surveys. Landsat-9 would provided data to used radiometric calibration to convert digital numbers (DN) to reflectance values. To removed the effect, apply the atmospheric correction. After that, the DEM would process the data to analyze the hydrological flow & create artificial water bodies.

### 3.3.2 Weight Overlay Method & Analysis

Navigate the Arc Toolbox in ArcGIS software & prepare the data, after DEM extracts the data to the reclassified river layer. Assign suitable scores based on criteria for a water reservoir (1-5). Start to access the data to Arc Toolbox, input the river layer data & other layer data as an input raster. Set the weight for each input layer based on relative importance to the reservoir until receiving 100%. After scaling the weight, specify the line scale with a minimum value of 1 to 5 or 1-10 with suitability scores (Falconer et al., 2019). Ran the tool to analyze until get to interpret the result such as the raster would depict suitability scores for high potential reservoir areas. To analyze only the specific area, a buffer tool to created only around the river. Statistical analysis was done with suitability zones in the ArcGIS tool. The result would show ideal site for the new water reservoir was the darker blue as in the map of Tanah Merah, Kelantan.



**Figure 3.4:** Weighted Overlay Method Table. (Source; ArcGIS software 10.8 (2019))

## CHAPTER 4

### RESULT AND DISCUSSION

#### 4.1 Supervised Land-Used Image Classification

Before created watered reservoirs map potential was needed to supervise land use images for classification methods. Supervised help to access the potential area for reservoirs. Training site selection that representative sample for each land such as (Figure 4.1) watered body, vegetation, urban, agriculture, bare soil & wetland. Training site selection that representative. Supervised layer created from Landsat-9 (shp) after composite band & add Kawasan DUN also clicked the area Tanah Merah. To create a supervised land use layer click Training Sample Manager (Figure 4.1). After the result, accuracy assessment for validate for classification of the result (Table 4.1). The environmental effect of hydro which explained how to classify land used to helped understand watershed because important to reservoirs' sustainability in Tanah Merah, Kelantan. Considerate ecology also environmental to identify land used sensitive to wetlands, to minimal ecological disruption in the Tanah Merah area (Chowdhury et al., 2022).

**Table 4.1** The result of the weighted of the criteria

OBJECTID*	Value	Class_name	Red	Green	Blue
1	1	Waterbody	0	112	255
2	31	Vegetation	56	168	0
3	94	Urban	255	0	0
4	125	Agriculture	255	255	0
5	150	Bare soil	178	178	178
6	251	Wetland	255	85	0

Table 4.1 shows the result of the weight of the criteria to create the supervised land-used image used ArcGIS & the introduction to the table describes the outcomes of the various criteria weighted during the classification process. Analysis in table 4.1 examines how the various land-used classes are distributed. The explained land used classes shown on the map were related to the individual rows. The value represents the assigned numerical for each of the land used classes that were being used in the classification process. The class name describes how the various land used classes, such as waterbody, vegetation, urban, agriculture, bare soil, & wetland, are listed in the 'Class\_name' column. For, RGB (Red, Green, Blue) valued shows the visual that represents the color codes of the map to each land used class represented by the columns labeled. Land used class had unique color combinations, which helped to identify & easily distinguish between other classes on the map. The relationship of Table 4.1 to the supervised classification map, was about to discuss how these color codes would create the map & this table involves training the model with known for each land used. The result of the supervised classification image in Table 4.1 mentions the result that the outcomes of this classification land used a map process, in which each pixel was given a class based on its spectral properties.

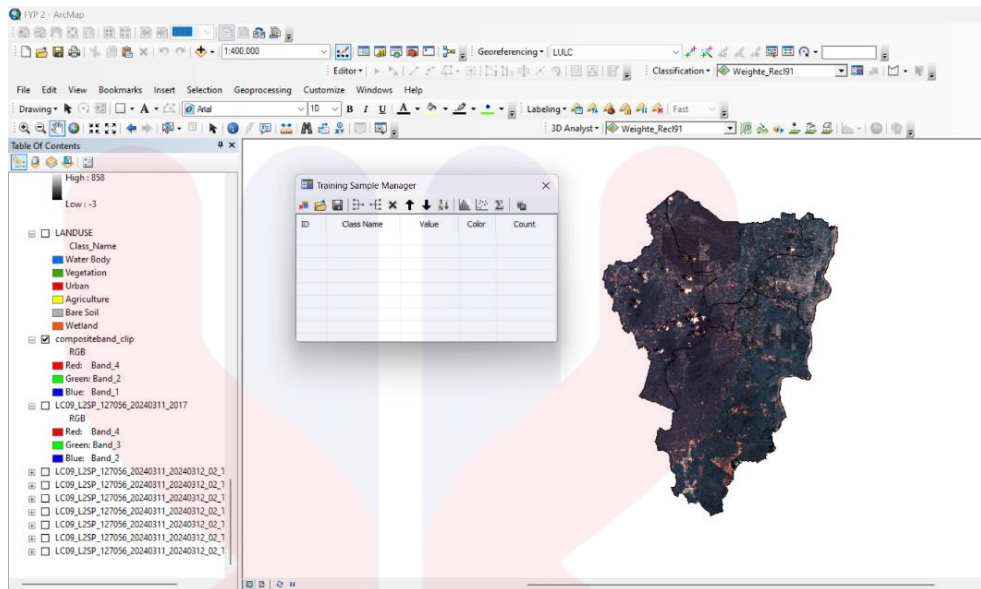


Figure 4.1: Composited band from Landsat-9

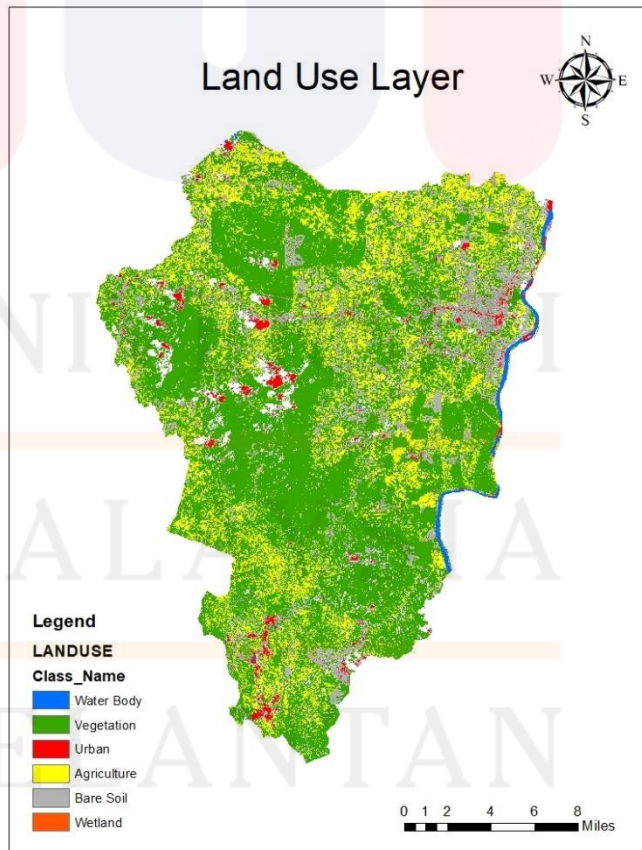


Figure 4.2: The Result Supervised Land Used in Tanah Merah, Kelantan

#### 4.2 Digital Elevation Model Layer Classification

The Digital Elevation Model (DEM) was a terrain surface represented as a 3D model by limited because had elevation & morphology terrain surface & sources of DEM data such as LiDAR or remote sensing (Konadu et al., 2009). After adding DEM data specific to Tanah Merah, the Kelantan area could create an aspect map & also design lines in any watered reservoir project. (Figure 4.2) show DEM data in Tanah Merah was added in ArcGIS & the data was already clipped to specific only the area.

DEM data would analyze topography, which provides elevation of data crucial according to the color of the legend. The darker pixels such as dark shades represented to lower elevation value of 856 meters the darker shades represented a lower area in Tanah Merah because the area was close to the basin area (Schumann & Bates, 2018). The value of brighter pixel color DEM in Tanah Merah was negative -3 meters (Figure 4.4) representing that area around higher elevations such as mountains & hills. This research showed the darker area high potential for water reservoirs & calculated the volume of watered in the Tanah Merah, Kelantan area while the bright color area low potential for getting water reservoir sources (Lane et al., 2003). Through the integration of these function, it was possible to created a comprehensive map that optimizes the environmental impact also, the feasibility of potential sites for water reservoirs.

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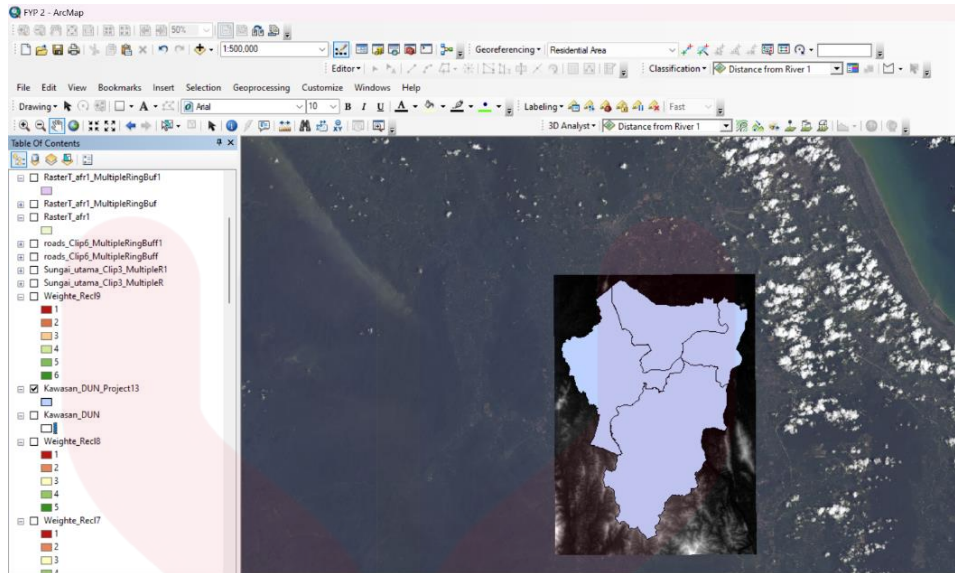


Figure 4.3: DEM Data & Landsat-9 in Tanah Merah, Kelantan

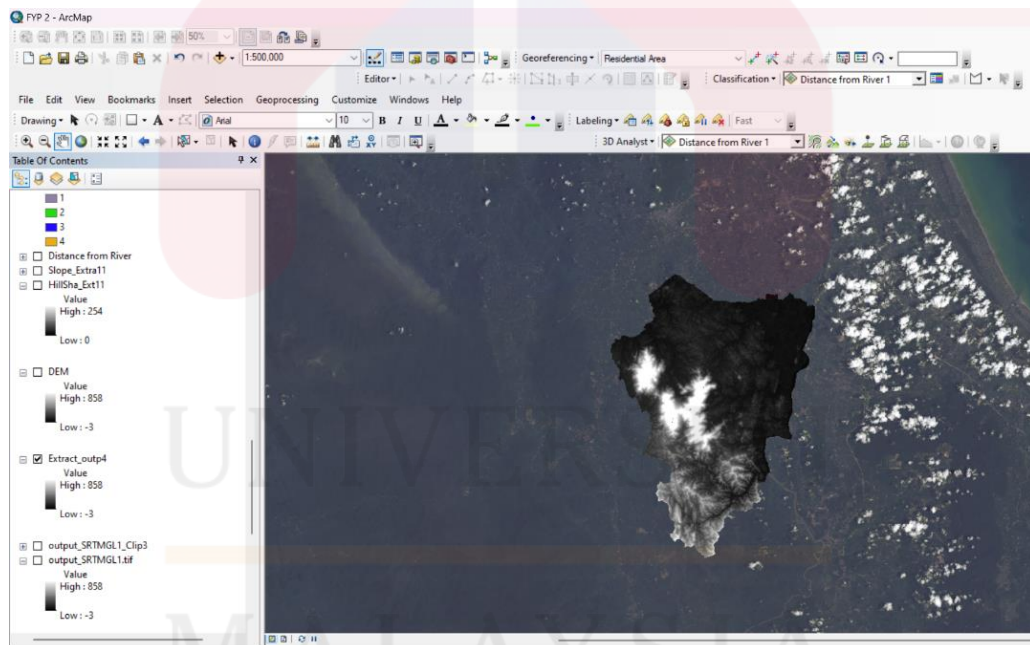


Figure 4.4: DEM in Tanah Merah, Kelantan

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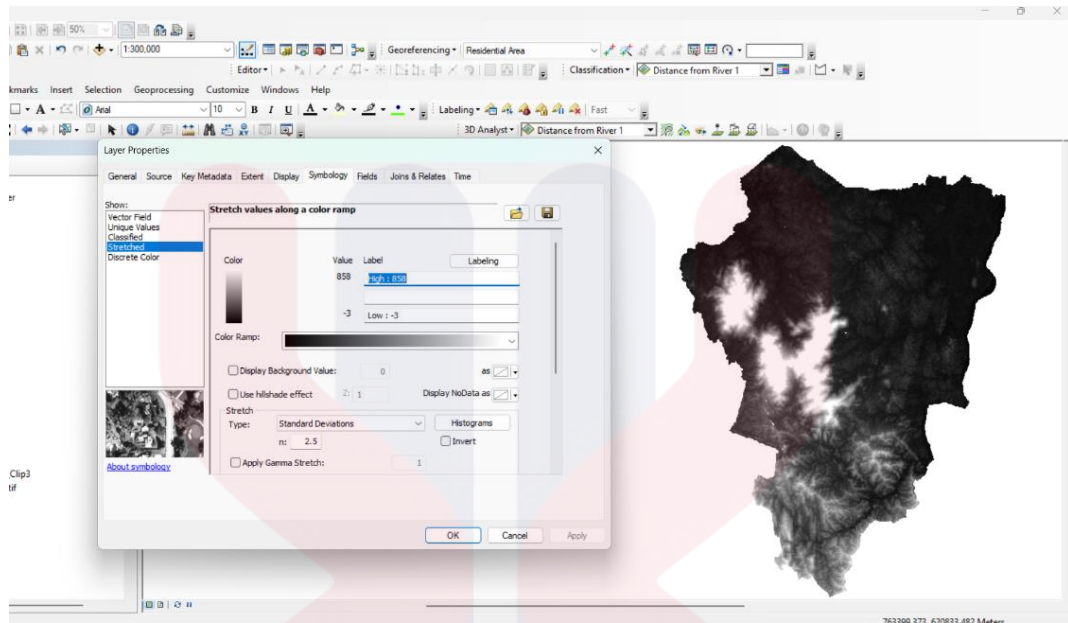


Figure 4.5: DEM Data After Extraction

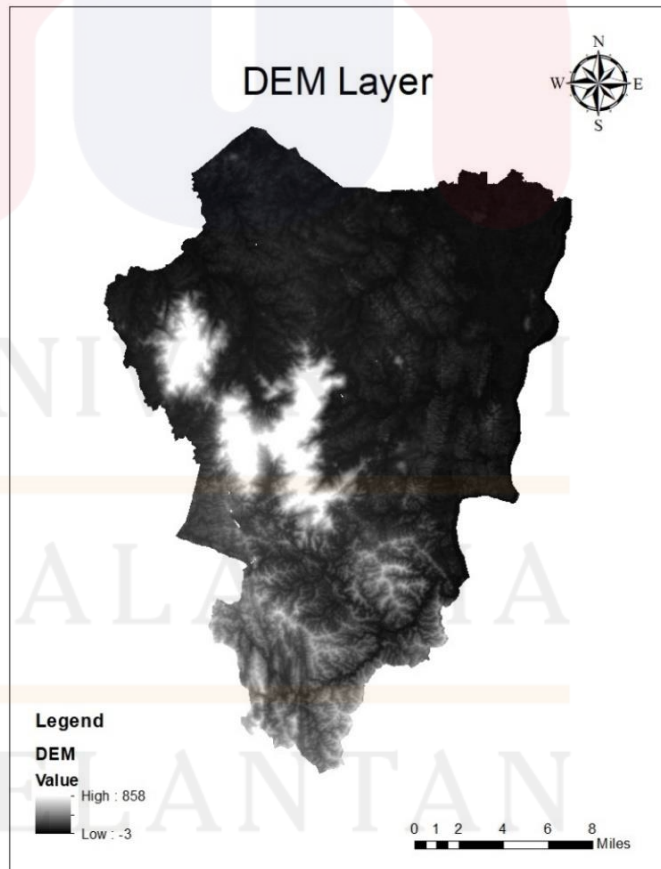
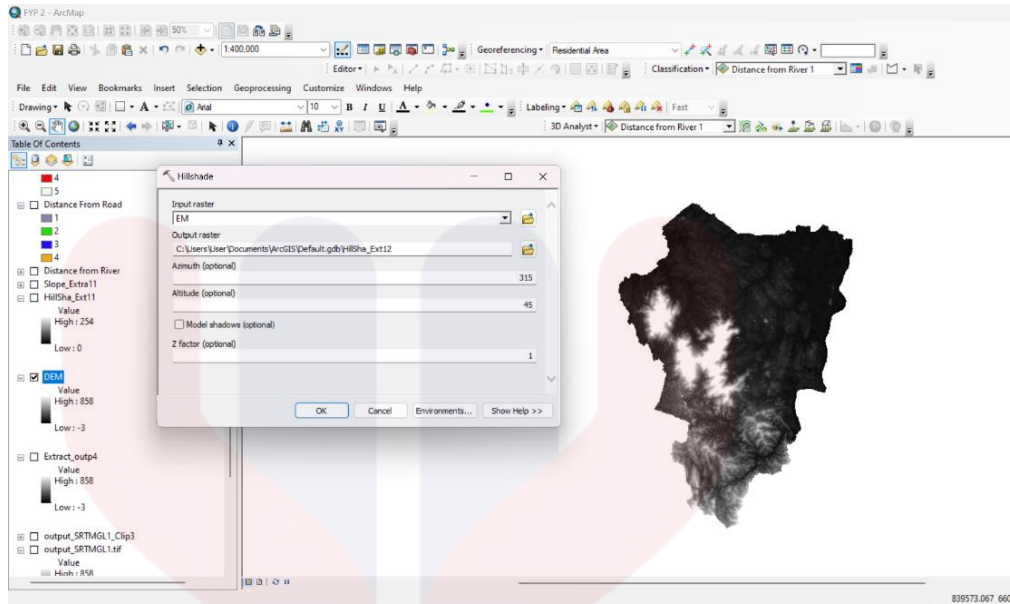


Figure 4.6: The Result of DEM Layer

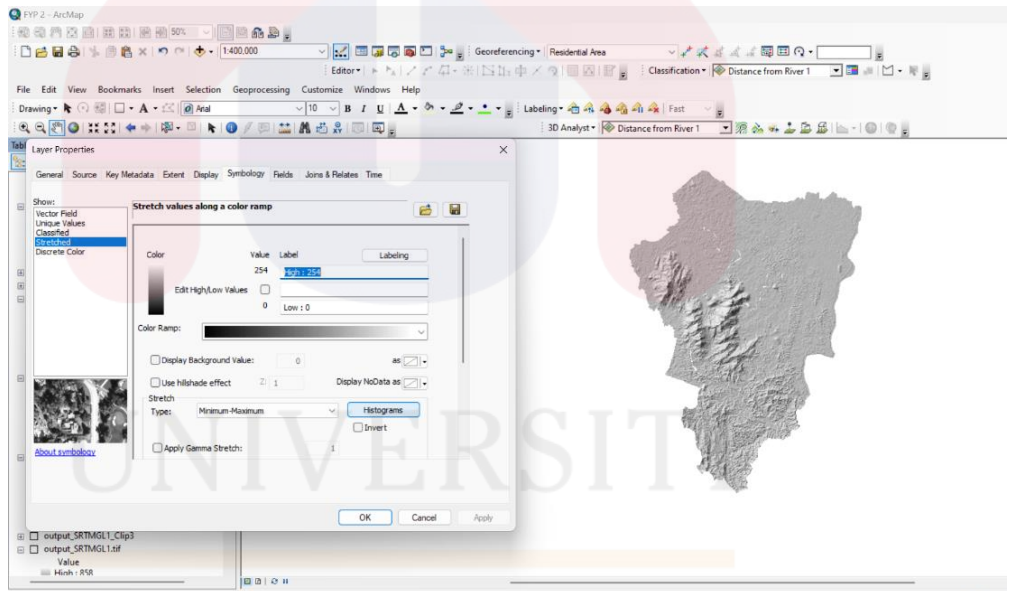
### 4.3 Hillshade Layer Classification

The 3D image of the hill shade showed visualization to create a map used one or more light resources or data from DEM (Figure 4.4). Hillshade was a visualizing determined by light source & slope also aspect elevation surface (Jenny et al., 2006). Illumination had lighter than the object a shadow effect was produced to be used in maps by increased visual topography of Earth's surface. The result after creates a hillshade shows the two different colors of pixels which were, dark & bright (Figure 4.6) & useful for organizing erosion control plans also other environmental preservation tactics.

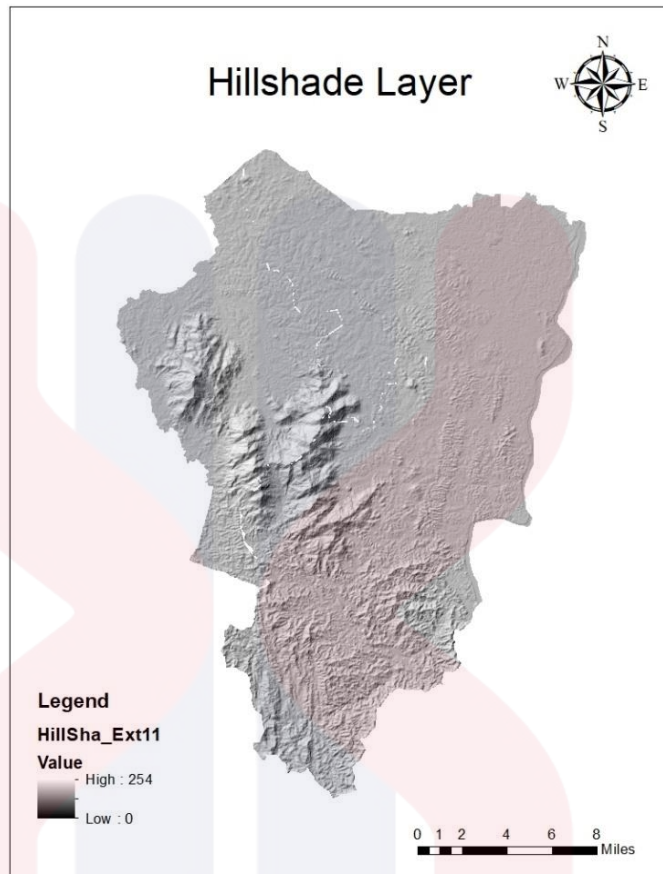
The bright shade was 254 degrees represents a higher elevation or lowered area that had the potential to collected water runoff or was suitable for water reservoirs. Higher elevation areas would flow the water to the reservoir areas like dams & bright areas potential to know where the suitable place to build dams for reservoirs also might be exposed to climate change or landslides. The hillshades layer represents the area where watered originates & downwards for the flow of watered to the reservoirs (Mulaji et al., 2022). DEM represents to area of reservoirs & identifies the flowed of water based on high elevation also gives the potential area of water reservoirs & watersheds. The darker color in this hillshade in Tanah Merah, Kelantan was 0 degrees represent an area with a lower evaluation like a steeper slope that shows were patterns of watered flow in the reservoir area. Watered naturally flows brighter to darker through reservoirs or dams & accesses the capacity to captured & also store more watered in reservoirs.



**Figure 4.7: How To Created A Hillshade Map in ArcToolBox**



**Figure 4.8: A Hillshade Map**



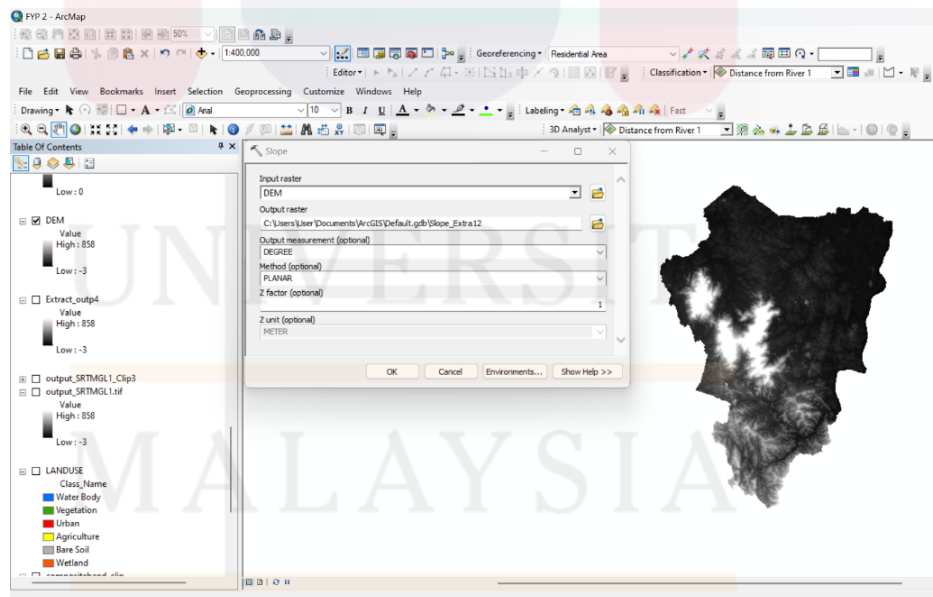
**Figure 4.9:** The Result of Hillshade Layer

#### 4.4 Slope Layer Classification

The slope layer was a tool to identified steepness at each cell raster surface which had more lowered slope valued, the flatter terrain & the higher slope valued, the steeper the terrain. The slope also shows the groundwater perspective & provides a general indication of groundwater flows & how (Gupta et al., 2010). Water flowed & reservoir slopes affect the movement of water in the landscape. If the slope was steep the flow of water is fast & causes increased watered accumulation in the Tanah Merah area, Kelantan. Higher potential to get sedimentation in reservoirs which is if, a flat slope area will increase the potential in the area (Rawat et al., 2010).

After creating a slope map the result showed (Figure 4.9) the difference between colors such as green, yellow-green, yellow, & red also orange had the value

in Natural Breaks (Jenks) for water reservoirs. The values for green colors was 0 to 4.68 degrees represent an area that had the lowest slope value or a flat area suitable for water reservoirs. Yellow-Green was a slightly steeper area in Tanah Merah, Kelantan which is 4.69 to 10.4 degrees & suitable for reservoirs with minimal challenges. Yellow color shows the values 10.5 to 17.1 degrees which means the area was moderately sloped & needed to be improved & planning to focus on managed water flow or sedimentation. The orange value in the Tanah Merah area was 17.2 to 25 degrees represented a steeper area where water runoff would be more rapid or faster, this why orange area was not suitable for watered reservoirs because of higher potential sedimentation or any issues. The values for red colors was 25.1 to 51.8 degrees which was the steeper area in Tanah Merah, Kelantan, unsuitable to reservoirs because of the high runoff & erosion risk.



**Figure 4.10:** Stepped To Created A Slope Map Used ArcToolBox

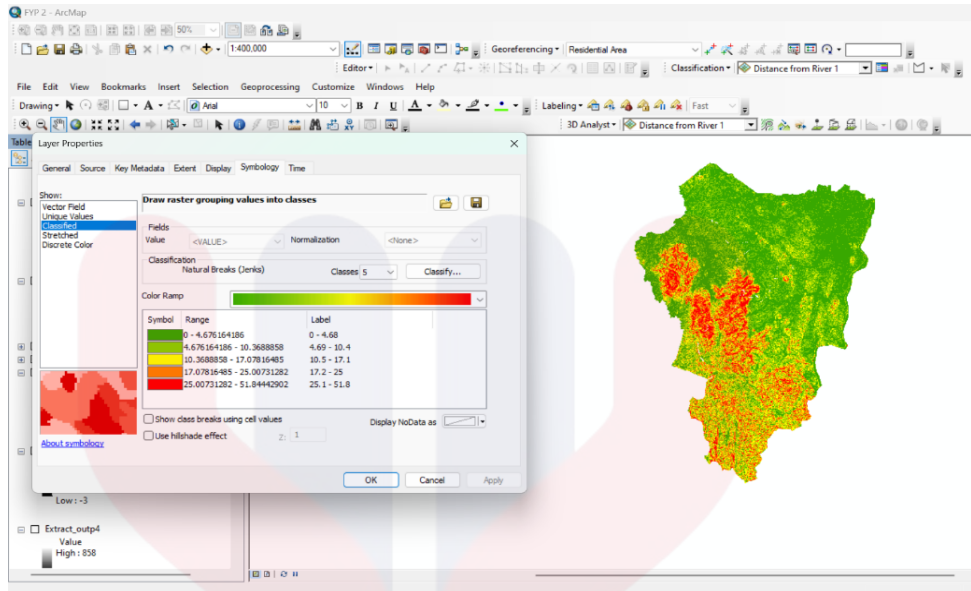


Figure 4.11: A Slope Map

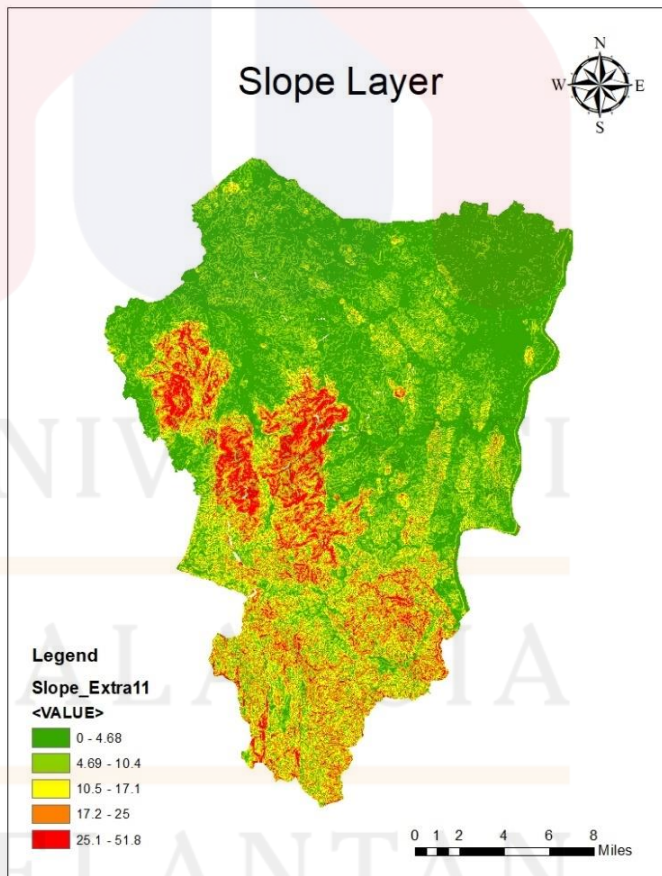


Figure 4.12: Slope Map of The Studied Area

**Table 4.2** The result slope layer

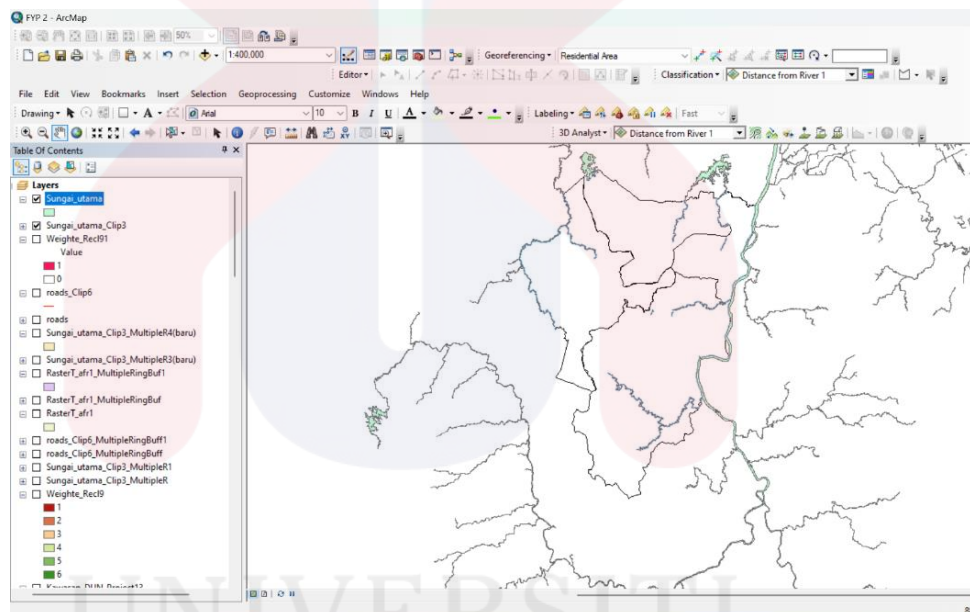
OBJECTID*	Value	Count
1	1	24853
2	2	203907
3	3	133910
4	4	93732
5	5	78894
6	6	68908
7	7	55935
8	8	3653
9	9	13937

Table 4.2 visually displays the varying degrees of slope maps across this studied area or provides a quantitative summary of the slope classification. OBJECTID\* represents unique identification also the value was the slope classification & count was the number of cells or pixels in that class. The significance of cell counts, which represent the number of cells or pixels, & statistical summaries that display the slope value distribution. The counts in Table 4.2 serve as a summary of the various numbers on the legend map, which were not related to the slope value itself. If class 1 (Value = 1) had a count of 24,853 & the map displays green areas for slopes between 0-4.68 degrees (slope class 1), then 24,853 cells in the study area.

#### 4.5 River Layer in Tanah Merah, Kelantan Classification

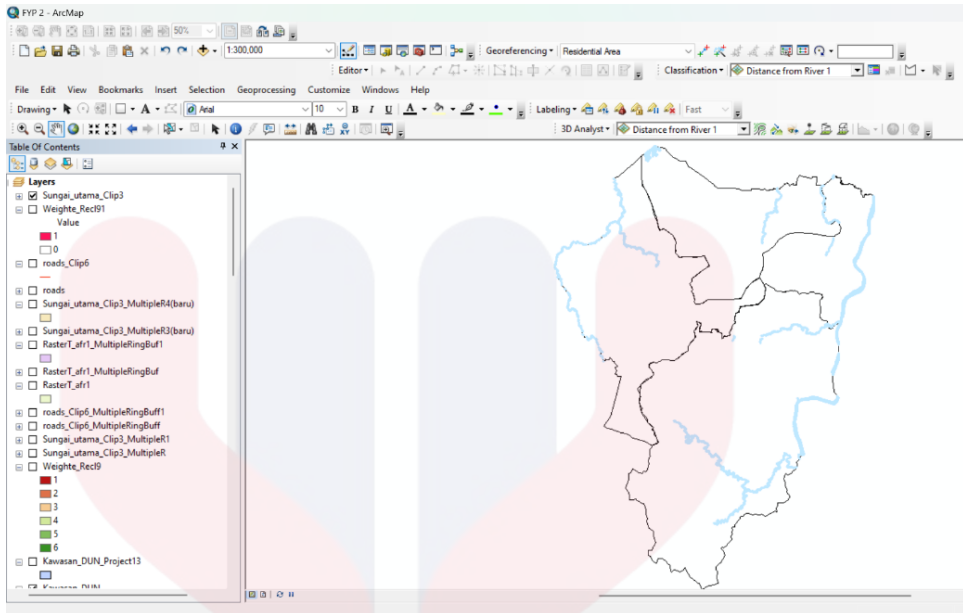
The river layer was a digital map containing information about all Kelantan rivers (Figure 4.11). The main river (shp) added in ArcGIS shows all the rivers in Kelantan & the watered flowed direction, centerlines, or depth. After clipped the main river to the only river in Tanah Merah, Kelantan shows (Figure 4.12). Tanah Merah was surrounded by the main river in Kelantan & among the rivers were Jedok & Jegor River (Figure 4.12). (Figure 4.12) shows the blue lines were buffer zones which were the rivers in ArcGIS watershed boundaries that could help to catchment reservoirs area & amount of water supply also stored.

The river in Tanah Merah was a water supply that shows the most potential sites or areas for water reservoirs & consistent watered supplies in the area (McManamay et al., 2016). The river layer helps to identify the area of the potential watered reservoir, visualization was to display existing reservoirs on the dun area. The environmental effect on the river layer was availability & watered flow because the river layer could understand the aspect of potential to source the watered also low water flowed. Ecology was important to the river layer because built reservoirs should to minimal disruption to preserve biodiversity.



**Figure 4.13: A Whole Kelantan River**

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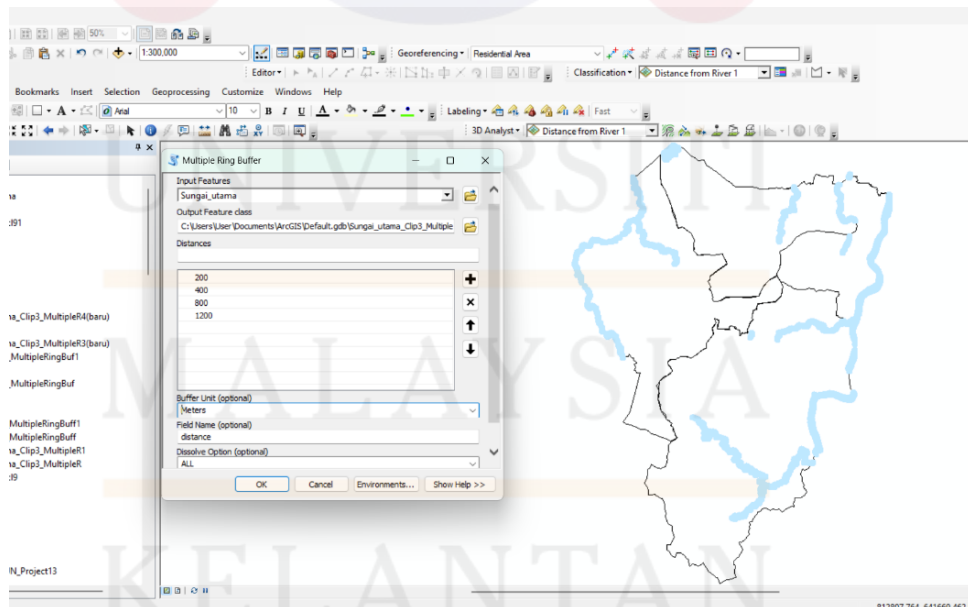
**Figure 4.14:** After Clipped Kelantan River in Area Tanah Merah



**Figure 4.15:** A Result River Layer in Tanah Merah, Kelantan

#### 4.6 River Distance Layer in Tanah Merah, Kelantan Classification

The river distance layer continued to the river layer (shp) that could be analyzed either straight-line (Euclidean) or distance. Raster contains Euclidean that had been separated from each cell to the closest source. Distance layer tools used in ArcGIS were to create a reasonableness outline to identified also these types of distances used to choose site selection for water reservoirs (Zhu et al., 2021). This helped to understand how far the watered supply was from the reservoir area or site. (Figure 4.14) the distance needs to input 200,400,800 & 1200 values before calculating the river distance layer map. Environmental effect to river distance layer was, if the area with surrounded river might had higher ecology valued. This had been maintained in the buffer zones to minimize the impact in that area. If a river near to urban area or agriculture was affected by pollution, this layer helped balance also minimum risks.



**Figure 4.16:** Stepped To Created A Slope Map Used ArcToolBox

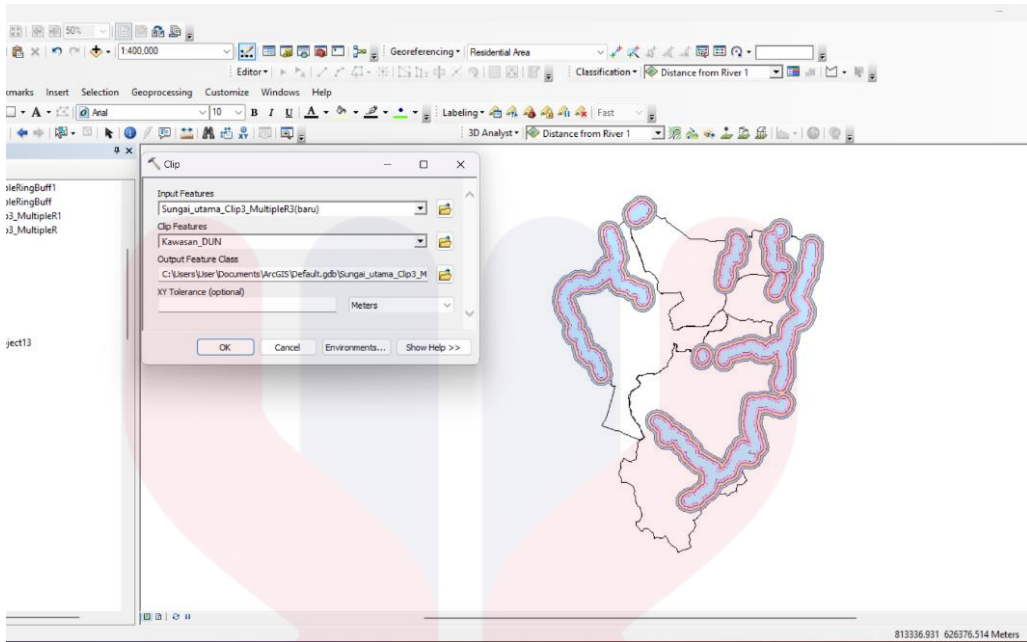


Figure 4.17: River Distance Layer Before Clipped

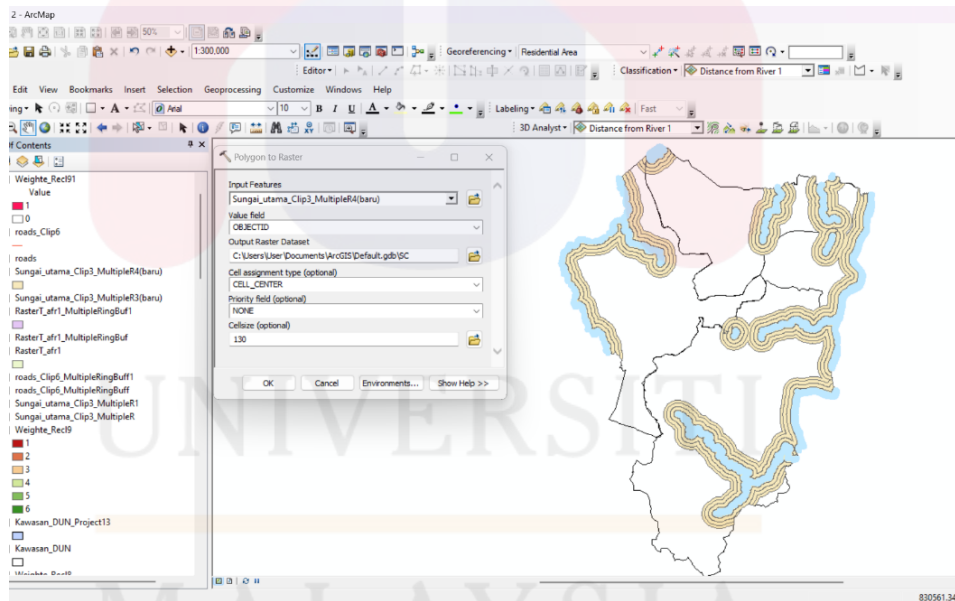
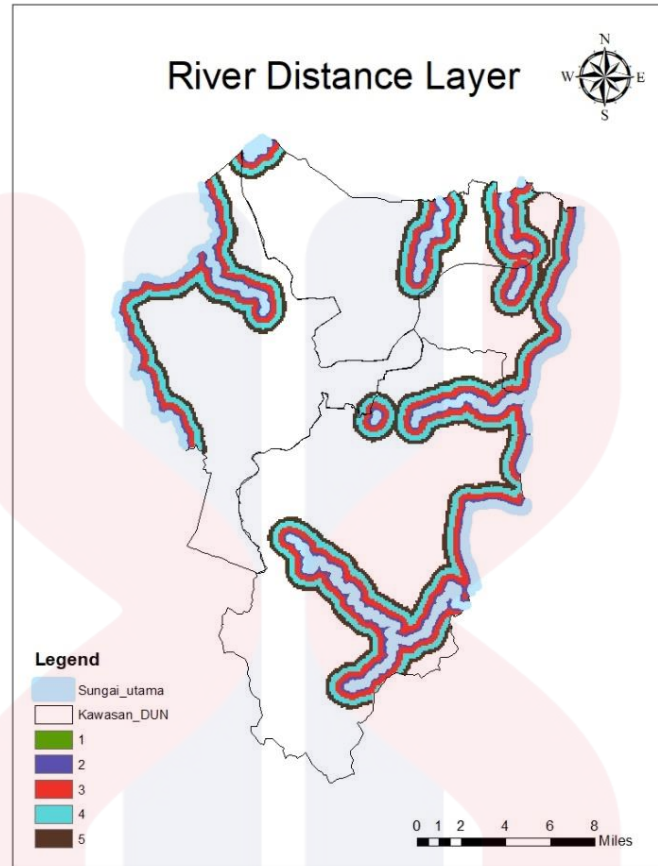


Figure 4.18: River Distance Layer After Clipped in Tanah Merah



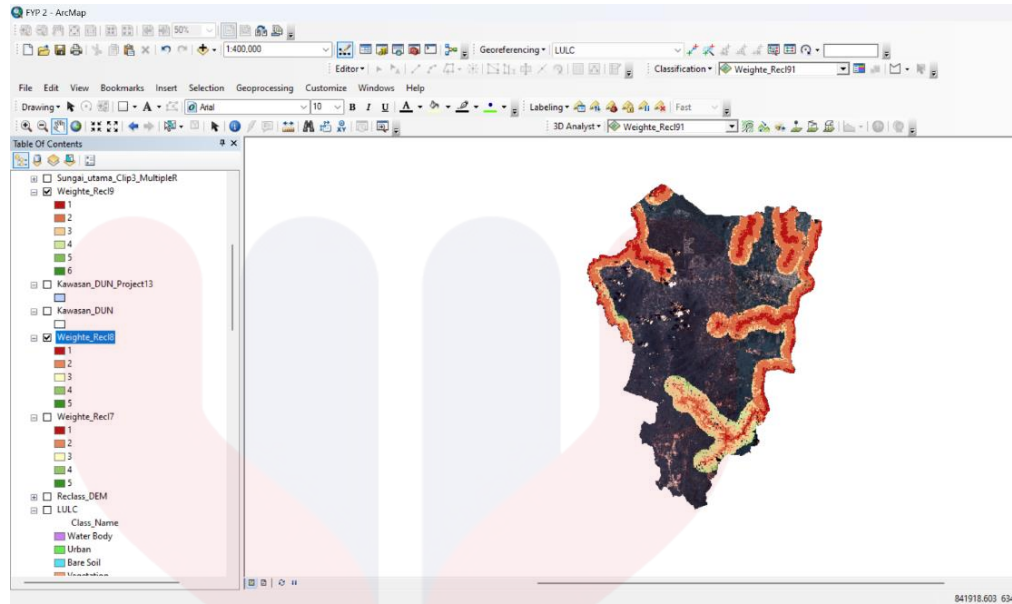
**Figure 4.19:** A Result River Distance Layer in Tanah Merah, Kelantan

#### 4.7 Weighted Overlay Layer in Tanah Merah, Kelantan Classification

ArcGIS was used to create a weighted overlay map method of modeling suitability to analyze & each raster layer was assigned a weight also the value was reclassified to a common suitability scale. Weighted overlay (WO) spatial analysis to combine multiple raster layers also helped to give the river layer to show the higher potential reservoirs in each area. Arc Toolbox gives the specific area or system to store or treat to distribute watered to industrial, agriculture, or homes. The process to identify criteria distance from the river, which shows the only place that high potential water reservoirs the different was the color of the focus river.

The assignment for the weighted that was chosen was the slope, land used, distance from the river & also DEM all data was already reclassified & shapefile (shp). The total weighted was 100% because the weighted was based on relative importance such as slope (15%), land used (15%), distance from the river (30%) & DEM (40%) (Figure 4.21). DEM was the higher percent normalized value; cause slope represents gentle slopes that can be suitable to see potential water reservoirs. The percentage lower such as slopes or rivers was a non-suitable area for water reservoirs because the long distance between rivers in Tanah Merah makes not easy to access the water supply. The result of the higher score was the potential water reservoir area in Tanah Merah (Figure 4.20), got three areas the higher potential reservoir represents the most intense color on the river (Figure 4.22). The final result shows (Figure 4.22) that the circle label with reservoir color shows the area had three potentials to have water reservoirs because the supply & storage of water was higher than the other areas.

The environmental factor in identifying the water reservoir was the hydro water source to ensure that the supply was also functional & a sufficient amount of water storage (Zhang et al., 2014). Three areas that were suitable for environmental effects were avoiding degradation such as landslides, increased water supply, or slow flow of water (Bonnema & Hossain, 2017). The table of results shows the area had higher or more water storage or supply the blue color in ArcGIS.

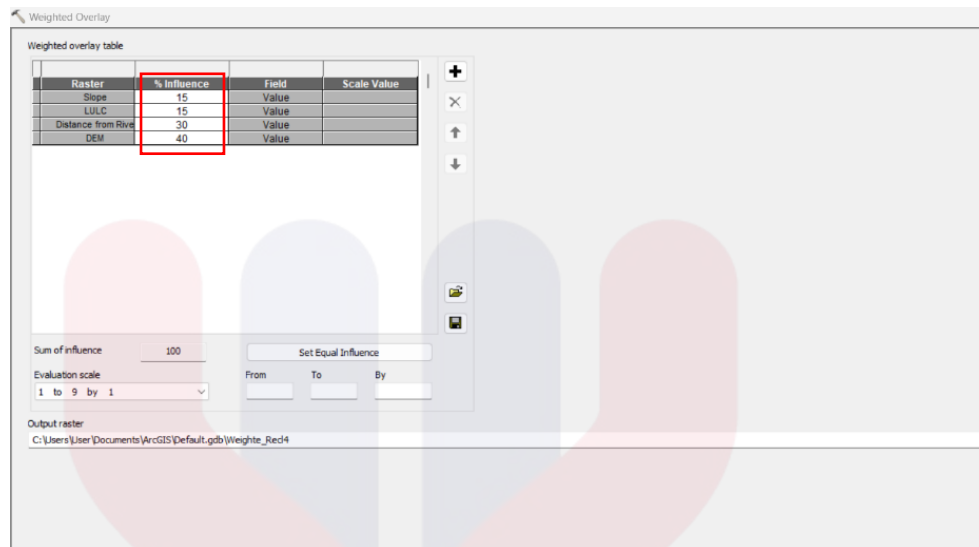


**Figure 4.20:** Weighted Overlay Shows Potential Water Reservoirs with Red Lines

**Table 4.3** The result weighted overlay

OBJECTID*	Value	Count
1	1	1424
2	2	7626
3	3	2677
4	4	411
5	5	7

OBJECTID\* in Table 4.3 describes the suitability class in the analysis while the value represents the appropriateness score or class obtained from the weighted overlay analysis. Illustration example, a value of 1 represents the most suitable water reservoir sites in that area & value of 5 shows the least appropriate value for reservoirs. for count digit was a distribution of suitability if value 1 had the highest reservoir suitability which means had 1424 cells while the value of 3 areas had moderate suitability that had 2677 cells or pixels & the red color had a different shade. While for the lowest suitability for water reservoirs was the value 5 because the cell only had 7 cells also the color was not dark but in the lightest shade, there was no red in that area.



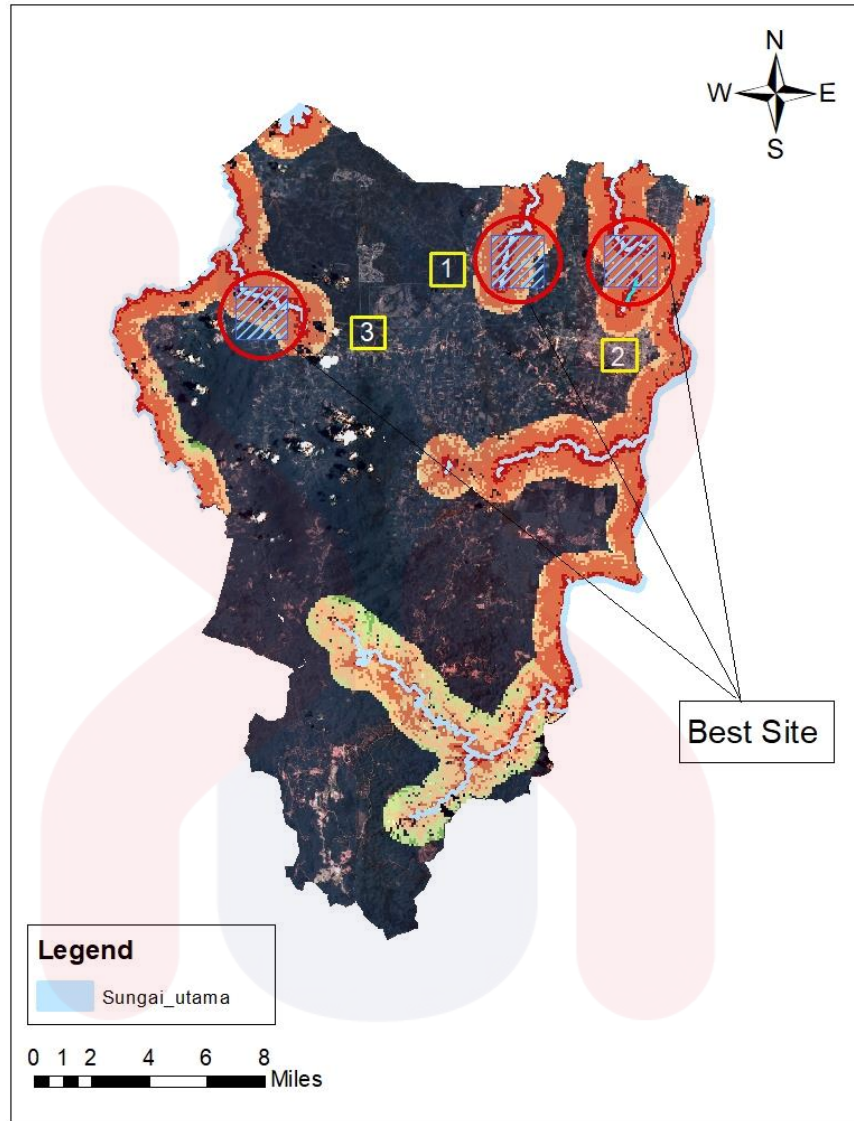
**Figure 4.21** Weighted Overlay Tools

#### 4.8 Selection of Suitable Site for Reservoir

ArcGIS used to extract or calculate Weighted Overlay (WO) data with percentages 100% to process the data & show the higher potential site for water reservoirs. The site had three areas representing red circles & blue reservoir squares, among the rivers involved in the reservoir area were rivers Jedok, Jegor & main river in Kelantan. The site potential water reservoirs because the water flow of River Kelantan just surrounded by the Tanah Merah area with the light blue area represent to river layer was provided to steady water flow (Vu et al., 2022). When watered supply closer to the river the potential was higher to build. Reservoir sites needed sufficient water & always function at all times, to maintain watered supply also quality that could stream to all in that area. The circle with a red outline represents to the potential zone considered for watered reservoirs constructed.

Legend shows main river represents to light-blue layer, while the scale bar helped to understand geographical analysis such as the distance of mile that area also contextualizes the size of the area. The environmental factors were the main factors in water reservoirs because hydro factors in that area or site such as the size of the

reservoir area the biggest (hectare) than another area, these three areas (Table 4.4) had river fast flow rates because smooth slope layer. This affects smooth watered flow & quality of watered clean also enough quantity in the Tanah Merah area (Biswas et al., 2021). Land used represented to effected the quality of watered reservoirs because landslide, pollution or filtration processes would happen. Water supply management may caused unclean watered, especially in the future, if this was not solved by means needed focus to find the best slope area (Das et al., 2022). For, ecological impact to environmental effect to biodiversity or wetlands area that could minimum also critical. Topographic (Figure 4.22) which was a red line represents to higher place complete & could support a natural basin large with water bodies.



**Figure 4.22** Selection of Suitable Site for Reservoir

**Table 4.4** The result of the river layer

FID*	Area	Hectares
1	319410.724	31.941
2	41929.812	4.193
3	89028.877	8.903
4	24445.104	2.445
5	7920.182	0.792
12	271189.232	27.119

The outcome of choosing appropriate site reservoirs in Tanah Merah was depicted in (Figure 4.22). The three best locations were selected based on their greater ability to serve as water reservoirs. The first location to appear was close to Kampung Chandan & Chasi & was an area to the Jegor River in Tanah Merah. According to (Table 4.4), FID\* was a feature ID or identifier for each polygon's water body & area, which indicates each polygon's area in square meters & hectares, with one hectare equaling 10,000 square meters. The area of each hectare polygon was equal to 31.941, & the area of the river in the first area was as high as 3.9410.724 for the water body. In the second area, the river was located close to the main river or river of Kelantan, this river state in Kampung Kuang or Kampung Bukit Mas Tanah Merah. The second area or river in FID\* 2 to 5 was represented by area & hectare, for example, 89028.877 for area & 8.903 for hectare.

(Table 4.4) a third area, which represents FID\*, indicates that the river's actual area was 27.119 hectares. The Jedok River was the third river, empties into the Golok River & was situated on the boundary between Kelantan and Thailand. A larger area has more potential for the reservoir in that area, & when the location was near a river, the height of the surrounding land was also taken into consideration. These are some of the characteristics shown in (Figure 4.22) & (Table 4.4) that indicate which water reservoirs have a higher potential.

## CHAPTER 5

### CONCLUSION AND RECOMMENDATION

#### 5.1 Conclusion

Based on this study, three areas in Tanah Merah were selected as the optimal sites or areas with higher potential for watered reservoir location. The results of this study fulfilled the study's goal was determining the environmental factors for identifying water reservoirs in Tanah Merah, Kelantan & assessing the potential area of a watered reservoir in Tanah Merah, Kelantan. These three areas were selected because the criteria were complete from watered storage to make sure could be distributed to all regarding watered used, also watered flow easy to connect the reservoirs with the river. Several rivers, such as the Jegor and Jedok rivers, had been chosen for areas of water reservoirs with higher potential. The first area was in the village of Chandan and Chasi, for second area was in Kampung Kuang, also known as Kampung Bukit Mas Tanah Merah, & the third area was on the border of Malaysia & Thailand, namely between the Jedok & Golok rivers. The result used weighted overlay (WO) concluded as a result of the suitable area by used ArcGIS software. DEM, slope, Land used, river, & river distance are used as a layer in the map to identify new reservoirs in this research. Slope analysis important to had a smooth slope & land used to ensure the place effect by a land slide. In this era, water reservoirs are very important to used because the water supply would increase every

year, this reservoir could help overcome the water shortage in Tanah Merah or the whole of Kelantan. Thus, ArcGIS functions to Weighted Overlay (WO) the tool would determine the potential area or new water reservoirs. Optimal sites for reservoir construction considering environmental factors which was to consistent watered supply or storage for reservoirs. The environmental effect was the ecosystem chose the suitable area to increase degradation.

## **5.2 Recommendation**

Based on the latest data were needed to continue studied this research for other or many places. Needed to enhance the quality of raster data for higher resolution to accurately analyze & always update the software on ArcGIS or GIS. Long-term monitoring helped to track the performance of watered reservoirs & more impacts of reservoirs by used GIS in land use or slope. Advanced data of GIS & remote sensing should been used such as LiDAR or drone, to collected the surface data detailed & easy to collected the data also save more time.

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