

MAPPING THE LOCATIONS OF SUITABLE NATURAL
HABITAT OF AROWANA FISH USING REMOTE SENSING
AND GIS APPLICATION (CASE STUDY:CHINI LAKE)

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OF AROWANA FISH USING REMOTE SENSING AND GIS
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**Thesis submitted to the Universiti Teknologi MARA Malaysia in
partial fulfillment for the award of the degree of the
Bachelor of Surveying Science and Geomatics (Honours)**

JANUARY 2012

DECLARATION

I declare that the work on this project/dissertation was carried out in accordance with the regulations of Universiti Teknologi MARA. The project/dissertation is original and it is the result of my own work, unless otherwise indicated or acknowledged as referenced work.

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ABSTRACT

Recently, the population number of Arowana fish in their natural habitat was decreasing and become extinction. This fish species protected from import and export activities by the Convention on the International Wild Fauna and Flora (CITES). Hence, this research was carried out to identify the suitable natural habitat of Arowana fish. The objectives of this research are to determine the suitable habitat for breeding and mapping the areas of Arowana fish within Chini Lake using the integration of Remote Sensing and Geographic Information System (GIS). The several criteria were selected focuses on the water quality such as temperature and pH. The other criteria that have been used were factors surrounding that lead to the pollution such as agriculture and settlement. Water quality at Chini lake generally will change due to the environment factors like anthropogenic activities around the lake. Remote Sensing imagery using Landsat TM is necessary in detecting water resource and provides the necessary information on temporal and spatial data on the study area. With the help of GIS technique using spatial analysis, map of water temperature and water pH were produced based on the coordinates Global Positioning System (GPS) provided by Department of Environment (DOE). The GPS coordinates data of 14 sampling stations involving 12 water bodies known as 'laut' by the local people were used in this research. Finally, based on the analysis results, the suitable habitat for Arowana fish breeding showed that the habitat need to be far from the agriculture and settlement area. It could be explained by the area near to settlement and agriculture could lead to the pollution of water and affect the water quality which resulting the migration of Arowana fish to the area that meets their needs.

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CHAPTER 1

INTRODUCTION

1.1 Background of study

Arowana is one of the most popular and expensive ornamental fish in aquarium. The Green Arowana most commonly found in Asian. It also can be found in the wild in Indonesia, Thailand and Malaysia. The fish is one of the cheaper Arowana because of its dull green color and very easily find in the wild.

The best quality of Arowana is known as Malaysia Golden Arowana. The Malaysia Golden Arowana is the most expensive fish in the world due to the less supplies than it demand. This type of Arowana can be found in area of Bukit Merah Lake in the state of Perak. The area is the most popular location as breeding the Arowana fish due to the pH range from 6.8 to 7.4, which is comes from the nearest lake. The area is originally a rice field farming area. The fish can be very sensitive to inappropriate water conditions. Because of the higher demand from their admirer, the industry of Arowana's breed should be expanding. In naturally, the habitat-breeding season usually occurs from August to October every year. Arowana fish breed in 1 to 2 times per year. It lives in slow moving water, shallow, slightly acidic water and unpolluted natural surroundings.

This study was performed to determine the area of natural habitat for Arowana fish as the best location of this population to live. Johor and Kedah are the other locations that do the breeding of Arowana fish activities widely after Bukit Merah. The criteria exist at Bukit Merah such as factors surrounding area, water temperature and water pH can be used as parameters to detect the suitable habitat of Arowana fish at Chini Lake.

Firstly, two Remote Sensing satellites images were used to view the locations, which involves from a Landsat TM image. The image can view the whole location involved for detection of the most suitable habitat of Arowana at surrounding Chini Lake. Then, ArcGIS software will be used, which involved spatial and attribute data to analyze the data collected. The software needed in processing and analyzing the data from the affected area where the most suitable for Arowana fish habitat. Results of analysis were processed by ArcGIS software to map the most applicable habitat location of Arowana fish base on the criteria will be use.

1.2 Study Area: Chini Lake, Pahang

Chini lake freshwater swamp is classified as natural lakes in Malaysia. Chini Lake is located in the southeastern of the state of Pahang where, is the second largest natural freshwater lake in Peninsular of Malaysia covering 202 hectare of open water and 700 hectare of Riparian, Peat, Mountain and Lowland Dipterocarp forest. There are surrounding by three hills namely Bt. Tebakang (210m) at the north, Bt. Ketaya (209m) and Bt. Chini (641m) located at the southest. The lake system lies between 3°22'30" to 3°28'00"N and 102° 52'40" to 102°58'10"E and divided into 12 water bodies called "laut" by the local people. They are Laut Gumum, Laut Pulau Balai, Laut Chenahan, Laut Jerangkang, Laut Genting Teratai/Tengkok, Laut Mempitih, Laut Kenawar, Laut Seradong, Laut Merai, Laut Batu Busuk (Busok), Laut Labuh and Laut Jemberau.

The lake drained by Chini River before it flowing into Pahang River, which is the longest river in Peninsular Malaysia. It needs 4.8 km before it reaches into Pahang River. Chini Lake also act as a wetland is important in natural ecosystems that help in reducing the frequency, level and velocity of floods and riverbank erosion. Moreover, it plays an important role in providing sources such as fisheries to the local people who living there. It provides an opportunity for breeding and spawning for both resident and migratory variety of fishes. Figure 1.1 shows Chini Lake area in Google Earth and Figure 1.2 shows their sampling station of water quality.



Figure 1.1: Chini Lake (source : Google Earth 2011)

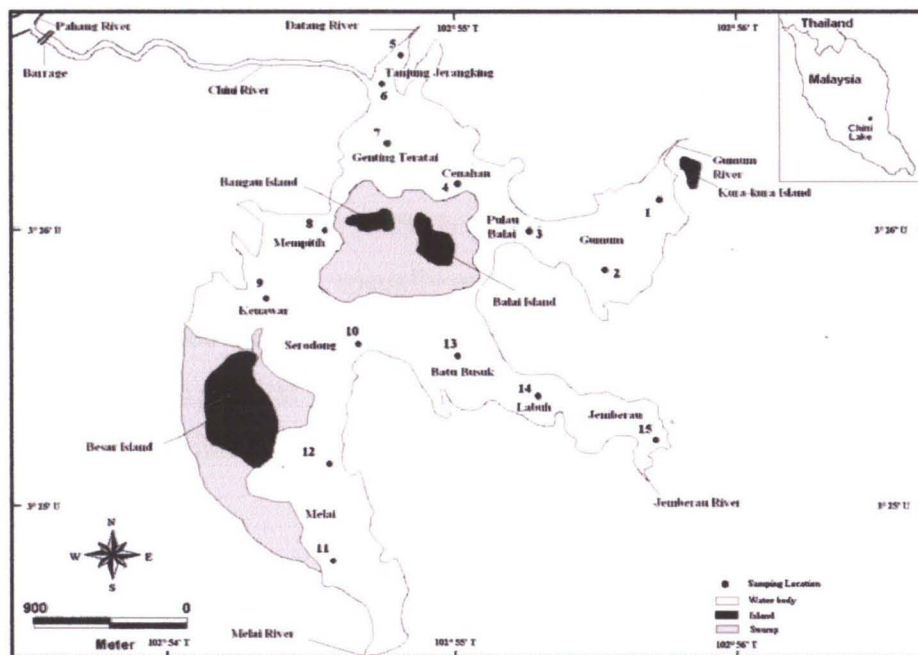


Figure 1.2: Chini Lake sampling stations (source : Othman et al, 2006)

1.3 PROBLEM STATEMENT

Recently, the number of population Arowana fish in their natural habitat is decreasing and become extinct. Based the information from Department of Fisheries, they are finding some other location for breed Arowana extensively to prevent this species from extinction. Therefore, this fish species have been protected from import and export activities, which control by the Convention on the International Wild Fauna and Flora (CITES). This is because this population near to reach of extinction in the wild.

The accurate and right information about Arowana fish need to identify in the research. Then, the investigation has been made on study area located at Chini Lake to find the most suitable area for natural habitat of Arowana fish. This is because Arowana fish is very sensitive fish. Therefore, it needs good water condition to survive. Nowadays, many factors disrupt the natural habitat of fish such as widespread logging, agriculture, urbanization and many more resulting the migration to the area that meet their needs.

Remote sensing is the science and art of collecting data by technical means on an object on or near the earth surface and interpreting the same to provide useful information. By using Remote Sensing data, the research area can be defined. While, Geographic Information System (GIS) is powerful tool that capable of organizing, analyzing and displaying large, spatially explicit datasets. It helps to detect the most suitable location based on the spatial analysis through the criteria involved. So that the area of suitable habitat for Arowana breeding is considered compatible as location as long as it fulfills the criteria needed.

1.4 AIM

To detect the suitable natural habitat of Arowana fish based on appropriate criteria using feasibility of Remote Sensing and GIS.

1.5 OBJECTIVES

The objectives of this study are to determine the suitable habitat area of Arowana fish breeding and to mapping the suitable area of Arowana fish at surrounding Chini Lake.

1.6 SCOPE AND LIMITATION OF STUDY

The limitation of this research includes the followings:

1. Due to the availability of satellite image, the Landsat TM images of Chini dated 3 September 2006 and 8 July 2000 are used for this research.
2. Nowadays, various softwares have been used to process the data. In this study, the software has been selected are ERDAS IMAGINE 9.1 and ArcGIS 9.
3. This research cover the area of Chini Lake located at Pekan, Pahang.
4. In detection the suitable natural habitat area, it limited to the main criteria such as the surrounding factors that affect the water condition at Chini Lake such as agriculture and settlement. There do not consist of types of soil, quality of soil and its thickness. Besides, this case does not focusing on the other water quality except temperature and pH.
5. This research gives attention to Arowana fish only and not to other freshwater fish.

1.7 EXPECTED OUTCOME

1. The expected probable outcome in this project is the map that will show the possible potential habitat area for Arowana breeding based on the criteria.
2. The integration between Remote Sensing and Geographic Information System (GIS) are considered as an important tool to detect the suitable natural habitat for Arowana breeding at Chini Lake.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview of Arowana Fish

There are various types of Asian Arowana, which are Gold (Over Back) from Malaysia, Gold (Red Tail) from Indonesia, Red from Indonesia and Green from Vietnam, Burma, Thailand and Malaysia as show in Figure 2.1, 2.2 and 2.3. The Asia Arowana was protected under Convention on the International Wild Fauna and Flora CITES (Smith, n.d). There are four different natural occurring color varieties for Asian Arowanas, namely Cross Back Golden from West Malaysia, Super Red from Indonesia's West Kalimantan, Red Tail Golden from Indonesia and the Green variety, which can be found in rivers of Malaysia, Indonesia, Myanmar and Thailand. The Asian Arowanas have been passionately hunting at its native habitat for profits, thus the population of these fish in the wild has declined. This is especially so for Malaysian Golden Arowanas and Red Arowanas, which have reached a stage of near extinction since 1980s.

Arowana fish breeding and farming is a grown industry. Arowana breeder and farmers keep the adult Arowana in large shoals and huge mud ponds. In moment of time, teams of farm labor will use a seine net and walk through the ponds. They will collect male Arowana fish, which brood eggs or fry.

According to Yeoh on 2010, Arowanas natural habitat must imitate for their success in captivity because as a closed system, it is difficult to leave the care of Arowana to the "natural" processes in the aquarium. Nevertheless, it is probable probable to let their natural inclinations guide how we care for them to support their health and encourage their prosperity.

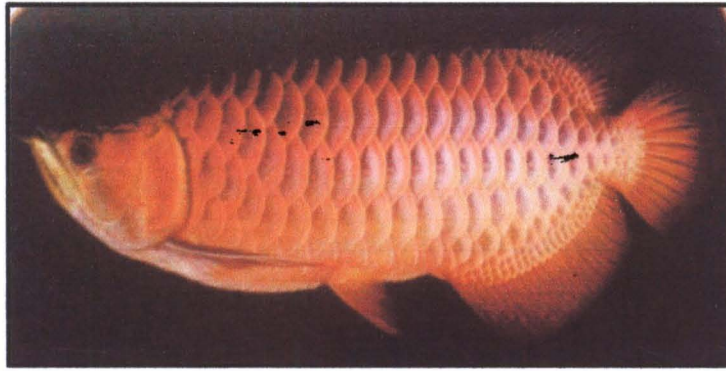


Figure 2.1: Golden Arowana (source: Book of Cadangan Perniagaan Projek
Pembenihan Ikan Arowana)

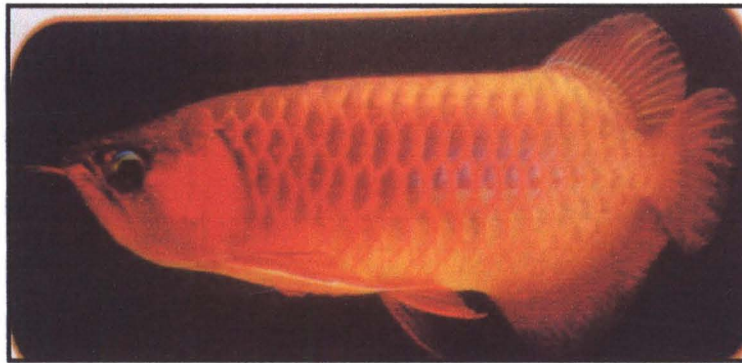


Figure 2.2: Red Arowana (source: Book of Cadangan Perniagaan Projek
Pembenihan Ikan Arowana)



Figure 2.3: Green Arowana (source: Book of Cadangan Perniagaan Projek
Pembenihan Ikan Arowana)

2.2 Value of Arowana Fish

According to many types of Arowana fish, the most expensive fish in the world is Asian Golden Arowana due to the high demand and less supply. Therefore, the market demand has exceeded the quantity available because of the price is rising continuously. The 3-centimeter size of Arowana fry can reach up to RM40 to RM60 each. This type of Arowana is not easy to breed and it will take about 3 to 5 years to reach their maturity. The breeding cycle is around 1 to 2 times per year. This behavior is rare where other Arowana usually spawn 3 times per year. Golden Arowana have life span about ten year or more in captivity. However, they do not easily breed in the wild and captivity. (Hoe, 2009). The Arowana lover requires passion and commitment because they need lots of time and money to spend on this fish. Hence, the affordable and rich can afford to buy Asian Arowana.

2.3 Treat To Arowana Fish

Many factors lead to the extinction of Arowana fish at their natural habitat. Due to the excessive to the demand of wild Arowana, it cause the capturing this fish rampantly. According to the Mohamed Semail on 2009, early August to December every year is a season of Arowana hatched. At that time, many Arowana hunters travel around the lake to catch the Arowana's baby. Most of the hunters come from Seremban and Segamat other than indigenous peoples itself. They will use scoop to scoop the fish guided by the illuminating of fish eyes when light up at night.

2.4 Habitat Loss

There are conservation efforts going on now to protect Arowanas from becoming extinct in many of their natural habitats. Many arowanas have lost a great deal of habitat, which has led to several species being classified as endangered. This is especially true for Asian Arowanas, although many others are still exposed. The aquarium trade has not helped the fish, and they are no longer allowed to be in aquariums in the United States without a permit. (Trudeau, 2010)

The limiting anthropogenic stressors in fish habitat could conserve the sustainable of fish populations and their associated fisheries. (Valavanis et al, 2008)

2.5 Bukit Merah

Arowana fish is widely breeds at Bukit Merah. This is because of the drainage water resources come from the nearest lake, which is Merah Lake. The best quality is the crossed-back full scale Arowana, which is the Malaysian Golden Arowana. This variety only occurs in Bukit Merah Lake in the state of Perak, Malaysia. The crossed-back Golden Arowana commonly inhabits the Kerian River and its tributaries in Perak. (Suleiman, 2003)

2.6 Chini Lake

Water supply is very important in breeding of Arowana, which is necessary over the year, where is flowing from natural water resources such as dam, lake, river, dam and water hill to flow into the ponds. Water is the most important element in keeping fish and is the key to having healthy fish (Li, n.d). The area for natural breeding for Arowana area is at the origin habitat with slow moving waters, rivers and streams. Chini Lake and Bera Lake were the important natural breeding area because the areas are still maintained from pollution and human disturbance. (Mohamed Semail, 2009) Chini Lake was a shallow and small natural lake, which was a sensitive ecosystem and responded to the changes, episodes from its surroundings (Othman et al, 2006). Most of the fish usually found in shaded and shallow areas where there have lots of insect life. It can be said that the lake that identify could be developed into Arowana Fish sanctuary to prohibit from any fishing activities.

2.7 Water quality at Chini Lake

2.7.1 Temperature

Water temperature is very important in water system. It can help to determine which species of fish may present in the system. It can affect feeding, the metabolism of fish, reproduction and their immunity. The temperature of 26°C and 31°C should be maintained for Arowana fish. Fish can be exposure to death if the drastic changes of temperature occur. The lower or higher of temperature can caused the death of fish. Yeoh on 2010 stated that the native Arowana habitats are located very close to the equator in tropical areas. So that, water temperature must be remain at approximately 27°C (80° F). Water temperature would vary little in an Arowana's natural environment.

The mean water temperature for 12 months sampling was 29.60±1.29°C, which ranged 32.19°C. The water temperature exceeded 30°C showing downward trend during low precipitation months, which was from September 2004 to January

2005 due to high precipitation rate. This means the variation in water quality occur due to seasonal changes (wet or dry season) and anthropogenic activities. (Othman et al, 2006).

2.7.2 pH

pH is one of the common water test. It measures the hydrogen ions in the water. The pH scale range scale is from 0 to 14 with the number 7 is neutral scale. A measurement above 7 is alkaline and below 7 is acidic. Farther a measurement from 7 is the more alkaline or acidic of water. The death for fish are when the acid and alkaline approximately pH 4 and pH 11. Fish growth and reproduction affected between pH 4 and 6 and some fishes between pH 9 and 10. However, for Arowana fish, it can live between pH 6.5 and 7.5 with slightly acidic water. The most pH problem for fishponds is when the water constantly acidic. The mean pH value in Chini Lake is 6.49 ± 0.15 , which ranges from 5.72 to 7.38. The pH was shown to be the most stable parameter which did not show drastic changes among sampling months (Othman et al, 2006).

Most of the water region showed slightly acidic pH values indicating the water to be in Class III according to Interim National Water Quality Standards (Gasim et al, 2006). That means, Chini Lake was the most suitable area for breeding Arowana fish at this surrounding area because of its slightly acidic water. Saniah Ghazali stated in her research that pH value between 6.5 and 7.0 is normal and does not threaten the aquatic community.

2.8 Impairment of water quality at Chini Lake

Based on article written by Gregory on April 2006, the surrounding area of Chini Lake present rattan, wood, medical plants and fruit while the lakes is the heaven many variety of fishes. Nowadays, the forest areas were taken away by oil palm and agriculture industries.

In order to increase tourism at Chini Lake, it faced with destruction. Due to the sediment from logging and oil palm estate clearance that ended up in the lake, the certain parts become shallow to ferry tourist. Therefore, to raise the water level, the boatmen requested to build a dam. However, after a year of the dam construction, many tree died due to inundation. More important, the fish species like Arowana fish and giant featherback are decreased because the lake that used to breed and nest had been cut off. The effect was continued until ten years, where Chini Lake still suffered from pollution. In 2000, when the dam redesigned, the annual flow pattern returned that allowed the migration of fish.

In 2004, a team from University Kebangsaan Malaysia (UKM) found bacteria with high levels in the lake that risk to the villagers and unsafe to drink. This contamination occurs due to improper sewage disposal from a resort and the national service camp nearby. It was exceeding 56 times the Department of Environment (DOE) standard for recreation waters. Othman and friends on 2006 also stated that the construction of National Service Camp since 2004 at Chini Lake also lead to the increase in organic loading and nutrient in the lake. There also experience the expansion in agriculture activities such as oil palm plantation. These activities contributed to release pollutant such as nitrate and phosphate into the lake. The conversation of forest to agriculture land and logging activities in this area generated soil erosion. For this reason, it increased the suspended solid concentration in the lake (Gasim et al, 2005).

Laut Gumum area was polluted by nutrient and organic loading. Based on Malaysian Water Quality Index (WQI) result show that Chini Lake water is classified as class II which in suitable for recreational area and allow body contact. (Othman et al, 2007)

2.9 Geographic Information System (GIS)

Geographic Information System (GIS) was a computer system for capturing, storing, querying, analyzing and displaying geospatial data. GIS activities can be categorized into spatial data input, attribute data management, data display, data exploration, data analysis and GIS modeling. (Chang, 2008). A Geographic Information System (GIS) can integrate and represent many types of data in a single view (Mahmoud, n.d)

Within the GIS database a user can enter, analyze, and manipulate data that is associated with some spatial element in the real world. The cartographic software of the GIS enables one to display the geographic information at any scale or projection and as a variety of layers which can be turned on or off. Each layer would show some different aspect of a place on the Earth. These layers could show things like a road network, topography, vegetation cover, streams and water bodies, or the distribution of annual precipitation received (Pidwirny, 2010)

2.10 Remote Sensing

The purpose of this research is to use remote sensing technique using Landsat TM image data integration with GIS for locating potential area as natural habitat for Arowana's breed at Chini Lake. Remote sensing can be defined as the collection of data about an object from a distance. Remote Sensing (RS) refers to the branch of science, which derives information about objects from measurements made from a distance without any contact with them. (Salgaonkar et al, 2011)

Remote sensing imagery has many applications in mapping such land-use and cover, agriculture, soils mapping, forestry, city planning, archaeological investigations, military observation, geomorphological surveying and many more (Pidwirny, 2010). It acquires information such as spectral, spatial and temporal about the objects, phenomenon and area, without any physical contact with them during the investigation.

According to Boivin and friends, natural phenomena and human activities can be seen from afar through remote observation of the earth surface. Nowadays, Remote Sensing becomes important for most resource mapping and inventory procedures because of the imagery can be obtained rapidly and repeatedly over large areas.

2.11 Geographic Information System (GIS) in Fisheries

Nowadays, GIS application is being widely used for variety projects related to Natural resource management. This is the implementation GIS to locating the potential location as habitat for Arowana fish. Determining the location for locating Arowana fish do not involve complicated process. The potential location depends on the parameters involved that need to be analyzed in GIS software. It will helps to mapping the area suitable after doing some process in the ArcGIS software.

GIS application in Fisheries is suitable identification of suitable sites for freshwater and brackish water aquaculture. This may expand the aquaculture industry in the conservation of freshwater fish species. Then, management of marine fisheries and coastal regulation zone can also helps in marine fish. GIS can be use in planning for water body, resource zonation and mapping of aquatic species and distribution of different fish species in relation to physical habitat characteristics.

Further more, through GIS, fish production and consumption can be study through temporal and spatial changes. So that, there are many useful of GIS in helping the management of fisheries in this country by using GIS technique. (Salgaonkar et al, 2011)

2.12 Remote Sensing in Fisheries

An application of Remote Sensing in fisheries is helps in water resources management and it provides the necessary spatial data on the study area. The data such as suspended sediments dissolved organic matter, phytoplankton, algal blooms and oil slicks are useful in fish stocks management in water quality monitoring, fish stocks management and natural water pollution which harmful to aquatic life such as oil or algal blooms. This application also proves in detection and monitoring of water quality. (Salgaonkar et al, 2011)

In addition, Remote Sensing techniques very helpful in provides the needed data for monitoring changes on coastal erosion, shoreline monitoring and management, rise of sea level, wetland mapping urbanization, loss of natural habitat and aquatic population.

Good news for fishermen and anglers outside is they may to know likely occurrence of fish herd which helps them for getting more catch. It happens due to the effectiveness of Remote Sensing in identifying the Potential Fishing Zones (PFZ). Continuous monitoring of land use or land cover with remote sensing imageries have been of immense use in providing information on temporal & spatial changes in area under aquaculture, mangrove areas, coral reef mapping & other land use patterns.

Combining remote Sensing data with data of population distribution and other secondary information sources in GIS is very useful tools in assessing the relationship between economic, environmental and social aspects of fisheries. (Boivin et al, n.d).

2.13 Mapping fish habitat

According to Metz and friends on 2006 research in mapping fish habitats in Lake Tahoe, IKONOS imagery is high spatial resolution multi-spectral data, which used to map near shore underwater substrate in Lake Tahoe. IKONOS imagery very effective in discriminate the different types of submerged substrate around the lake, produce digital substrate map and correlating the data with observed fish habitat data to produce fish habitat maps. It also can improve the spatial extent and the detail habitat data of existing fish by using a consistent and repeatable method.

The agency currently relies on data layer from Geographic Information System (GIS) by integrating field observation data with an existing administrative boundaries layer. The data provides spatial referenced data that describe about the substrate around the lake. At 1989, the first GIS layer about fish habitat was created and promise the precision in mapping with reasonable cost.

Valavanis and friends on 2008 stated environmental and habitat descriptor datasets can be inserted into GIS, which is projected under georeference system to extract a set of environmental parameters. Satellite imagery provides information of sea surface condition through their high and low-resolution forms. So, the important ocean processes that influence species distributions can be mapping. Then, GIS technology and spatial statistical analysis provide the tools to model the relationship of species and their habitat and identify the essential habitat areas. Throughout the predictive habitat of species modeling have been presented for many types species in marine ecosystem and freshwater. Many marine species have wide distribution range and respond to the environmental variation by changing their habitat use and distribution patterns.

2.14 Water Quality Changes in Chini Lake

Began in May 2004 and ended in April 2000, a study of the water quality changes of Chini Lake was carried out. Fifteen sampling stations were selected representing the open water body in the lake. 14 water quality parameters were measured and Malaysian Department of Environment Water Quality Index (DOE-WQI) was calculated and classified according to the Interim National Water Quality Standard, Malaysia (INWQS). The examples of physical and chemical variables are temperature, dissolved oxygen (DO), conductivity, pH, total dissolved solid (TDS), turbidity, chlorophyll-a, biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solid (TSS), ammonia- N, nitrate, phosphate and sulphate. Results from Malaysian WQI, shown that the water in Chini Lake is classified as class II, which was suitable for recreational activities and allows body contact (Othman et al, 2007)

A small barrage about 2 meter height was constructed downstream of Chini River in 1995 to hold the lake water for tourism purposes. The side effect due to the changed of the lake from semi-lotic to lentic system were damages to the plant community, aquatic ecosystems and increased sedimentation rates in the lake. Water quality may be affected due to the wetland functions provided by the swamp forest to Chini Lake such as water purification and unpolluted area are lost. The studies have shown that dams can disrupt the structure and function of river ecosystems by modifying flow regimes, disrupting sediment transport, altering water quality, and severing their biological continuity (Othman et al, 2007)

2.15 Fish Diversity at Chini Lake.

According to the samplings that have been done, 24 fish species were recorded which comprises of 944 individuals. Paired t-test analysis demonstrates that there was a significant fish density difference between day time and night time sampling. The predators were dominant during night time. Fish diversity and density were high at Chini Lake during season catch due to immigrant fish of Pahang River to Chini Lake. All fish also spent most of the time in a particular habitat apart moving freely. A different habitat would be live by different species of fish. The areas near to Chini River have the highest diversity and density of fish. It may be due to the immigrant fish from Pahang River. The densities fish were lower at certain areas at Chini Lake, which be caused by environmental factors that not suitable as fish habitat. The densities fish were lower, due to the environmental factors that are not suitable as fish habitat such as areas of human activity. They usually use water from lake for bathing and washing clothes. Consequently, the disruption of the ecosystem will reduce the diversity species of fish. (Kutty et al, 2009)

CHAPTER 3

METHODOLOGY

3.1 Introduction

Several stages would be taken with the aim to achieve the objectives of this project. Various sources of data had been used to understand the important characteristics involve and then analyze it as workflow. The sources of information were from articles, website, references book, thesis and newspaper.

After that, based on the collected information, the related study has to be gathered. Certain data will be obtained from related agencies or department such as Department of Fisheries and MACRES. The data needed from the department such as satellite image focus on study area and other information related to the study. Then, some fieldwork or process will be done for combining the information with study area.

In satellite image processing, ERDAS IMAGINE 9.1 software was used to perform geometric correction, subset etc. Then, the processed image will be integrated into GIS using ArcGIS software in order to analyze them. Figure 3.1 shows the flow diagram of general methodology and Figure 3.2 shows the flow diagram of detail methodology.

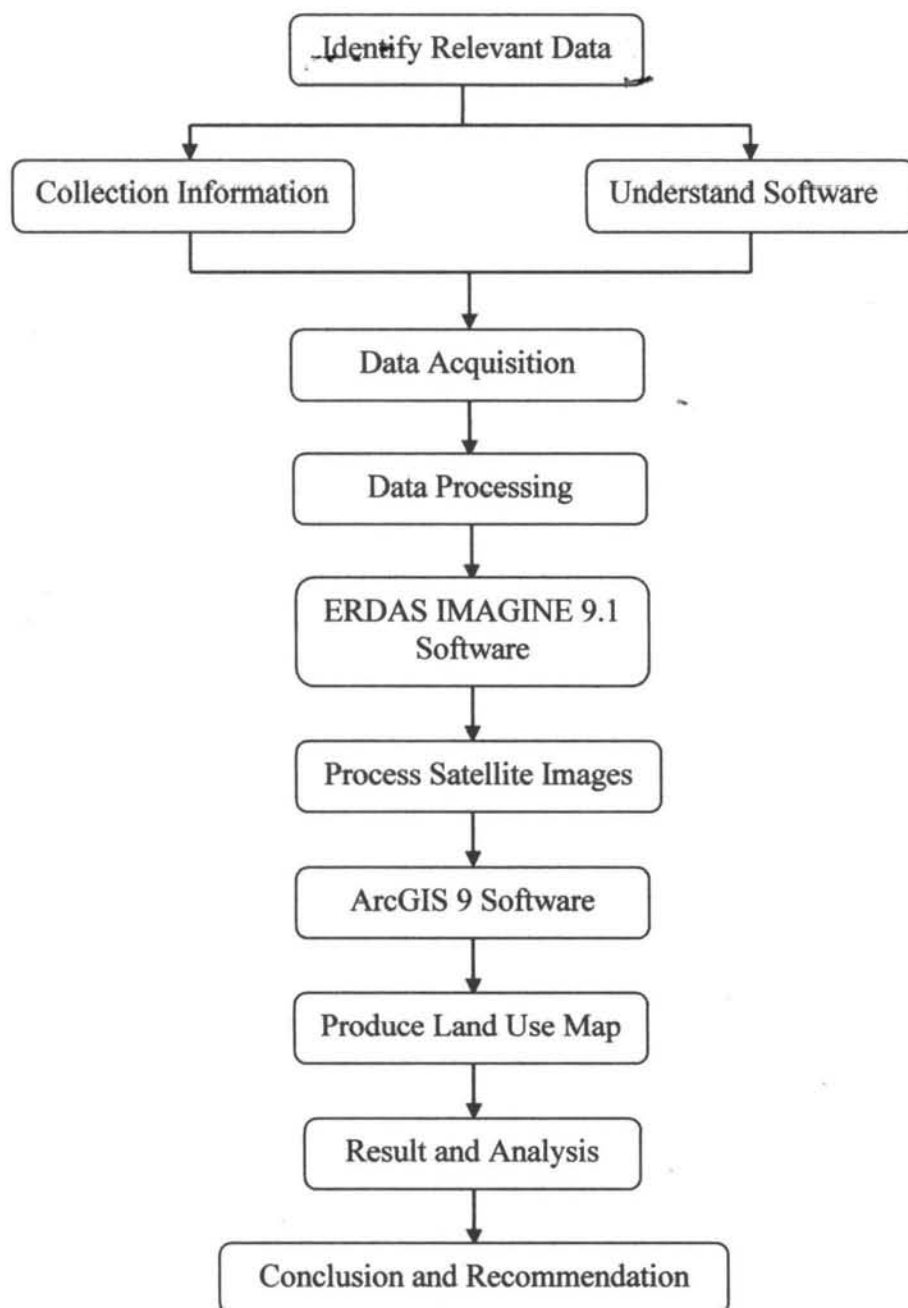


Figure 3.1: Flow diagram of general methodology

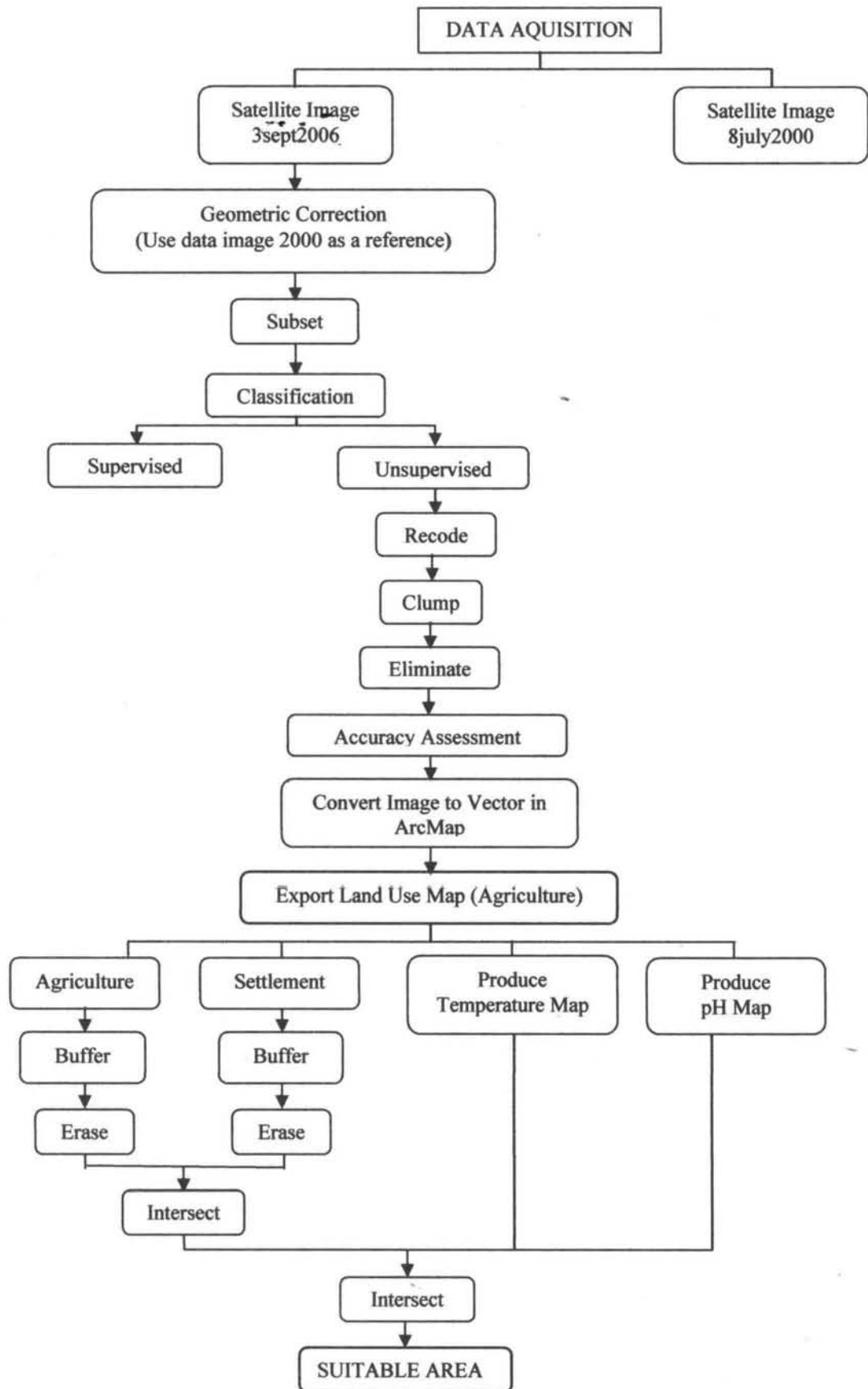


Figure 3.2: Flow diagram of detail methodology using ERDAS and ArcGIS software

3.2 Site Selection

Chini lake freshwater swamp is the second largest of natural lakes in Malaysia. The area of this lake is around 12 565 acres or 5085 ha. It is divided into 12 water bodies call 'laut' by locals, which provide an avenue for breeding, spawning and nursery grounds for resident and migratory fish species. 144 species of freshwater fishes can be found in the lake including Arowana fish.

3.3 Criteria Selection

The selection of natural habitat around Chini Lake for Arowana fish should be compatible with the lifestyle of this fish. The criteria involved should be emphasizing in order to ensure the most suitable area for Arowana fish habitat. This study was carried out to identify the main areas for natural breeding of Arowana fish without any interference from external elements in their natural habitat.

The external elements will greatly affect the quality of water and inviting the water pollution like industrial areas, agricultural at once disrupts the ecology of Arowana fish and other water ecology. Table 3.1 shows the list of suitable criteria use to determine the most suitable habitat for Arowana fish in this project.

Table 3.1: List of suitable criteria use to determine the most suitable habitat for Arowana Fish.

NO	Types	Criteria
1	Agriculture	• Buffer 500m
2	Settlement	• Buffer 500m
3	Temperature	• 23°c - 31°c
4	pH	• 5 - 6.5

3.4 Data Acquisition

Data for this research project were acquired from various organizations like:

- Satellite image (Landsat TM) from Malaysia Remote Sensing Agency (MACRES).
- Arowana fish information from Department of Fisheries (DOF).
- Temperature and pH data from Department of Environment (DOE).
- Unrestricted topology map as indirect reference from Department of Survey and Mapping (JUPEM).

3.5 Software and Hardware

3.5.1 Erdas Imagine 9.1 Software

Erdas Imagine 9.1 software is use to:

- Geometric Correction
- Subset
- Supervised and Unsupervised
- Clump
- Eliminate

3.5.2 ArcGIS 9 Software

ArcGis 9 Software is use to:

- Convert image to vector format
- Buffering operation
- Overlay data (intersect)
- Map layout

3.6 Digital Image Processing

Image is a digital picture or representation of an object on earth base on their general terms. In remotely sensed image data, each pixel represents an area on Earth at a specific location.

Two Landsat TM images of Chini Lake have been used in this study. The image dated 3 September 2006 has been used to produce land use map. For a reference image, the other image of same area dated 8 July 2000 had been used for Geometric Correction process. Figure 3.3 shows Chini Lake image year 2006 and Figure 3.4 shows Chini Lake image year 2000.

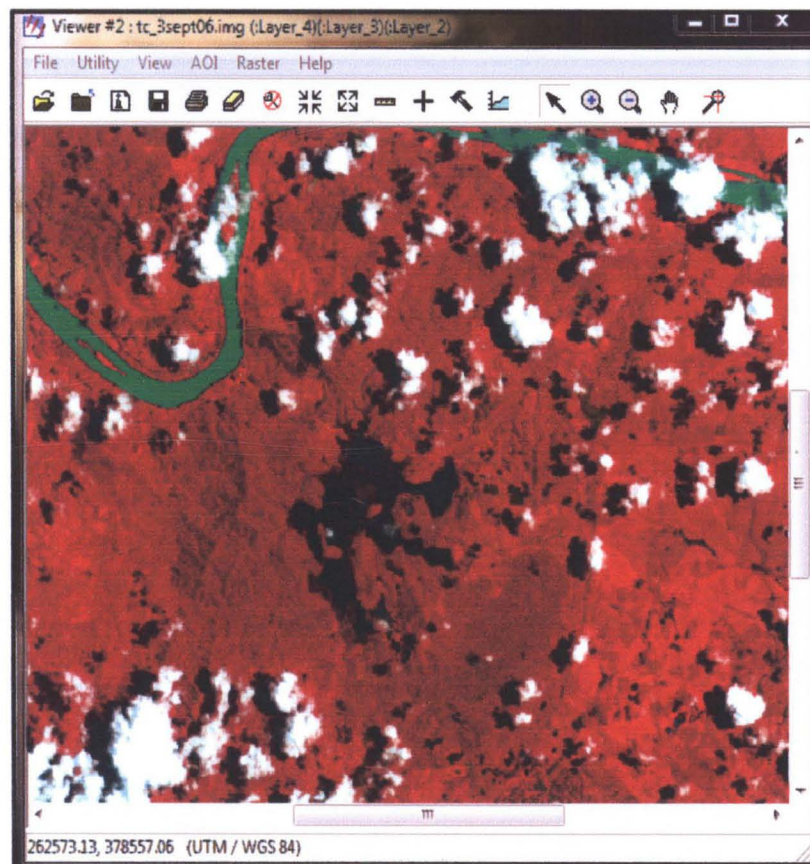


Figure 3.3: Chini Lake image year 2006

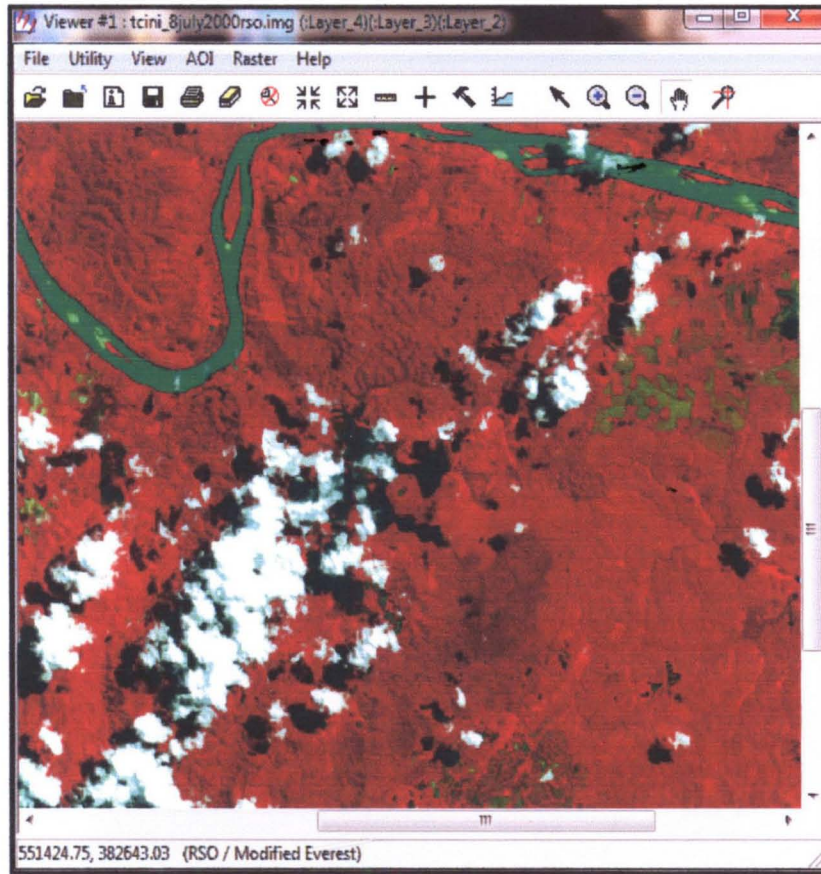


Figure 3.4: Chini Lake image year 2000 as reference

3.6.1 Geometric Correction

Geometric correction is process to correct an image distortion by using any other corrected image as a reference. There were two types of geometric correction namely Image-to-Image registration and Image to Map registration. In this process, satellite image year 2000 used as reference to satellite image year 2006 by collection Ground Control Points (GCPs). The image year 2006 is in UTM/WGS 84 projection and need to be transformed into RSO/Modified Everest projection before the next process can proceeds. Figure 3.5 shows the distribution of GCP'S and Figure 3.6 shows the Root Mean Square Error (RMSE) for geometric correction.

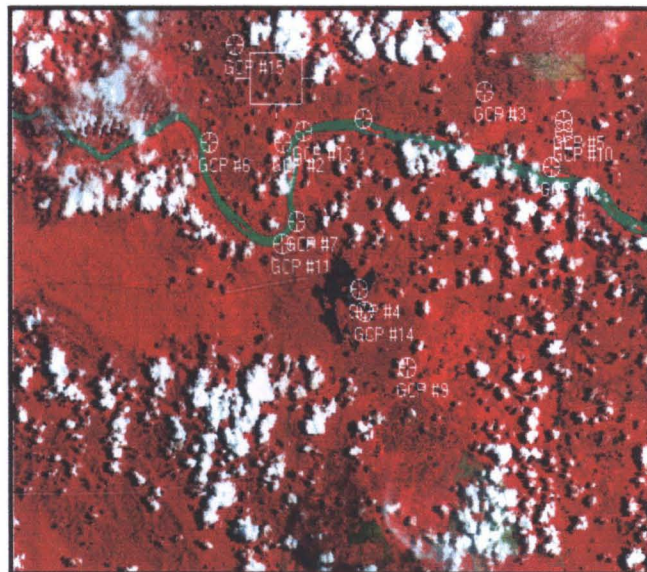


Figure 3.5: Distribution of GCP'S

GCP Tool : (Input : tc_3sept06.img) (Reference : refgcp.gcc)

File View Edit Help

Control Point Error: (X) 0.7473 (Y) 0.7038 (Total) 1.0265

Point #	Point ID	Color	X Input	Y Input	Color	X Ref.	Y Ref.	Type	X Residual	Y Residual	RMS Error	Contrib	Match
1	GCP #1		269431.234	386743.919		547928.748	396880.372	Control	0.945	-0.904	1.365	1.329	
2	GCP #2		265290.194	385685.486		543795.436	385826.685	Control	0.029	-0.774	0.775	0.755	
3	GCP #3		279671.248	387986.468		954153.889	388138.115	Control	-1.869	1.141	2.189	2.133	
4	GCP #4		269203.291	379326.316		547723.185	379467.791	Control	0.717	-0.009	0.717	0.698	
5	GCP #5		279740.378	386705.109		958222.920	386858.678	Control	-0.394	0.825	0.914	0.891	
6	GCP #6		261518.227	385685.105		540028.776	385824.919	Control	0.249	0.541	0.595	0.580	
7	GCP #7		265972.127	382289.359		544487.577	382409.298	Control	0.813	-0.753	1.108	1.079	
8	GCP #8		290204.948	387656.227		528723.823	387788.248	Control	-0.584	-0.221	0.625	0.609	
9	GCP #9		271718.275	375906.126		958243.802	376048.182	Control	-0.584	0.535	0.792	0.771	
10	GCP #10		279733.118	386222.331		958218.064	386373.774	Control	0.544	-1.049	1.181	1.151	
11	GCP #11		265231.625	381267.504		543749.200	381407.690	Control	-1.062	0.534	1.188	1.158	
12	GCP #12		279148.702	384668.730		957639.020	384819.414	Control	0.465	-0.598	0.757	0.737	
13	GCP #13		266361.693	386224.659		544854.289	386388.573	Control	0.344	0.930	0.991	0.966	
14	GCP #14		269510.613	378331.233		548832.365	378472.176	Control	-0.009	-0.250	0.250	0.244	0.638
15	GCP #15		262824.965	390001.068		541320.971	390143.610	Control	0.388	0.133	0.420	0.408	0.962

Figure 3.6: RMS Error

3.6.2 Subset

Subset image refers to the process of cutting out the portion of large area on satellite image into smaller study area. Usually, the original image file that provided, contain larger area than specific study area. Therefore, this process is helpful to trim down the image, focusing to the Area of Interest (AOI) only. It may help to speed up the processing due to the only smaller amount of data to deal with. Figure 3.7 shows image after subset.

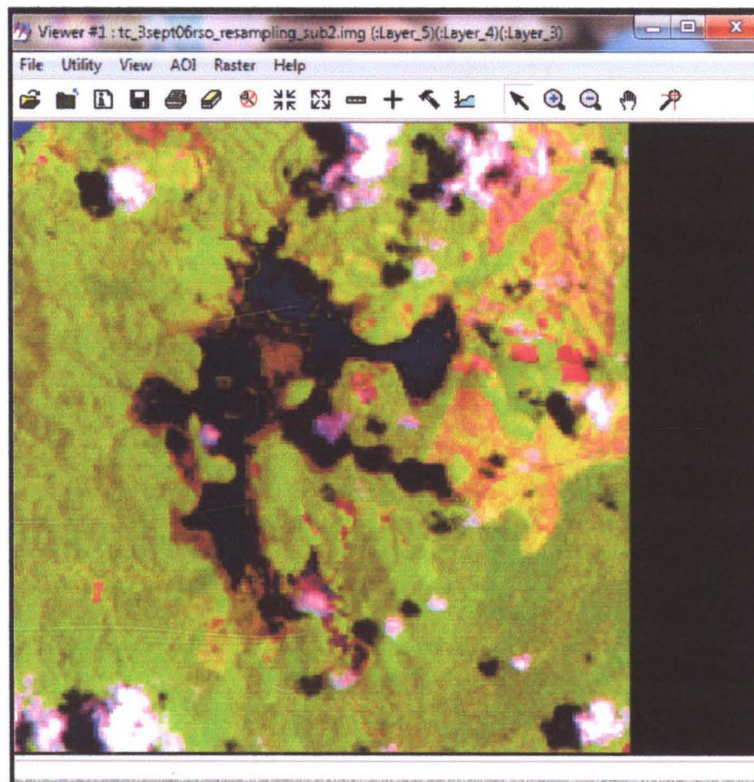


Figure 3.7: Image Subset

3.6.3 Classification

Classification is the process of sorting pixels into a finite number of individual classes or categories of data based on their data file value. The pixel will be classified to the class to match to the criteria if the pixel is suit to the certain criteria.

In the early stage of classification process, the computer must be trained to recognize patterns in the data. Training is the process in identifying the criteria that help in recognized the patterns.

The process of classify the image divided into 2 main categories namely:

- Supervised Classification
- Unsupervised Classification

Supervised Classification

Supervised classification image, and raster attribute table it shown in Figure 3.8 and Figure3.9.

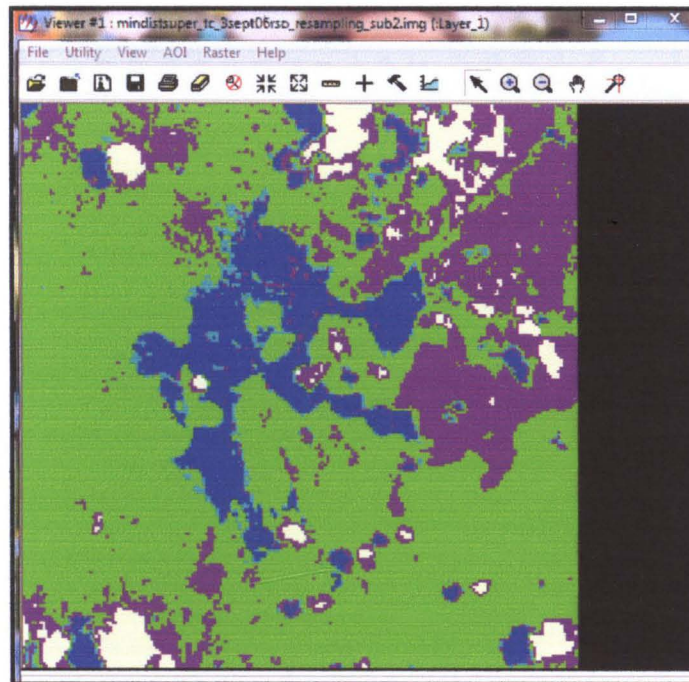


Figure 3.8: Supervised Classification image

Row	Class Names	Histogram	Color	Red	Green
0	Unclassified	0		0	0
1	water1	1687		0	0
2	water2	296		0	0
3	water3	2377		0	0
4	open land	1097		0	1
5	forest1	1724		0.498039	1
6	forest2	1913		0.5	1
7	forest3	5140		0.5	1
8	forest4	9338		0.498039	1
9	forest5	6796		0.498039	1
10	vegetation1	2597		0.627451	0.12549
11	vegetation2	711		0.627451	0.12549
12	vegetation3	2201		0.627451	0.12549
13	vegetation4	3444		0.627451	0.12549
14	Class14	1349		0.96	0.96

Figure 3.9: Raster Attribute Table for Supervised Classification

Unsupervised Classification

Unsupervised classification image, and raster attribute table it shown in figure 3.10 and Figure 3.11

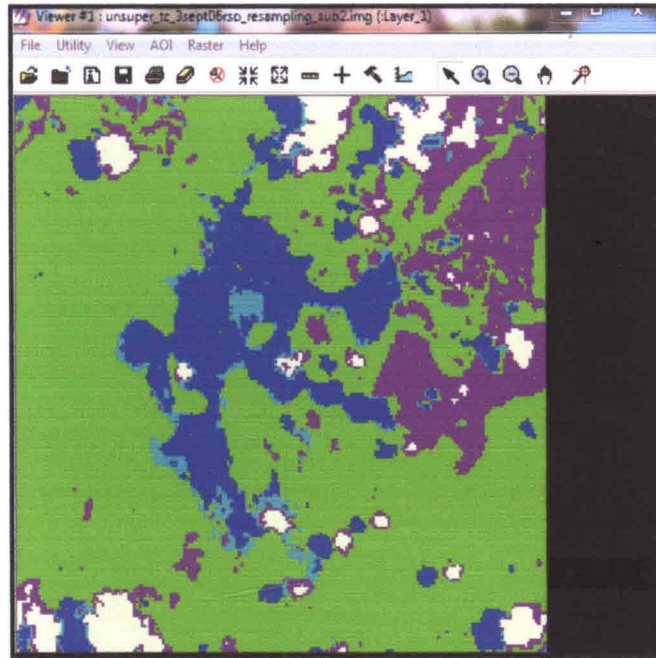


Figure 3.10: Unsupervised Classification Image

Row	Class Names	Histogram	Color	Red	Green
0	Unclassified	0		0	
1	water1	2668		0	
2	water2	2148		0	
3	water3	1234		0	
4	open land	1341		0	
5	forest1	2459		0.498039	
6	forest2	6364		0.498039	
7	forest3	8200		0.498039	
8	forest4	5797		0.498039	
9	forest5	2686		0.498039	
10	vegetation1	1235		0.627451	0.12
11	vegetation2	1397		0.627451	0.12
12	vegetation3	2278		0.627451	0.12
13	vegetation4	1257		0.627451	0.12
14	Class14	1328		0.96	

Figure 3.11: Raster Attribute Table for Unsupervised Classification

After comparing between both classifications processes, unsupervised classification gave better result than supervised classification in classifying the feature. Therefore, the next step of unsupervised classification would be continuing until the suitable area is determined. Figure 3.12 shows unsupervised image after the process of recode, clump and eliminate.

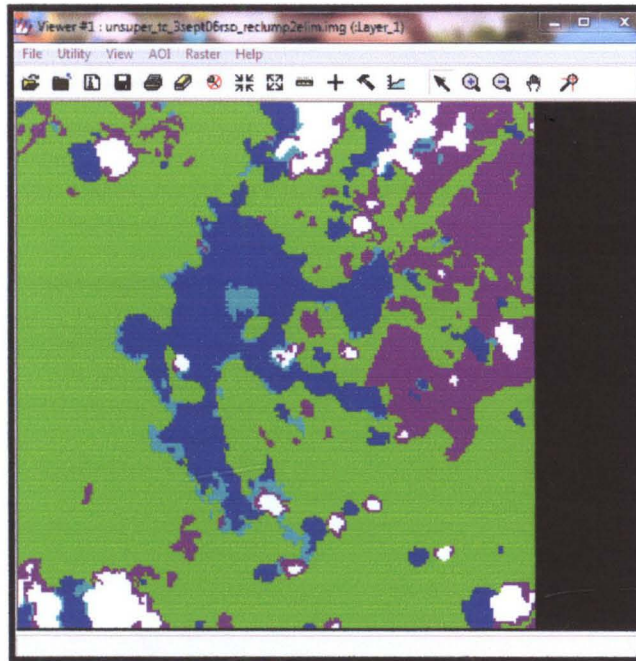


Figure 3.12: Unsupervised Classification Image after Eliminate Process

3.7 Processing Data in ArcGIS Software

3.7.1 Produce land use map from satellite image

This process integrates Remote Sensing and GIS application, in which land use map has been produced by satellite image.

- Image satellite is converted from raster to vector (features) in ArcGIS software. Refer to Figure 3.13.
- Road and settlement had been digitized based on unrestricted topographic map and Google Earth. Refer to Figure 3.14.

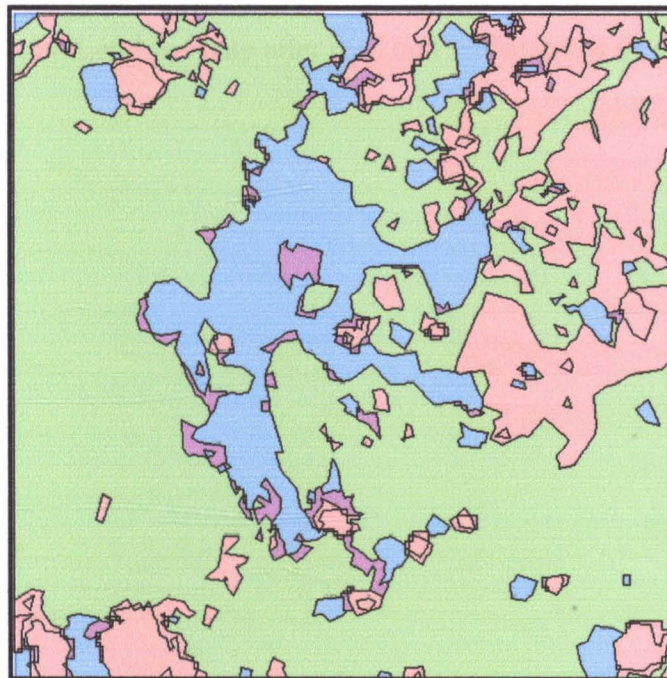


Figure 3.13: Land use map in vector format

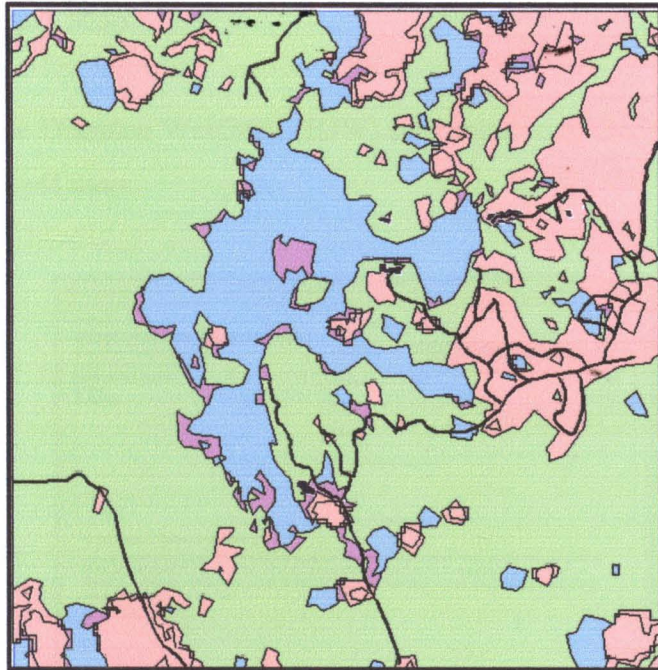


Figure 3.14: Land use map after road and settlement were digitized

3.7.2 Produce pH Map

1. Use Inverse Distance Weighted (IDW) interpolation at Geostatistical Analyst to produce pH map.

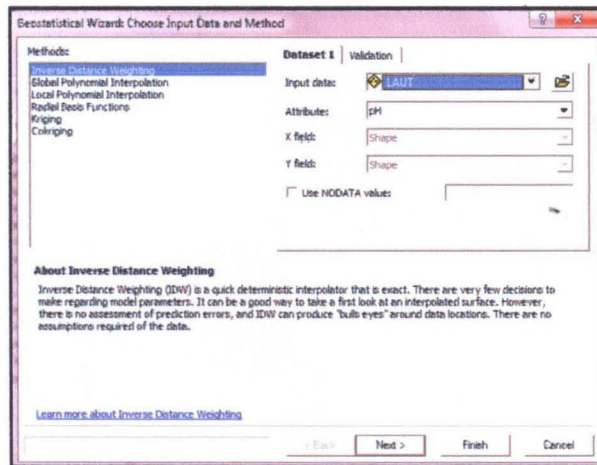


Figure 3.15: Inverse Distance Weighted (IDW) interpolation process for pH

2. The graphic frame of prediction pH map had shown as below.

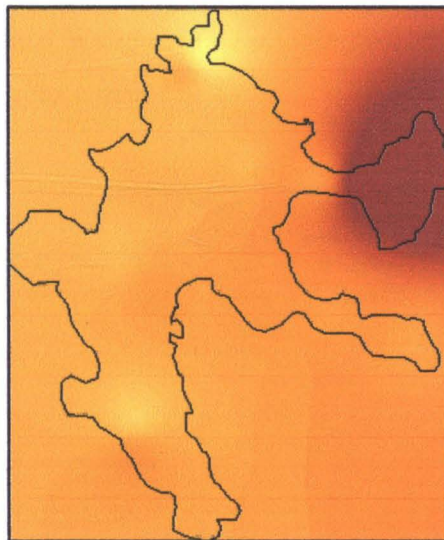


Figure 3.16: Graphic frame of prediction pH map at Chini Lake

3. After convert Inverse Distance Weighted (IDW) Prediction Map to a raster, use extract by mask to create within the lake only. Reclassify into two classes.

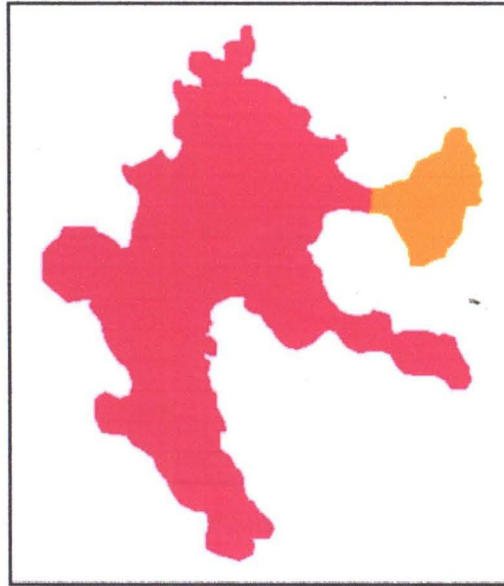


Figure 3.17: pH map after process extract by mask

3.7.3 Produce Temperature Map

1. Use Inverse Distance Weighted (IDW) interpolation at Geostatistical Analyst to produce Temperature map.

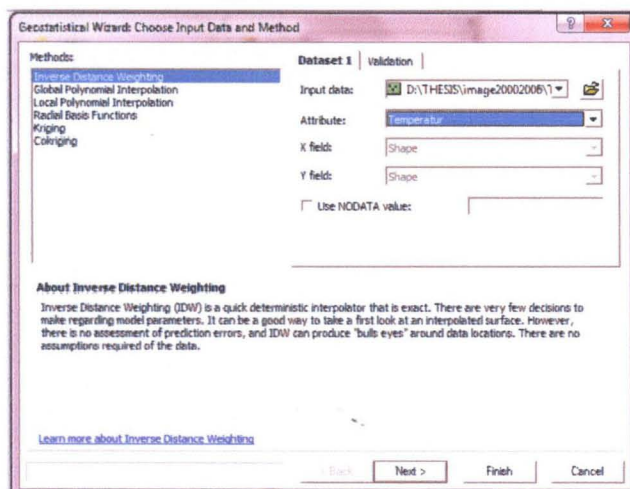


Figure 3.18: Inverse Distance Weighted (IDW) interpolation process for temperature

2. The graphic frame of prediction temperature map had shown as below.

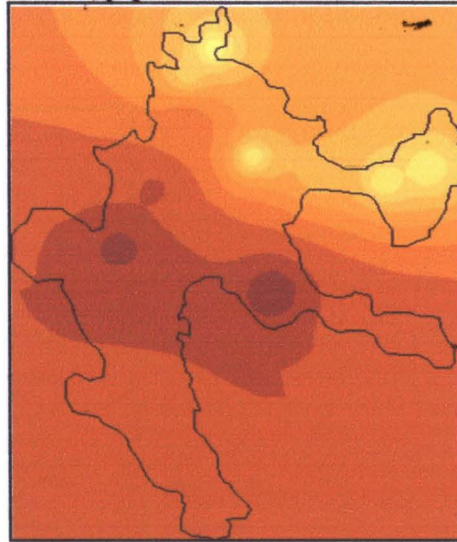


Figure 3.19: Graphic frame of prediction temperature map at Chini Lake

3. After convert Inverse Distance Weighted (IDW) Prediction Map to a raster, use extract by mask to create within the lake only. Reclassify into one class.

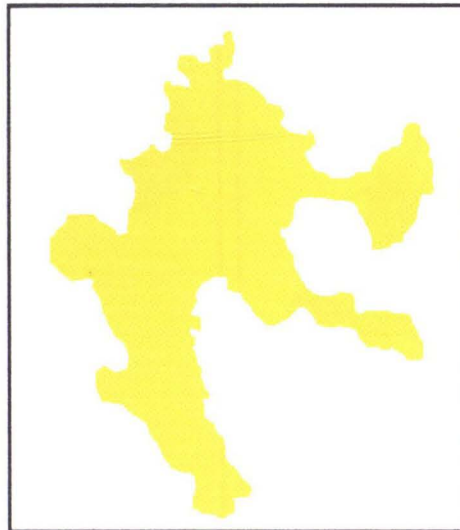


Figure 3.20: Temperature map after process extract by mask

3.7.4 Produce the buffer area

1. Do buffer for layer agriculture and settlement (500meter).

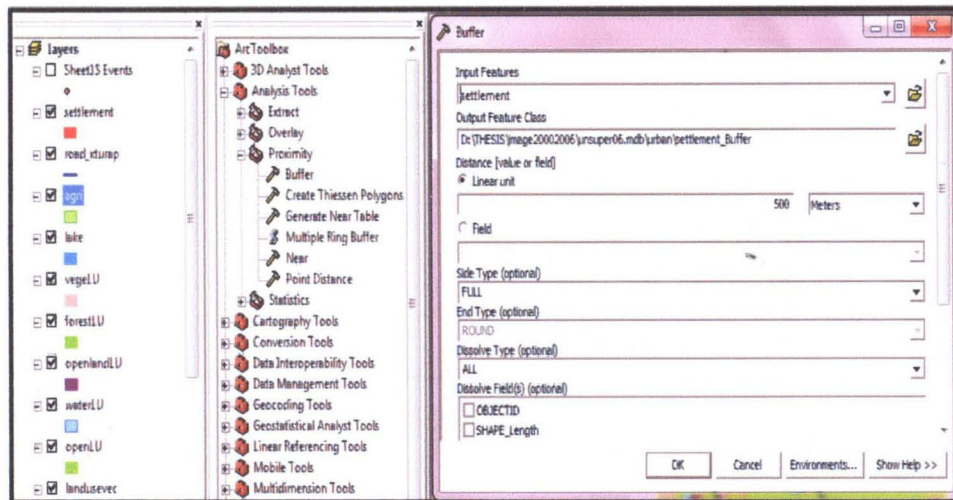


Figure 3.21: Process buffer

2. The result will be show. Then repeat the same step for layer agriculture.

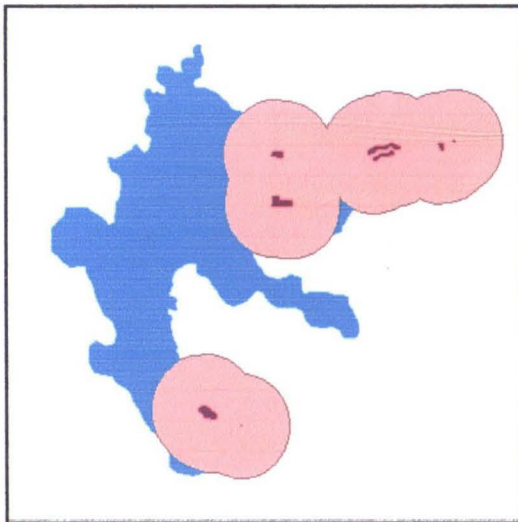


Figure 3.22: Buffer settlement result

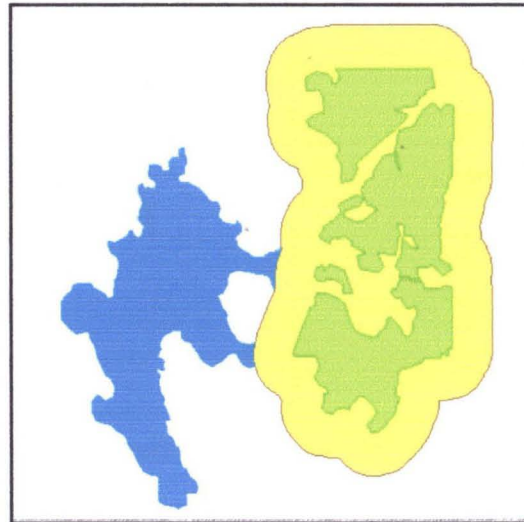


Figure 3.23: Buffer agriculture result

3. After performed buffer settlement, do the erase process between buffer settlement and lake.

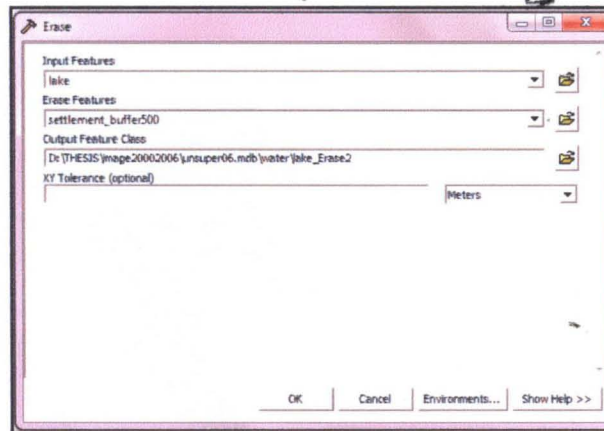


Figure 3.24: Process Erase

4. The result shows below after erase process of buffer settlement and lake.

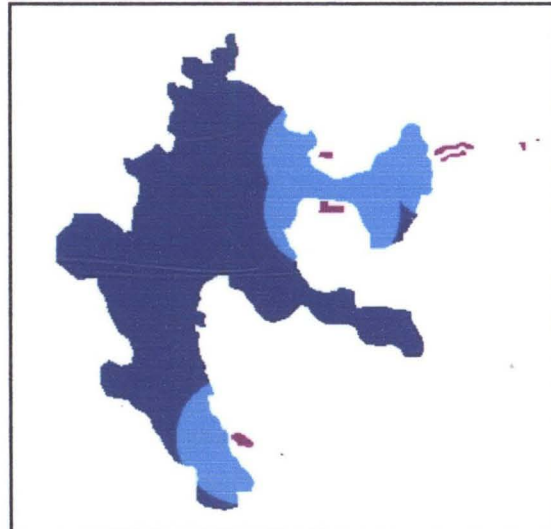


Figure 3.25: Result after erase process of buffer settlement and lake

- Step 3 repeated to erase buffer agriculture and lake. The result shows as below.

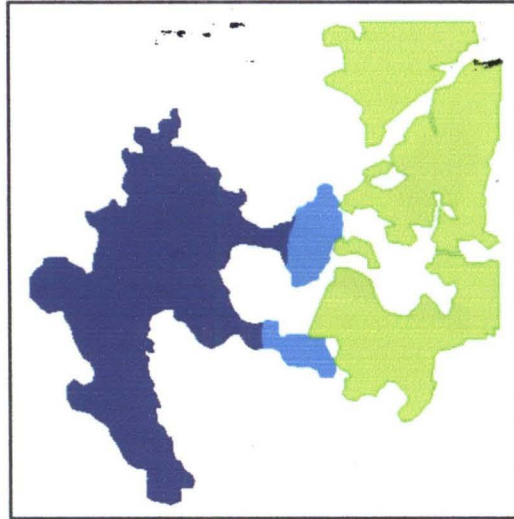


Figure 3.26: Result after erase process of buffer agriculture and lake

- Next, for the purpose to select the suitable area outside the buffer area, intersect both lakes (after erase process).

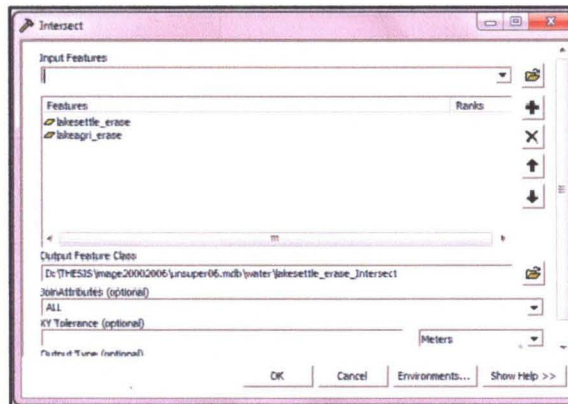


Figure 3.27: Process intersect for both lakes (after erase process)

7. The intersection of both lakes resulted.

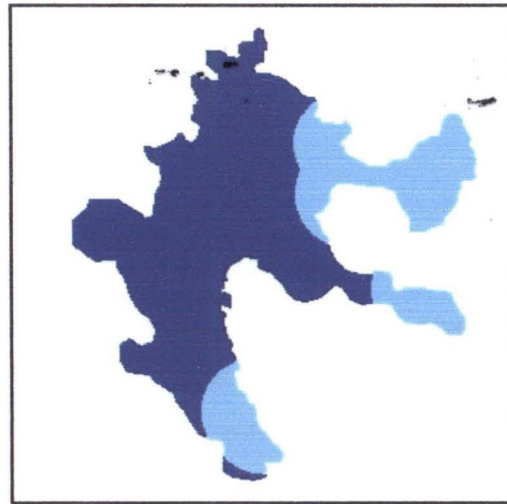


Figure 3.28: Result of intersect process of lake

3.7.5 Produce suitable habitat area

1. Finally, to produce the suitable area, intersect all result such as Buffer Lake, pH map and temperature map. The result has shown as below.

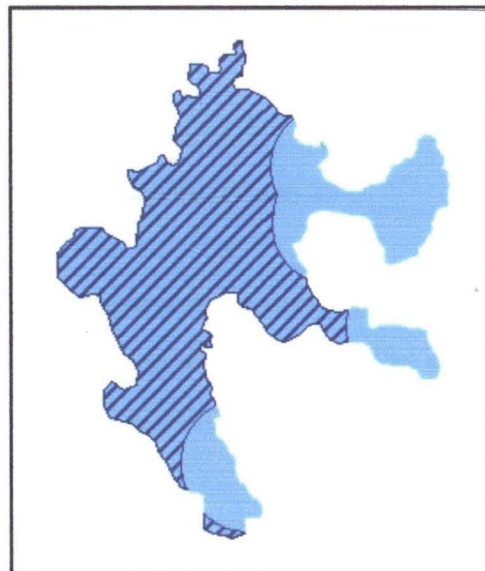


Figure 3.29: Result of suitable area

CHAPTER 4

ANALYSIS AND RESULT

4.1 Introduction

Spatial analysis tool is being used in ArcMap software for data analysis process. It is very important and act as backbone to Geographic Information System (GIS). The capability to present spatial analysis is made GIS difference from other information system. Query of user's question likes how, why, what and where can be tackle using GIS software through GIS spatial analysis.

Four different analyses have been carried out from this project. The analysis based on the criteria that have been chosen in order to determine the suitable habitat area for Arowana fish.

4.2 Analysis I: Analysis on area suitable for habitat of Arowana fish breeding based on pH within 5 to 6.5.

4.3 Analysis II: Analysis on area suitable for habitat of Arowana fish breeding based on temperature within 23°c to 31°c.

4.4 Analysis III: Analysis on area suitable for natural habitat of Arowana fish breeding based on area rely on buffer outside 500 meter from both settlement and agriculture.

4.5 Analysis IV: Analysis for the most suitable natural habitat for Arowana fish using all above criteria.

4.2 Analysis I: Analysis on area suitable for habitat of Arowana fish breeding based on pH within 5 to 6.5.

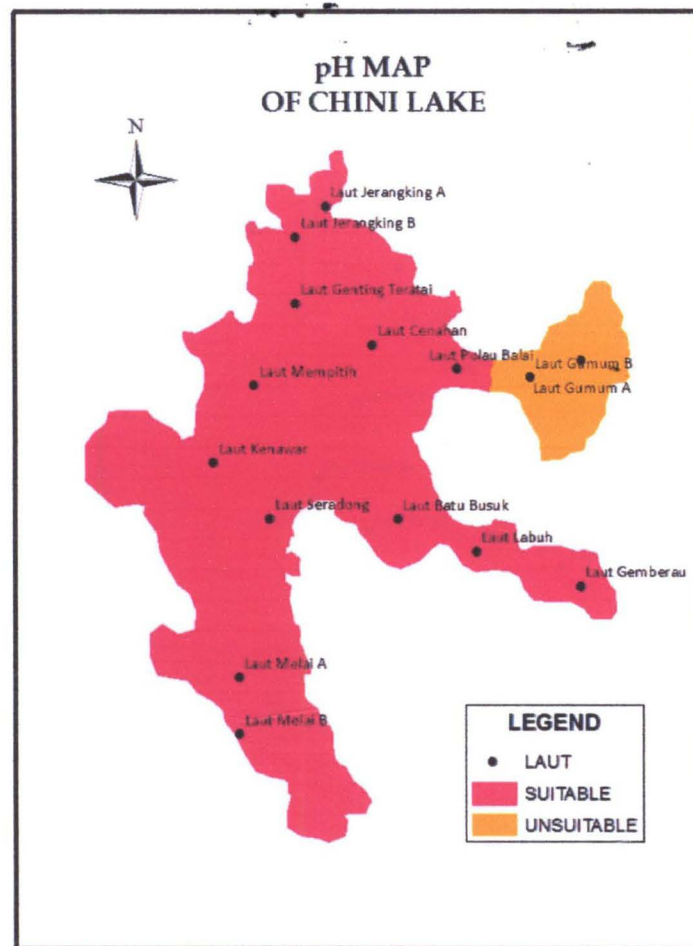


Figure 4.1: pH map

Figure 4.3 shows that the pH suitability at Chini Lake for Arowana fish breeding habitat. Based on the map produced, certain parts at Chini Lake area were suitable for location habitat of Arowana fish because the ideal pH value for Arowana fish natural habitat breeding was around 5 to 6.5, which was slightly acidic water. According to data given by Department of Environment, the pH sampling station at all 12 water bodies at Chini Lake was range from 5 to 8.2. Therefore, all 'laut' was suitable for habitat of Arowana fish breed except Laut Gumum A and B because the high pH value was obtained, which was range from 7.13 to 8.15 pH. Laut Gumum showed the highest rate pH value due to the development of nearby the areas such as indigenous people settlement, resort and expose with agriculture nearby which contributed to the rise of the pH value, compared to other 'laut' which was far from sources of pollution.

4.3 Analysis II: Analysis on area suitable for habitat of Arowana fish breeding based on temperature within 23°C to 31°C.



Figure 4.2: Temperature Map

Figure 4.3 shows that the temperature suitability at Chini Lake for Arowana fish breeding habitat. Based on the map produced, all Chini Lake area was suitable for location habitat of Arowana fish because the appropriate temperature for Arowana fish at their natural habitat is around 23°C to 31°C. According to data given by Department of Environment, their sampling station on all 12 water bodies at Chini Lake was range between 30.31°C to 30.92°C. The lower temperature value was 30.1°C at Laut Jerangking. Meanwhile, the highest temperature value was 30.92°C, which came from Laut Batu Busuk. However, the temperature can changes depend on the weather. Ordinarily, temperature will a slightly fall at the end of the year due to the rainy season.

4.4 Analysis III: Analysis on area suitable for natural habitat of Arowana fish

breeding based on area rely on buffer outside 500 meter from both settlement and agriculture.

The suitable natural habitat for Arowana fish should far from the agriculture area because the waste of nutrient and phosphorus from the area could caused an excess nutrient to Chini Lake. The agriculture areas such as oil palm and rubber plantation released pesticides, fertilizers, wastewater lead to phenomena of Eutrofication in the lake. Eutrofication is phenomena when the water acquires the high concentration of nutrient in the water. When the sediment increased, it assists the growth of algae that leads to the death of Arowana fish and other fish species. Thus, the area close to the agriculture is not the suitable habitat for Arowana fish breed. The figure 4.1 shows the agriculture buffer.

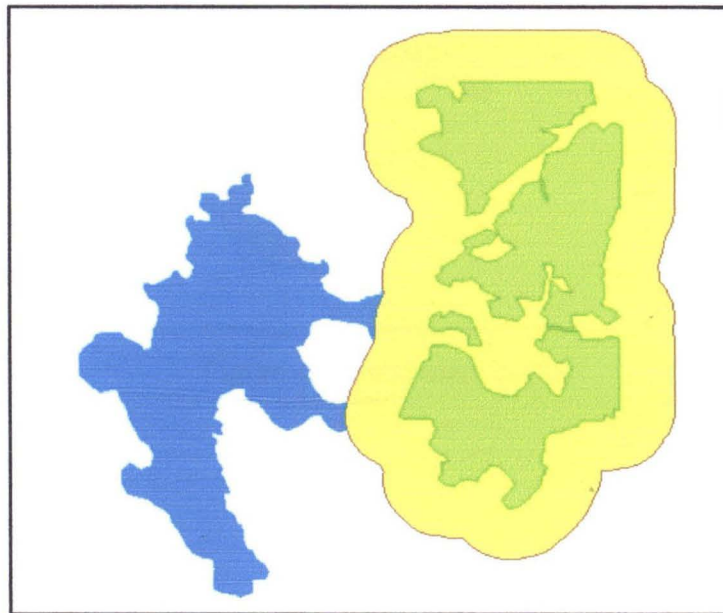


Figure 4.3: Agriculture buffer

The buffering 500 meter of settlement area might help the identification of suitable habitat for Arowana fish. The urban area such as indigenous settlement, a resort and national camp rely within 500 meter could contributed the organic loading and not suitable for habitat Arowana fish breeding. The organic loading was come from the daily activities of local community, tourist and the camp residents such as human waste and use of detergent. These wastes are eventually contaminating the water bodies that disrupt Arowana habitat. Figure 4.2 shows the settlement buffer.

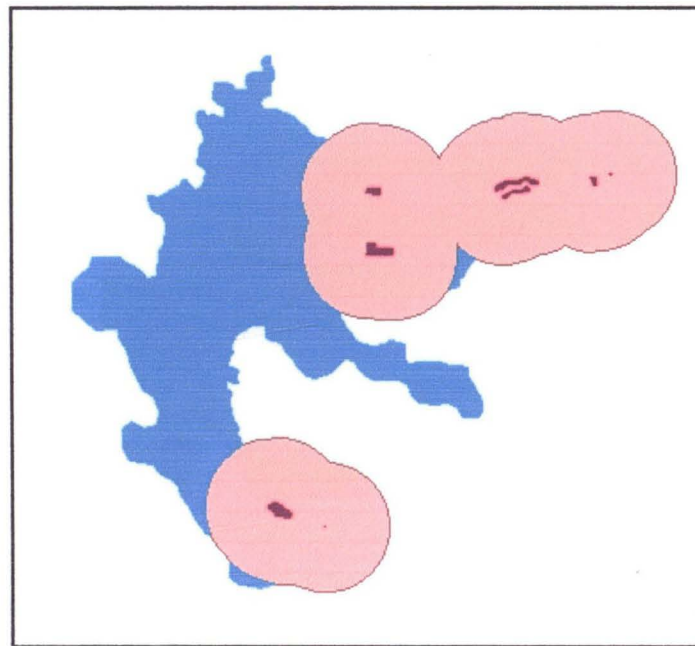


Figure 4.4: Settlement buffer

4.5 Analysis IV: Analysis for the most suitable natural habitat for Arowana fish using all above criteria.

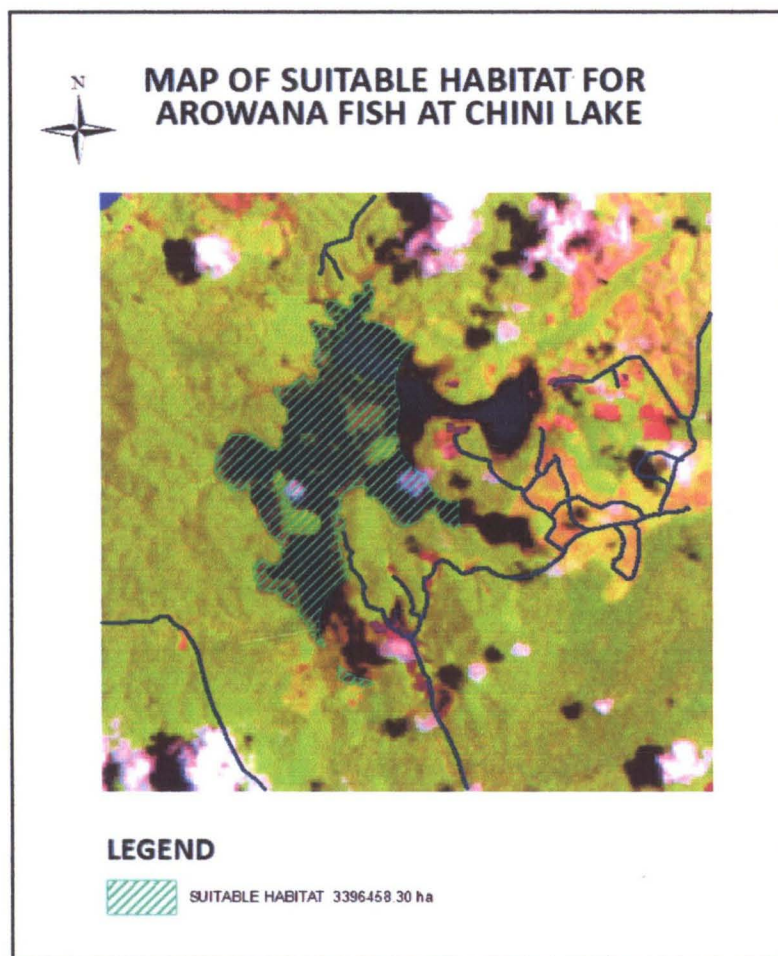


Figure 4.5: Detection of suitable habitat for Arowana Fish

Figure 4.5 shows the detection of suitable area for Arowana Fish breeding by overlaying the result from GIS analysis on a satellite image. The suitable area at Chini Lake was around 3396458.30255112 hectares. Majority of the suitable areas for breeding was far from agriculture and settlement areas correspond with the GIS analysis result. This integration shows that the area from satellite image verified the selected criteria. Laut Gumum, Laut Pulau Balai, Laut Gemberau, and Laut Melai proved as unsuitable habitat for Arowana fish after the overlaying process had been done. Therefore, it can be concluded that the suitable habitat areas were the areas where are far from agriculture area and settlement area and unaffected by the pollution's factor such as agriculture and settlement or urban area.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Based on the analysis, it can be concluded that the criteria chosen were very important aspect required in detecting the suitable habitat for Arowana fish. These parameters and factors were selected based on the surrounding areas that are exposed to pollution such as tourism resort, indigenous people settlement, national service camp, agriculture etc. With the help water temperature and pH, the suitability of the habitat can be obtained.

Nowadays, Geographic Information System (GIS) and Remote Sensing integration is not only important but compulsory in order to fulfill the information needed. This application really complements each other, in which the best result can be obtained by their integration. Therefore, this method can be used for other sectors and various applications for getting the best outcome.

5.2 Recommendations

Based on this study, there are some recommendations that can be suggested. This study only focuses on water quality such as water temperature, pH and other surrounding factor such as agriculture and urban area. Therefore, for the next study, the additional criteria need to be considered such as Dissolved Oxygen (DO) and turbidity. The quantity of criteria chosen also can influence the selected suitable area for Arowana's habitat. Hence, the more criteria chosen, the more accurate of suitable area will be shown.

Furthermore, to further the study about Arowana fish habitat, these criteria can be used in detecting the suitable locations for Arowana fish farming. Many factors can be considered in locating some other places as Arowana farming to extent and keep this fish from extinction. The criteria that can be concerned are land use, area slope, soil class and area surrounding factor.

5.3 Final Remarks

In this final remark, it can be said that the aim and objectives are achieved. The potential habitat was identified using integrating Remote Sensing and Geographic Information System (GIS). Nowadays, these both techniques become popular and very effective in detecting and mapping the suitable habitat. The pattern mapping of habitat predicted based on the satellite image data and the water quality data provided by Department of Environment.

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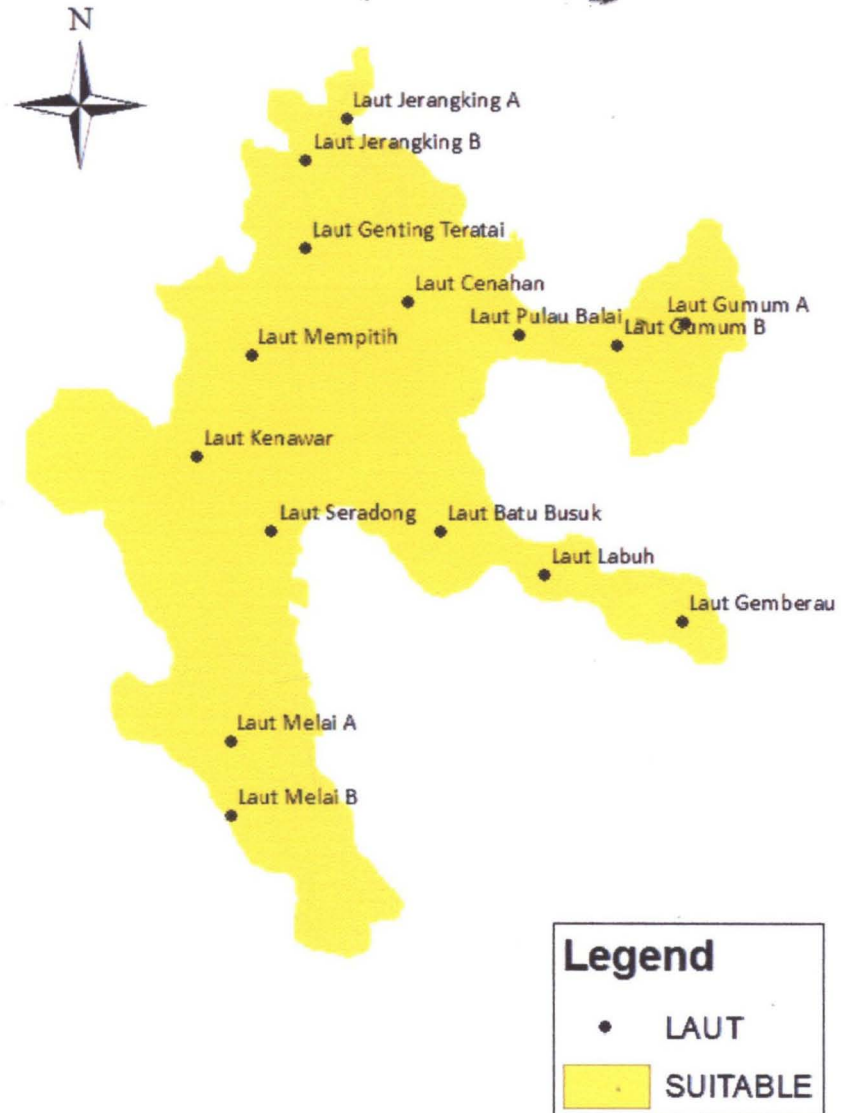
APPENDICES

pH MAP OF CHINI LAKE



APPENDIX A

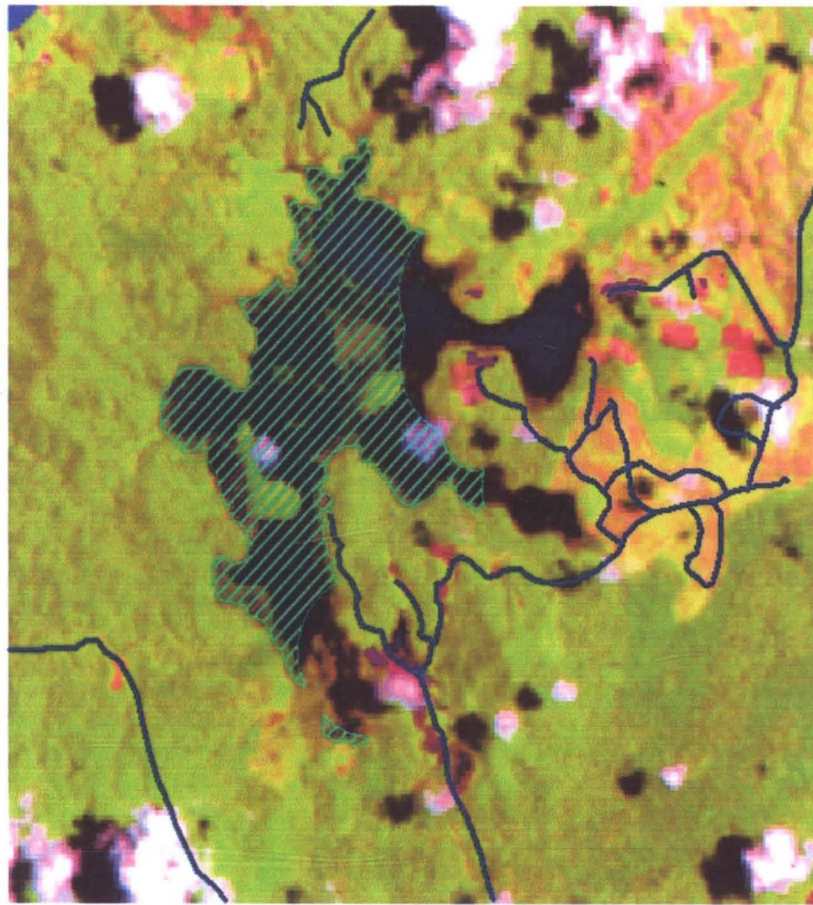
TEMPERATURE MAP OF CHINI LAKE



APPENDIX B



MAP OF SUITABLE HABITAT FOR AROWANA FISH AT CHINI LAKE



LEGEND

 SUITABLE HABITAT 3396458.30 ha

ID	Nama Laut	X	Y	Temperature	pH
1	Laut Gumum A	548277.383	379903.202	30.32	8.15
2	Laut Gumum B	547966.086	379802.551	30.32	7.13
3	Laut Pulau Balai	547524.69	379849.014	30.36	6.02
4	Laut Cenahan	547012.137	379996.714	30.32	5.82
5	Laut Jerangking A	546735.287	380826.227	30.31	5.29
6	Laut Jerangking B	546549.914	380642.162	30.34	5.91
7	Laut Genting Teratai	546549.475	380242.913	30.56	5.79
8	Laut Mempitih	546302.038	379751.801	30.78	5.86
9	Laut Kenawar	546054.632	379291.402	30.9	5.75
10	Laut Seradong	546393.745	378953.202	30.83	6.04
11	Laut Melai A	546207.521	378001.353	30.69	5.63
12	Laut Melai B	546207.149	377663.534	30.75	6.12
13	Laut Batu Busuk	547165.305	378952.356	30.94	6.07
14	Laut Labuh	547640.847	378757.138	30.76	6.02
15	Laut Gemberau	548268.094	378548.056	30.76	5.98

APPENDIC D

