THE APPLICATION OF GIS BASED MULTI-CRITERIA ANALYSIS FOR SELECTING AN OPTIMUM WATER RESERVOIR SITE

BAKHTYAR ALI AHMAD

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This work is dedicated to my beloved parents, my father **ALI AHMAD** and my mother **TUBA TAHA** for their resilience in insisting to educate me amidst the absolute poverty in which they raised me.

To **PESHMARGA**, Kurdish forces who devote their entire life to defending the holy land of Kurdistan.

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ABSTRACT

Malaysia is well endowed with abundance of natural water resources, which has significantly contributed to the socio-economic development of the country. However, the situation has somewhat changed over the last decade. The water demand was 174.22 M/l/d in year 2010 and it is projected to be 270.77 M/l/d in 2050. In such scenario, a reliable and safe supply of water for future generations, more and more reservoirs will be required. The aim of this study is to apply GIS in identifying the most suitable location for water reservoir for area of Batu Pahat, Johor, West Malaysia. Methodology is designed in such a way to achieve the objectives of this study as to identify the important criteria for locating water reservoir, to model the location of reservoir using Analytical Hierarchy Process (AHP) and to analyze and evaluate the most potential sites for water reservoir using ArcGIS 10.1 software. Based on the criteria chosen, the data are processed and analyzed the existing 52 reservoir locations and their capacities. Based on the projected number of population for the year 2050, as a result, 5 new reservoir locations have been identified to fulfill the future demands of water for the study area. Thus, it can be concluded that the weights derived from AHP integrated in ArcGIS can be a useful tool in GIS analysis for the determination of suitable locations for water reservoir in the study area.

ABSTRAK

Malaysia dikurniakan dengan banyak sumber-sumber air semula jadi yang telah banyak menyumbang kepada pembangunan sosio-ekonomi negara. Walau bagaimanapun, keadaan agak berubah dalam beberapa dekad mutakhir. Permintaan air adalah sebanyak 174.22 M/l/d pada tahun 2010 dan ia dijangka akan meningkat kepada 270.77 M/l/d pada tahun 2050. Dalam senario sebegini, bekalan air yang boleh digunakan dan selamat untuk generasi akan datang, memerlukan lebih banyak takungan air untuk masa hadapan. Kajian ini bertujuan untuk mengaplikasi GIS dalam mengenal pasti lokasi yang paling sesuai untuk takungan air bagi kawasan Batu Pahat, Johor, Malaysia Barat. Metodologi kajian ini direka sedemikian rupa untuk mencapai objektif-objektif kajian ini yakni untuk mengenalpasti kriteria penting untuk mengesan takungan air, untuk pemodelan lokasi takungan menggunakan proses analisis hiraki (AHP) dan untuk menganalisis dan menilai kawasan yang berpotensi untuk takungan air menggunakan perisian ArcGIS 10.1. Berdasarkan kriteria-kriteria yang dipilih, data diproses dan dianalisis berasaskan 52 lokasi takungan yang sedia ada termasuklah keupayaan masakini. Berdasarkan unjuran bilangan penduduk pada tahun 2050, hasilnya, 5 lokasi takungan baru telah dikenalpasti untuk memenuhi permintaan masa hadapan air bagi kawasan kajian. Oleh itu, ianya dapat disimpulkan bahawa pemberat yang diperolehi daripada AHP yang diintegrasikan dengan ArcGIS boleh menjadi alat yang berguna dalam analisis GIS bagi menentukan lokasi yang sesuai untuk takungan air di kawasan kajian.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Water is absolutely fundamental to life and luckily the earth is almost submerged in with water. An amount 325 mi^3 occupies 71% of the globe. Salt water of the oceans and sea accounts for about 97.5% of this volume. The remaining 2.5% is fresh water (Wright and Nebel, 2004) of the 2.5% though; two/third is stored in glaciers and polar ice caps. Thus, only 0.77% of all water is available in atmosphere, soil, groundwater, rivers, wetland and lakes (Wright and Nebel, 2004).

Malaysia is fully blessed with plentiful supply of water naturally; this has prominently assisted importantly to the socio-economic advancement of the country. However, in recent years the condition has transformed to that of shortage of water (Moorthy and Jeyabalan, 2011). In certain river basins, paucity of water is experienced in periods of prolong droughts while flooding and surplus of water is present in the rainy season (Husaini, 2007). The rapid increase in population, urbanization, industrialization and increased in irrigated agriculture imposing increasing water demand and inserting extra pressure on existing water resources. There is a need to construct new water reservoirs for meeting the future water demand effectively. The selection of suitable site for water reservoir is very important as many parameters need to be considered such as topographical and geological conditions, hydrological features, and availability of construction material, safety, environmental issues and economic evaluation (Arai and Hiros, 2003). It is necessary to identify and quantify

these factors for selecting a suitable area for water reservoir in a particular area. A Geographic Information System (GIS) can be used effectively for this purpose to combine different themes objectively and analyse those systematically for identifying suitable places (Shahid, Nath, and Roy, 2000)

The aim of this research is to identify the suitable sites for water reservoir. The evaluation system is based on number of multiple criteria indicators. The main criteria selected for this study are pipe line, elevation, rive, Land use, road network, water supply network and slope. The Analytical Hierarchy Process (AHP) proposed for use to derive weights. The Batu Pahat a district in Johor state is selected as the study area. The water demand was 174.22 M/l/d in year 2010 and it is projected to be 270.77 M/l/d in 2050 (DID, 2010). In such scenario, a reliable and safe supply of water for future generations, more and more reservoirs will be required.

1.2 Problem Statement

The rising tendency in urbanization and population has increased the water demand. This rising tendency in urbanization and population has raised the demand for new water reservoirs to meet the growing need of water. To ensure a reliable and safe supply for future generations, more and more reservoirs will be required. The selection of suitable site for water reservoir is extremely difficult in recent years as the proper selection of suitable site considers many factors such as hydrological, geological and socio-economic parameters. The water demand was 174.22 M/l/d in year 2010 and it is projected to be 270.77 M/l/d in 2050 (DID, 2010). In such scenario, a reliable and safe supply of water for future generations, more and more reservoirs will be required.

1.3 Study Area

Batu Pahat is a town under Johor state of Malaysia. Geographically it is located between Longitudes 102°56′ and 102.933'E and Latitudes 1°51′N and 1.850°N. The town share borders with Pontian, Muar, Kluang to the southeast, west and east respectively and in the north Ledang and Segamat . The area of Batu Pahat is 1,999 km^2 with a population of 406,000 and is the second populous district in Johor state. The population density is 203 person/km^2 with a growth rate (DOS, 2010). The urbanization rate is related to population growth. It is projected that urbanization will be 95% in 2050. The long term mean monthly rainfall at Batu Pahat station is 2057 mm and mean potential evaporation rate is 1324 mm. The water demand was 174.22 Million litter per day (M/l/d) and it is projected to be 270.77 M/l/d in 2050 (DID, 2010) Figure1.1 shows the study area.

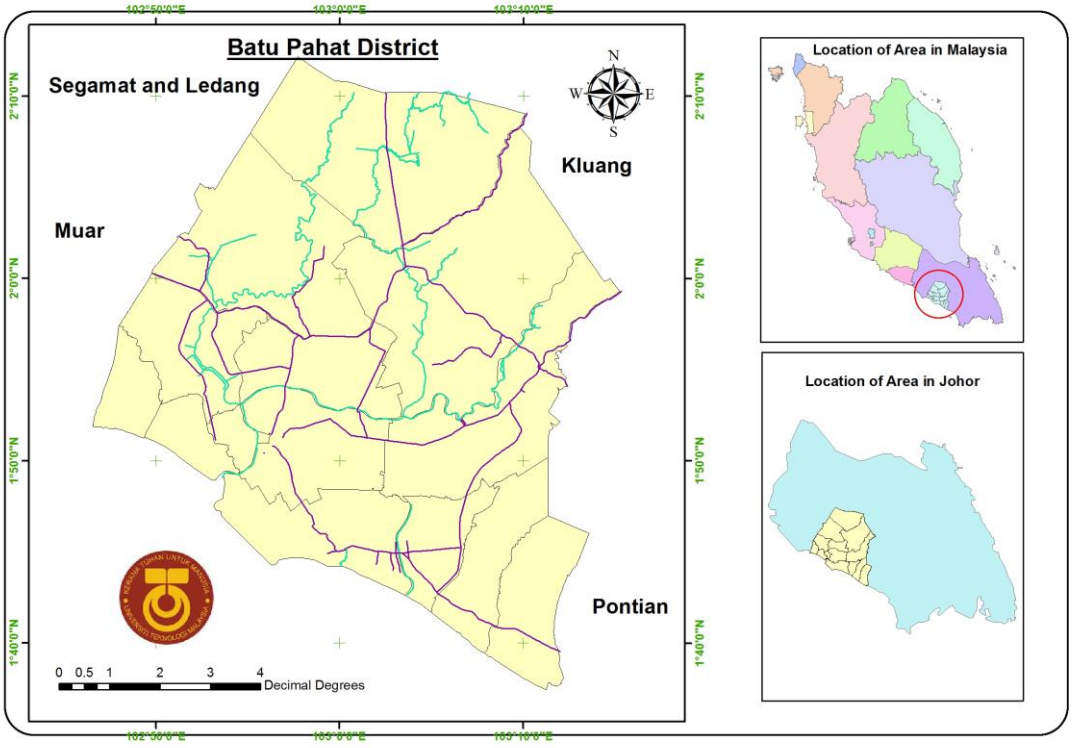

Figure 1.1 Study Area

1.4 Main Research Question

How to use a GIS based on Multi-criteria Analysis (MCA) for selecting the suitable location of water reservoir.

1.5 Aim of Study

The aim of study is to utilise GIS model analysis in identifying the suitable location for water reservoir in the area of Batu Pahat, Johor.

1.6 Objectives of Study

1. To identify the important criteria for locating water reservoir.

2. To model the location of Reservoir using Analytic Hierarchy Process (AHP).

3. To analyse and evaluate the most potential sites for water reservoir.

1.7 Specific Research Questions

1. What are the important criteria for locating water reservoir in Batu Pahat?

2. What are the population and the water demand of the study?

3. What is Analytic Hierarchy Process and it uses?

4. How to use Analytic Hierarchy Process to analysis a suitable location for water reservoir?

5. How to apply GIS model and analysis to show the potential sites for water reservoir?

1.8 Scope of Study

The applications of GIS are numerous in different fields of Sciences and Engineering. In this study, GIS is used to identify the suitable sites for water reservoir to meet the future water demand. The selection of suitable site is challenging as it is based on multiple criteria. AHP is popular multiple criteria methods for deriving the importance of one criteria over the other. The proposed study area will be conducted for Batu Pahat covering an area of 1,999 km^2 located in Johor state of Malaysia.

1.9 Need of the Study

The rapid increase in population, urbanization, industrialization and increased in irrigated agriculture imposing increasing water demand and inserting extra pressure on existing water resources. There is a need to construct new water reservoirs for meeting the future water demand effectively. The selection of suitable site for water reservoir is very important. The urban planners and decision makers take proper decision on allocation of land for future expansion.

1.10 Summary

This chapter highlights the importance of water to human lives. As the population increased the demands for water consumption also increased and becoming more critical and hard to manage. As a result, the needs for water supply also increased tremendously. Thus, the existing reservoir's capacity could not cope for future water demands. In relation to this, aim and objectives of this study are determined in this chapter. Similarly, the scope of study, methodology to be used, expected results and significance of the study have been identified and specified.

In relation to this chapter, Chapter 2 is dedicated to literature reviews and related studies whereas Chapter 3 is focused on the methodology used in this study. The results and analysis are discussed and presented in Chapter 4 and conclusion is drawn in Chapter 5.

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