UNIVERSITI PUTRA MALAYSIA

APPLICATION OF GEOGRAPHIC INFORMATION SYSTEM FOR IRRIGATION MANAGEMENT

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Master of Science

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Dedicated to my beloved Parents, Brothers, Family members and Friends

To my Respected Supervisors, Teachers, and all others who guided me till now

Abstract of this thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirements for the degree of Master of Science

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Chairman: **Associate Professor Ir. Dr. Mohd. Amin. Mohd. Soom**

Faculty: **Engineering**

Water plays an important role in crop production. A good irrigation water management system has to be provided to give adequate and timely supply of water to improve the crop production. In order to achieve this, it is necessary to have adequate water source, a good conveyance system, a good distribution system and a strong database to store all the required data. Improved management can be achieved when the study area has been provided with a good database to store the real time data according to the seasons that will help the users and the decision makers to make a firm decision with respect to the management aspect. Visual Basic and GIS can greatly help to achieve efficient water management. The Tanjung Karang Rice Irrigation Project in Northwest Selangor Malaysia was selected for this study and three compartments Sawah Sempadan, Sungai Burong and Sungai Nipah were considered for the study.

The Visual Basic program designed in this study with several screens provides unique results based on the water management. The program was designed, tested and the results stored in MS-Access database. This study concentrates on creating an irrigation water management database and providing a user-friendly on-farm decision support system to benefit the farmers and the farm managers. Critical solutions can be achieved by creating a useful database for irrigation management. The designed database can store, edit, update and delete the data records whenever necessary.

The GIS user interface for the irrigation system promises to provide comprehensible results to improve the decision making process in the operation and management of the scheme. MapInfo Professional Software 5.0 was used to digitize the Tanjung Karang study area. The digitized maps were exported from MapInfo to ArcView GIS 3.1 using Universal Translator. ArcView GIS 3.1 was used for analysis and the results shown in the form of thematic maps, tables, graphs and charts to benefit the users and decision makers involve with irrigation water management.

Abastrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi sebahagian daripada keperluan untuk ijazah Master Sains

APPLIKASI GEOGRAPHIK INFORMATION SISTEM DALAM PENGURUSAN SISTEM PENGAIRAN

Oleh

DEEPAK. T. J.

Oktober 2002

Pengerusi: **Professor. Madya. Ir. Dr. Mohd. Amin Mohd. Soom**

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Air memainkan peranan yang penting dalam penghasilan tanaman. Satu sistem pengurusan pangairan yang baik perlu disediakan untuk membekalkan air yang secukupnya pada waktu yang sesuai supaya penghasilan tanaman dapat ditingkatkan. Sumber air yang secukupnya, sistem pengangkutan serta sistem pengedaran yang baik adalah diperlukan untuk mencapai objektif di atas. Justeru itu, kita memerlukan pangkalan data yang kukuh untuk menyimpan segala data yang dikehendaki dan mendapatkannya kembali dengan mudah apabila data tersebut diperlukan. Pengurusan pengairan yang baik boleh dicapai dengan bantuan Program Asas Visual dan GIS. Projek Pengairan Padi di Tanjung Karang yang terletak di Barat Laut Negeri Selangor, Malaysia telah dijadikan model untuk kajian ini dan kompatmen seperti Sawah Sempadan, Sungai Burung dan Sungai Nipah diambil kira sebagai kawasan kajian utama.

Program Asas Visual yang direkabentuk dengan pelbagai layar memberikan hasil yang unik berdasarkan kepada pengurusan air. Program yang direkabentuk itu diuji dan hasilnya disimpan dalam pangkalan data 'MS-Access' dalam format yang diingini. Kajian ini memberi tumpun ke atas penciptaan satu pangkalan data dalam pengurusan sistem pengairan serta menyadiakan satu sistem 'user friendly' sebagai sokongan terhadap keputusan yang dibuat di ladang secara langsung yong dapat memanfaatkan para peladang dan pengurus-pengurus ladang tersebut. Pelbagai penyelesaian kritikal boleh dicapai dengan mencipta satu pangkalan data yang berfoedah untuk pengurusan pengairan. Pangkalan data yang direkabentuk boleh menyimpan, mengedit, mengemaskini-dan menghapuskan rekod-rekod data bilamana diperlukan.

Antaramuka GIS bagi sistem pengairan memastikan kita mendapat keputusan yang boleh dipercayai dengan set data-data baru bagi memperbaki proses membuat keputusan dalam skim operasi dan pengurusan. Perisian MapInfo Professional 5.0 telah digunakan untuk mendigitkan kawasan kajian utama, Tanjung Karang. Peta yang telah didigitkan telah dibawa dari MapInfo ke ArcView GIS dengan menggunakan penterjemah universal. Dalam perisian ArcView GIS, data boleh digunakan untuk memanipulasi, menganalisa, menyimpan dan mendapatkan semula data yang disimpan apabila diperlukan. Output boleh dipaparkan dalam bentuk peta bertema, jadual, graf dan carta untuk memanfaatkan pengguna dan penganalisis untuk membuat keputusan terhadap masalah-masalah pengurusan air.

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LIST OF ABBREVIATIONS

A	-	Targeted irrigation area, ha.
BRH	-	Bernam River Headworks
CI	-	Cropping Intensity
CHO	-	Constant Head Orifice
CRW	-	Crop Water Requirement
CRWS	-	Cumulative Relative Water Supply
CPU	-	Central Processing Unit
D_D	-	Design depth of water for a period, cm.
DID	-	Drainage and Irrigation Department
DR	-	Drainage
ET	-	Evapotranspiration
ERF	-	Effective Rainfall
FAO	-	Food and Agricultural Organization
GIS	-	Geographic Information System
IADP	-	Integrated Agricultural Development Project
IRRI	-	International Rice Research Institute
IR	-	Irrigation Requirement
ISA	-	Irrigation Schedule Area
JICA	-	Japan International Co-operation Agency
JPS	-	Jabatan Pengairan dan Saliran
KADA	-	Kemubu Agricultural Development Authority
MADA		Malaysian Agricultural Development Authority
NIADB	-	National Irrigation Administration and Asian Development Bank
NWMP	-	National Water Management Policy
NWU	-	Net Water Use
OPP2	-	Second Outline Perspective Plan
PBLS	-	Northwest Selangor Agricultural Development Project
RWS	-	Relative Water Supply

IR_t - Depth of diversion of irrigation water supply during the period.

RF_t - Rainfall during the irrigation period, cm.

ET_t - Evapotranspiration from the paddy field during the period, cm.

SP_t - Average seepage and percolation loss from the field during the period, cm.

t - Period of water management for irrigation scheme, days

ER_t - Effective Rainfall, mm/day.

K_P - Pan coefficient (0.75) assumed value.

EP_t - Pan evaporation in mm/day

E_s - Irrigation system efficiency expressed as a decimal.

Q_d - Targeted diversion water supply from CHO in Main canal, cusec.

Q_P - Predicted diversion water supply from CHO in main canal, cusec

RWS - Relative Water Supply

WD_t - Depth of water in the paddy field at the end of period, cm.

WD_{t-1} - Depth of water in the paddy field at the beginning of the period, cm

WPI - Water Productivity Index

WUE - Water Use Efficiency

CHAPTER 1

INTRODUCTION

General

Demand for food is on the increase and rice is a staple food in Asia better systems should be implemented to meet the demand for rice production. Since the demand for rice has gone up due to increase in population, we should also find better solutions to adapt and produce more rice for the country and to the people. In Malaysia, irrigation has been exclusively devoted to the cultivation of wet paddy. The area of rice production is about 12.7% of total agricultural area. Based on National Agricultural Policy (NAP, 1992-2010), the Malaysian Government aims to have the capacity of producing 1.20 million tons of rice by 2010 with a self-sufficiency level of 65%.

The Malaysian Government policies that affect rice production industry are the Second Outline Perspective Plan 1991 – 2000(OPP2); and the National Agricultural Policy 1992 – 2010 (NAP). The OPP2 has stated, among other pertinent issues, that the agriculture sector will have to compete for various resources with other higher growth sectors like manufacturing and services industries. "Resources" this includes water, an important ingredient in rice cultivation.

The NAP has targeted rice production in Malaysia to achieve a self – sufficiency level of 65%. It further states that this level of production shall be met from the eight

Granary Areas with a combined paddy area of 210,500 ha and the mini granary areas totaling 28,500 ha of paddy land. The eight granaries are as follows:

1. Muda Agricultural Development Authority (MADA) in Kedah – 96,000ha
2. Kemubu Agricultural Development Authority (KADA) in Kelantan – 19,000ha
3. Integrated Agricultural Development Project (IADP) Kerian – 24,010ha
4. IADP Barat Laut Selangor – 18,730ha
5. IADP Pulau Pinang in Penang – 9,848ha
6. IADP Seberang Perak in Perak – 8,938ha
7. IADP Kemasin – Semerak in Kelantan – 52,630ha
8. Project Pembangunan Pertanian Terengganu Utara (KETARA) – 5,100ha

Among the above eight granary areas MADA has the largest area of 96,000 ha and KETARA has the smallest area of 5,100 ha. (Chong, 1999).

In the NAP3 (1998-2010), two new strategic approaches are employed. The first is the agro forestry approach aimed at addressing the increasingly scarce resources including land and raw material availability. In this approach, agriculture and forestry are viewed as mutually compatible and complementary, thereby providing a scope for joint development. The integration of agriculture and forestry is also aimed to create a larger productive base for both sectors. The main target is to increase the production of food products. Rice being a major food in Malaysia, it needs to be given importance and NAP has strategic plans to increase the yield. In order to increase the yield there are many factors

to be considered and a lot of efforts are required from researchers and government officials from the government to improvise the facilities in the paddy fields.

Irrigation water management is becoming a challenging issue. More importance has been given towards the improvement and effective management of water for irrigation. Water is important for rice irrigation and is often not available at the right time or in right quantity. Hence management of water becomes very important in rice production.

A good irrigation water management system has to be provided to give adequate and timely supply of water to improve the crop production. In order to achieve this, it is necessary to have adequate water source, a good conveyance system and good distribution system to distribute irrigation water over the paddy area. In order to achieve this we require database to store all the required data and to retrieve them easily whenever it is required. Visual basic programming language can play an important role in creating the database and to calculate the irrigation requirements. A large amount of spatial data needs to be analyzed in water management for rice irrigation. This is achievable through the Geographic Information System (GIS), which is a computerized system for storage, retrieval, manipulation, analysis and display of geographically referenced data. In recent times GIS has become a powerful tool for spatial analysis and effective management tool for water resources. GIS can sort out and update the available data. Besides GIS can locate the control structures and leaking points in the water supply system. As a result large amount of data regarding crop irrigation and management can be processed easily by GIS techniques.

This study emphasized in creating a GIS database where a large amount of relevant water management data is centrally stored and can be easily accessible to all concerned water managers even at other locations. Previously, Rowshon (2000) has used this same methodology for a different irrigation scheme with different software's. This work has included Visual Basic programs to make the database interface user-friendly. Provisions are made in the Visual Basic program to edit, update, delete and store the relevant data of the study area.

Statement of the Problem

A irrigation project is good when it possesses a reliable water source and good distribution network. But most of the projects are running short of water sources especially in dry seasons. This may be due to increase in population and increase in industries. The Tanjung Karang study area is suffering from severe shortage of water for irrigation during dry seasons. The main source of water is from the Bernam river and rainfall. The runoff from the Bernam river basin has gradually decreased in recent years. That has happened due to the decrease of annual and seasonal basin rainfall. From the previous study (Abeda, 2000), it is seen that the average rainfall in the recent ten years between 1985-1995 has decreased by 37%. During dry seasons there is an acute shortage of water for irrigation. There are some areas in this project where seepage is much higher than in the other areas. Structural defects, defects in the distribution systems and in distribution network were the other defects identified from earlier studies. These defects have caused a major impact on the present irrigation system.

The major problems that are faced in the study area are stated below

1. Lack of an efficient database in the study area.
2. The overall irrigation water use efficiency is low.
3. The existing irrigation water quantity monitoring system is not that effective.
4. There is acute shortage of water in dry years.
5. There are more losses of water in distribution due to flumes.
6. Difficult to manage the entire network due to lack of real time data.
7. Inadequate field water management due to the unavailability of the onsite decision support system.

OBJECTIVES

The main objective in the study is to create irrigation water management database using Visual Basic and Geographic Information System at the Tanjung Karang irrigation project.

The specific objectives of the study are stated below.

1. To create a Visual Basic program for calculating irrigation requirements and store them in a Microsoft access database for retrieval and updating
2. To link the MS-Access database with ArcView GIS to provide visualization of results for water related problems by thematic maps.
3. To provide a Visual Basic program and the GIS user interface to benefit the users and decision makers to make decisions by providing an onsite decision support system to the users.