



UNIVERSITI PUTRA MALAYSIA

**APPLICATION OF GEOGRAPHIC INFORMATION SYSTEM FOR
IRRIGATION MANAGEMENT**

DEEPAK .T.J.

FK 2002 25

**APPLICATION OF GEOGRAPHIC INFORMATION SYSTEM FOR
IRRIGATION MANAGEMENT**

By

DEEPAK .T. J.

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

October 2002



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

**APPLICATION OF GEOGRAPHIC INFORMATION SYSTEM FOR
IRRIGATION MANAGEMENT**

By

DEEPAK. T. J.

October 2002

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

**APLIKASI GEOGRAPHIK INFORMATION SISTEM DALAM PENGURUSAN
SISTEM PENGAIRAN**

Oleh

DEEPAK. T. J.

Oktober 2002

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

Fakulti: Kejuruteraan

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 kompartmen 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 diinginkan. Kajian ini memberi tumpuan ke atas penciptaan satu pangkalan data dalam pengurusan sistem pengairan serta menyediakan satu sistem 'user friendly' sebagai sokongan terhadap keputusan yang dibuat di ladang secara langsung yang 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 memperbaiki 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.

ACKNOWLEDGEMENTS

I would like to express my wholehearted indebtedness to my major advisor, Associate Professor Ir. Dr. Mohd. Amin Mohd. Soom, for his inestimable and propitious guidance throughout the course of research and in transcription of this thesis. I am grateful to my advisor for giving me an opportunity to do M.S. in Malaysia. I am grateful to my co-supervisors, Dr. Abdul Rashid Mohd Shariff and Dr. Lee Teang Shui for their valuable advice and comments.

I owe my heartfelt thanks to my brothers Dr.T.J.Kamalanabhan and Mr.T.J.Mahesh Kumar and my mother T.J.Rajalakshmi for their moral support and encouragement during my stay over here. I would like to thank my cousin Mr.Santosh for his kind help and encouraging me in my research. My thanks to Mr.Gopal from MTDC who had given me suggestions in the research and always encouraged my work. Also thanks to Mr. Ghazali Kasim for his cordial co-operation. Appreciation to my roommates and friends those who have helped me in the course of my study.

I thank heartily Universiti Putra Malaysia for giving me this opportunity to pursue my M.S. in Malaysia.



I certify that an Examination Committee met on 21st October 2002, to conduct the final examination of Deepak. T. J. on his Master of Science thesis entitled “Application of Geographic Information System for Irrigation Management” in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

KWOK CHEE YAN.

Associate Professor
Department of Biological and Agricultural Engineering
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

MOHD. AMIN MOHD. SOOM, Ph.D.


Associate Professor
Department of Biological and Agricultural Engineering
Faculty of Engineering
Universiti Putra Malaysia
(Member)

ABDUL RASHID MOHD SHARIFF, Ph.D.

Department of Biological and Agricultural Engineering
Faculty of Engineering
Universiti Putra Malaysia
(Member)

LEE TEANG SHUI, Ph.D.

Department of Biological and Agricultural Engineering
Faculty of Engineering
Universiti Putra Malaysia
(Member)



SHAMSHER MOHAMAD RAMADILI, Ph.D.

Professor/Deputy Dean
School of Graduate Studies,
Universiti Putra Malaysia.

Date: 5 NOV 2002



This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as partial fulfillment of the requirements for the degree of Master of Science. The members of the Supervisory Committee are as follows:

MOHD. AMIN MOHD. SOOM, Ph.D.

Associate Professor
Department of Biological and Agricultural Engineering
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

ABDUL RASHID MOHD SHARIFF, Ph.D.

Department of Biological and Agricultural Engineering
Faculty of Engineering
Universiti Putra Malaysia
(Member)

LEE TEANG SHUI, Ph.D.

Department of Biological and Agricultural Engineering
Faculty of Engineering
Universiti Putra Malaysia
(Member)



AINI IDERIS, Ph.D.

Professor/Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 9 JAN 2003



DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.



DEEPAK. T. J.

Date: 31/10/2002.

TABLE OF CONTENTS

	Page
DEDICATION	ii
ABSTRACT	iii
ABSTRAK	v
ACKNOWLEDGEMENTS	vii
APPROVAL	viii
DECLARATION	x
TABLE OF CONTENTS	xi
LIST OF TABLES	xiv
LIST OF FIGURES	xv
LIST OF PLATES	xvii
LIST OF ABBREVIATIONS	xviii
CHAPTER	
I INTRODUCTION	1
General	1
Statement of the Problem	4
Objectives	5
II LITERATURE REVIEW	6
Irrigation Water Management for Rice	6
GIS Application in Irrigation Water Management	9
Conveyance Loss of Water	9
Water Balance Approach for Rice Irrigation Management	10
Irrigation System Efficiency	12
Depth of Diversion Irrigation Water	13
Effective Rainfall	14
Evapotranspiration	15
Seepage and Percolation	16
Drainage Requirement	16
Net Irrigation Requirement	17
Targeted Diversion Water Supply	18
Predicted Diversion Water Supply	18
Relative Water Supply	20
Water Use Efficiency	21
Cumulative Relative Water Supply	22
Cropping Intensity	22
Water Productivity Index	23
Visual Basic	23
ArcView3.1	24



	GIS in Water Management	25
III	METHODOLOGY	31
	Study Area	31
	Soil	35
	Main Conveyance System	36
	Distribution System	38
	Scheme Level Water Management	40
	Cropping Pattern and Calendar	40
	Present Farming Practices	42
	Wet Seeded Rice	43
	Dry Seeded Rice	43
	Step by step procedure involved in the study	44
	Features of Proposed Database	45
	Digitizing the Maps	49
	Identification and Editing of Digitizing Error	50
	Exporting the map from MapInfo to ArcView	50
	Resources Used for Project Implementation	52
IV	RESULTS AND DISCUSSIONS	53
	Visual Basic Program	53
	On-Farm Irrigation Efficiency Calculation	55
	Scheduling and Monitoring Calculation for Three Compartments	56
	Scheduling and Monitoring Calculation for All Compartments	57
	Water Productivity Index Calculation	58
	MS-Access Database	60
	Linking Database Files To ArcView	63
	Database SQL Connect	65
	Importing External Data	67
	Updating the ArcView Database Table	69
	Joining the External Database table to the ArcView Spatial Database and Generate Graphs and Charts	70
	Legends of the Digitized Maps	76
	ArcView Digitized Map	77
	Tanjung Karang Irrigation Project	77
	Sawah Sempadan, Sg.Burong and Sg.Nipah	78
	Sawah Sempadan Compartment	79
	Thematic Maps	81
	Discussions	83
V	SUMMARY, CONCLUSIONS AND RECOMMENDATIONS	85
	Summary	85
	Conclusions	88
	Recommendations	89

REFERENCES	90
APPENDIX – A	98
CURRICULUM VITAE	125



LIST OF TABLES

1.	Cropping Pattern Calendar	40
2.	Database table of Efficiency for Irrigation Efficiency Screen of VB	61
3.	Database table of Monitoring1 for Scheduling & Monitoring Screen of VB	61
4.	Database table of Monitoring1 for Scheduling & Monitoring for all Compartments Screen of VB	62
5.	Database table of Monitoring1 for Water Productivity Index Screen of VB	62
6.	Digitized themes of the Tanjung Karang Irrigation Scheme	76

LIST OF FIGURES

1.	Deposition of Water Diverted for Irrigation	9
2.	Main Conveyance System of the Tanjung Karang Irrigation Project	36
3.	Distribution network of the study area.	37
4.	Present Irrigation Schedule Area	41
5.	Methodology involved in the project study	46
6.	Steps involved in planning VB programming	47
7.	Steps involved in creating the MS-Access database	48
8.	Flowchart showing how GIS works.	49
9.	MapInfo Screen Showing Universal Translator	50
10.	MapInfo screen showing the UT file formats.	51
11.	MapInfo screen shows the UT Translating	51
12.	MapInfo screen shows the UT Successfully Translated	51
13.	GIS database model for Water Management	52
14.	Main screen of VB project	53
15.	VB Input Screen for Irrigation System Efficiency	55
16.	VB Output Screen for Irrigation System Efficiency	55
17.	VB Input Screen for Scheduling & Monitoring for Three Compartments	56
18.	VB Output Screen for Scheduling & Monitoring for Three Compartments	56
19.	VB Input Screen for Scheduling & Monitoring for All Compartments	57
20.	VB Output Screen for Scheduling & Monitoring for All Compartments	57
21.	VB Input Screen for Water Productivity Index	58
22.	VB Input Screen for Water Productivity Index	58
23.	Microsoft Access Database of the VB Program	60
24.	ArcView Opening Screen	63
25.	Opening the Project file in ArcView	64
26.	Opening the Database file in ArcView	64
27.	ArcView screen showing the SQL Connect	65
28.	ArcView screen showing the SQL database connection	65
29.	ArcView screen showing the database tables imported from MS-Access	66
30.	Importing the external data through the “Add” option	67
31.	After importing the external data	68
32.	ArcView screen updating the data in the tables	69
33.	ArcView screen showing Attributes of Block and Monitoringl tables	70
34.	Linking the tables using the command Join	70
35.	ArcView screen showing the legend editor	71
36.	ArcView screen showing graphs on the respective blocks	71
37.	To create charts in ArcView	73
38.	Chart Properties in ArcView	73
39.	Chart Showing Efficiency results	74
40.	Chart showing EPT, SPT, ET	74
41.	ArcView main project window showing the charts	75
42.	Digitized map of Tanjung Karang Irrigation Project	77
43.	Layout of the study area in Tanjung Karang Irrigation Scheme	78
44.	Layout of the Sawah Sempadan Compartment	79



45.	ArcView screen showing the views designed in the project	80
46.	Map showing the graphs on the compartment layer	81
47.	Map showing results and graphs for each block	82



LIST OF PLATES

1.	Diversion to the Feeder Canal at Bernam River Headworks.	33
2.	Siltation and Weed Growth in the Main Canal.	33
3.	Bagan Terap Pump House.	34
4.	Sungai Tengi Headworks at the Main Canal.	34
5.	Drainage Control Gate.	35
6.	View of a Tertiary Canal.	38
7.	A Constant Head Orifice Off take Structure in the Main Canal.	39

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.