UNIVERSITI PUTRA MALAYSIA

WEB BASED PARTICIPATORY IRRIGATION MANAGEMENT FOR TANJUNG KARANG IRRIGATION SCHEME, MALAYSIA

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By

T. J. DEEPAK

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Doctor of Philosophy

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With God's Blessings and Love this thesis work is ….

Dedicated to my beloved Father T. J. Devarajulu, who has been guiding me through my path of success from heaven…..

Special Dedication to my beloved Mother, Brothers, Family members and Friends…

And

Dedicated to my Respected Supervisors, Teachers, and all others who guided me ….

Abstract of this thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirements for the Doctor of Philosophy

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Chairman: **Professor Mohd. Amin Mohd. Soom PhD, P. Eng., FIEM**

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In this technological and information age, water is becoming a source of conflict between domestic, industrial, agricultural and environmental use. Since irrigation uses about 70% of the total freshwater withdrawal, irrigation water management is becoming a challenging issue in Malaysia. The Tanjung Karang Rice Irrigation Scheme (TAKRIS) is no exception. Irrigation water management relies more on information for decision making, while good decisions rely on good information. The usefulness of information depends very much on how well it is organized and how easy it is to use and to access. Thus, accessing information through a web based system is an emerging area of computer applications for real-world problems expected to support the decision making process and also promote the participatory irrigation management. In that notion a three-tier architecture framework was carefully studied and implemented to create the Web Based Participatory Irrigation Management (WebPIM) model. WebPIM was created to benefit the users to make timely decisions on irrigation water management through internet. It is a comprehensive model framework designed using Visual Studio 2003 and

ASP.Net Programming language. It is a user friendly irrigation water management tool for interactive data storing, viewing, analyzing and for accurate decision making by all stakeholders.

The results of mathematical models were incorporated into the decision support tool, which can enhance irrigation water management in TAKRIS. WebPIM model was developed to determine the Total Water Use (TWU) for each paddy plot along the tertiary canal in the study area. Since mid season drainage is beneficial for higher yield, the irrigation season can be split into two stages. The WebPIM program can compute the water supply on day to day basis or with a particular stage of growth with specified number of days. The total rice yield for each lot and water depth in the field are fed by the farmers and Water productivity Index (WPI) are calculated by the model. This enhances the participatory irrigation water management for higher water productivity in the near future.

The WebPIM model created to calculate the irrigation water was analyzed through SPSS by using paired samples t-test, to confirm the validity of the model. SPSS analysis show high significant level for two modules, hence the results generated from this WebPIM model are acceptable. WebPIM has the ability to provide access to those users with password and internet connection, bridging the digital divide between rural and urban communities. Decisions made by people who have contributed in its making will be better accepted and implemented towards an improved productivity of the land and water.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

KETERLIBATAN PENGURUSAN PENGAIRAN PADI BERASASKAN SESAWANG DI SKIM PENGAIRAN PADI TANJUNG KARANG, MALAYSIA

Oleh

T. J. DEEPAK

Mei - 2011

Pengerusi: **Profesor Mohd. Amin Mohd. Soom, PhD, P. Eng., FIEM**

Fakulti: **Kejuruteraan**

Dalam era teknologi dan informasi terkini, penggunaan air menjadi punca konflik antara sektor domestik, industri, pertanian dan alam sekitar. Memandangkan pengairan menggunakan 70% daripada jumlah pengeluaran air tawar, pengurusan pengairan turut menjadi isu mencabar di Malaysia. Skim Pengairan Padi Tanjung Karang (TAKRIS) juga tidak terkecuali daripada cabaran ini. Pengurusan pengairan lebih bergantung kepada maklumat untuk pembuatan keputusan, manakala keputusan yang baik bergantung kepada maklumat yang jitu. Kegunaan maklumat pula bergantung kepada organisasi maklumat yang baik, penggunaan dan capaiannya. Maka, sistem berasaskan sesawang adalah aplikasi komputer yang semakin meluas penggunaannya bagi proses membuat keputusan untuk masalah dunia sebenar, dijangka mendorong dalam proses pembuatan keputusan dan taksiran produktiviti pengairan. Justeru itu, model Keterlibatan Pengurusan Pengairan Padi Berasaskan Sesawang (WebPIM) dibentuk berdasarkan rangka kerja arkitek 3-lapis yang dikaji dengan teliti dan diimplimentasi untuk model ini. WebPIM ialah model berasaskan internet yang telah direka untuk keperluan pengguna dalam sektor pengurusan air bagi membuat keputusan berkenaan

keterlibatan pengurusan pengairan. Ia merupakan model rangka kerja komprehensif yang direka dengan menggunakan perisian Visual Studio 2003 dan ASP.Net. Sistem pengurusan pengairan ini mudah digunakan untuk menyimpan, merujuk dan menganalisis data secara interaktif dan untuk membuat keputusan secara tepat oleh pelbagai pengguna.

Hasil model matematik telah diasimilasikan dalam bentuk alat pendorong keputusan, yang dapat meningkatkan taksiran pengurusan pengairan di TAKRIS. Model WebPIM direka untuk menentukan Jumlah Penggunaan Air bagi setiap lot sawah di sepanjang saluran tersier di kawasan kajian. Oleh kerana saliran semasa musim pertengahan mampu membawa hasil yang lumayan, musim pengairan dibahagikan kepada dua peringkat, di mana program WebPim boleh mengira bekalan air berasaskan hari ke hari atau dengan satu tahap pertumbuhan tertentu, dengan menentukan bilangan hari. Jumlah hasil padi bagi setiap lot dan kedalaman air di dalam sawah akan diinput oleh pesawah dan Indeks Produktiviti Air ditaksir dengan menggunakan model yang dibangunkan. Ini akan mungkinkan peningkatan dalam taksiran produktiviti pengairan padi di masa hadapan.

. Model WebPIM yang direka untuk mengira penggunaan air ini dianalisis melalui SPSS dengan menggunakan *paired samples t-test*, bagi menguji kesahihan pemprosesan data oleh model tersebut. Analysis melalui SPSS menunjukkan signifikans yang tinggi untuk dua model, maka hasil yang diperolehi melalui model WebPIM boleh digunapakai. WebPIM mampu menyediakan akses kepada pengguna yang mempunyai kata laluan dan kemudahan internet, maka merapatkan jurang digital antara komuniti desa dan bandar.

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LIST OF ABBREVIATIONS AND SYMBOLS

A	-	Targeted irrigation area, ha.
AWS	-	Available Water Supply
BRH	-	Bernam River Headworks
CHO	-	Constant Head Orifice
CRW	-	Crop Water Requirement
CPU	-	Central Processing Unit
DID	-	Drainage and Irrigation Department
D	-	Drainage
DRj	-	The drainage requirement during the period (mm)
e_s	-	Mean Saturated Vapor Pressure of the Air (kPa)
e_a	-	Mean Actual Vapor Pressure of the Air (kPa)
ERj	-	The effective rainfall during the period (mm)
ETj	-	The evapotranspiration from the paddy field during the period (mm)
ET_c	-	Crop Evapotranspiration, mm/day
ETo	-	Reference Crop Evapotranspiration (mm/day)
ER	-	Effective Rainfall, mm
FAO	-	Food and Agricultural Organization
G	-	Soil Heat Flux Density ($MJ/m^2/day$)
ha	-	Hectares (Area)
IADP	-	Integrated Agricultural Development Project
IRRI	-	International Rice Research Institute
IRj	-	The depth of diversion of irrigation water supply during the period (mm)
IR	-	Irrigation Requirement

IS	-	Irrigation Service
ISA	-	Irrigation Schedule Area
j	-	The period of water management.
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
P	-	Precipitation
PBLS	-	Northwest Selangor Agricultural Development Project
R	-	Rainfall during the irrigation period, mm.
R_n	-	Net Radiation at the Crop Surface ($MJ/m^2/day$)
SP	-	Seepage and Percolation loss during the period, mm.
SPj	-	The seepage and percolation loss during the period (mm)
SW	-	Standing Water Level, mm
SWD	-	Season Water Depth, mm/plot
T	-	Air Temperature at 2m height (^0C)
t	-	Period of water management for irrigation scheme, days
TAKRIS	-	Tanjung Karang Rice Irrigation Scheme
Tcanal	-	Tertiary Canal
TWU-S1	-	Total Water Use for Stage-1, m^3/plot
TWU-S2	-	Total Water Use for Stage-2, m^3/plot
TWU	-	Total Water Use, m^3/plot
U_2	-	Wind Speed at 2m height (m/sec)

WebPIM	-	Web based Participatory Irrigation Management
WPI	-	Water Productivity Index, kg/m^3
WUG	-	Water User Group
WDj	-	The depth of water in the paddy field at the end of period (mm)
WDj−1	-	The depth of water in the paddy field at the beginning of a period (mm)
Y	-	Yield, kg/ha
Δ	-	Slope of Vapor Pressure Curve (kPa/ ^{0}C)
γ	-	Psychometric Constant (kPa/ ^{0}C)

CHAPTER 1

INTRODUCTION

1.1 General

Water resources are to be regarded as a national heritage inherited from our ancestors to be passed on to future generations in good, if not in better conditions. Recognition of water resources as national heritage will contribute towards sustainable development. There is also a need to streamline urbanization and industrialization with the identification of new water resources or developments are undertaken based on the carrying capacity of the river basins. Any river basin should be managed according to their natural physical boundaries rather than administrative and political boundaries. The realization of the Federal Government involvement in the management of water resources and water supply services nationwide can expedite the implementation of new systems in order to reverse environmental degradation and ensure sustainable water resources development, besides providing efficient water supply services.

Water is everybody's property and we have to take the responsibility to provide solutions for better water management practice. We no longer live in an era in which we could have indefinite expansion of water services and supplies. We have to focus on how we use water and manage water resources. That's where new water will be 'found'. The authorities, researchers, experts, consumers and communities must play their role in water resources and supply conservation from capture to consumption, and to wastewater discharge.

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To ensure sustainable water resources development and efficient water supply services, the Malaysian government is moving towards greater involvement in the management of water resources and water supply services in all the states. Third National Agricultural Policy (NAP3, 1999) 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 shown in Figure 1.1 below with a combined paddy area of 210,500 ha and the mini granary areas totaling 28,500 ha of paddy land.

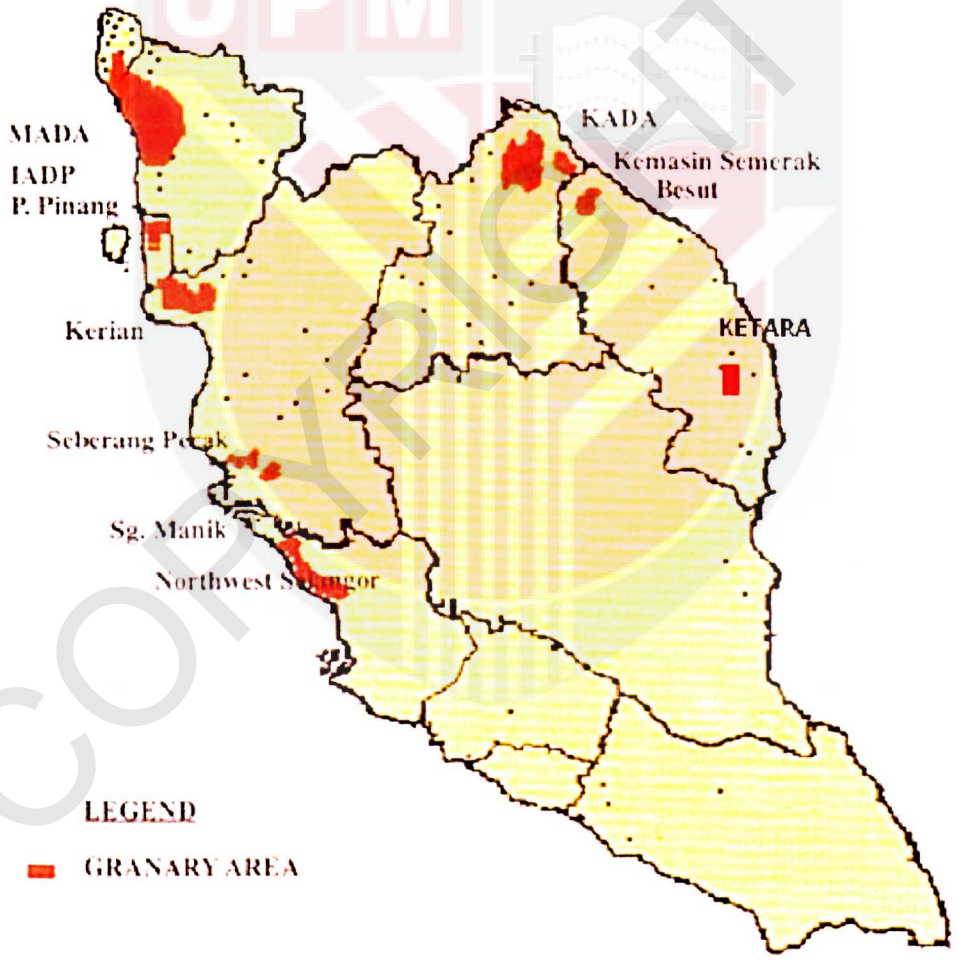

Figure 1.1 Eight Rice Granaries in Malaysia (MANCID, 2010)

The eight granaries in Malaysia are stated below:

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

Among the eight granary areas shown in Figure 1.1, MADA has the largest area of 96,000 ha and KETARA has the smallest area of 5,100 ha. (Chong, 1999). Irrigation water management is becoming a challenging issue since it is often not available at the right time or in right quantity. More importance has therefore been given towards the improvement and effective management of water for irrigation of rice.

1.2 Statement of the Problem

An irrigation project is successful when it possesses a reliable water source, appropriate distribution network and control structures with proper operation and maintenance together with an efficient database for Decision Support System (DSS). But most of the projects are running short of water sources for double cropping especially in dry seasons. The study area has no reservoir to store water since it is a run-of-the river scheme which experiences acute shortage of water for irrigation during dry

seasons. With impending greater future competition for water, it is imperative to account irrigation water use.

Water Productivity Index (WPI) and Water Use Efficiency in the study area are only approximated at macro scale. There is difficulty in getting data on these parameters hence causing inaccurate information. Rice yield data is also difficult to obtain quickly since the rice harvests are sold to many different buyers by the farmers. Water engineers can improve the irrigation water management in the irrigation scheme by having a tool for accessing and analyzing the data quickly. This tool will help to make decisions in order to provide the correct amount of water at the right time and place considering all the aforementioned constraints. Therefore there is a need for water productivity assessment on a micro scale and tertiary canal based so that the water user groups and other stakeholders can have a transparent platform in practicing precision irrigation. The database can then be utilized for Participatory Irrigation Management (PIM) where the farmers, farm heads and decision makers can actively involve in providing data for future management practices with the aim to achieve higher water productivity.

1.3 Objectives

The main objective of the study was to provide an online database with reasonable accuracy that will help decision makers to assess the irrigation performance. The online database system known as "WebPIM" is a Decision Support System (DSS) designed to facilitate the engineers and tertiary canal based water user groups in achieving higher water productivity.

The specific objectives of the study were:

i. To develop a Web based Participatory Irrigation Management-DSS tool for double cropping with a database that will allow users to analyze and store different data formats.

ii. To expound precision irrigation to the tertiary canal based WUG (Farmers and Water Managers) and to contribute their inputs towards better water productivity.

iii. To set and test hypotheses as well as validate the developed WebPIM DSS model.

1.4 Scope of the Study

The main scope of the study is confined to predict the necessary amount of irrigation water and determining the Water Productivity Index (WPI) in order to improve decision making process with respect to irrigation water supply in the Tanjung Karang Rice Irrigation Scheme (TAKRIS). The scope of work includes the following:

i. Development of algorithm and mathematical equations for determining various parameters in irrigation water management for TAKRIS

ii. Collection of historical data such as weather data, hydrological data, canal data, crop data and knowledge acquisition on irrigation water management aspects of the Tanjung Karang Rice Irrigation Scheme.

iii. Determination of irrigation water supply during pre-saturation and normal supply periods, WPI with the actual Yield data for all lots obtained from the farmers for both main and off season.

iv. Integrate data from various sources in a SQL database to help the decision makers in allocating water.

1.5 Contribution

WebPIM (Web based Participatory Irrigation Management) system was created for improving water management aiming towards precision irrigation. Irrigation water managers who are used to macro scale management based on irrigation compartments and blocks are now able to manage at micro scale management based on plots within tertiary canals with the aid of WebPIM. WebPIM is an online tool for the farm heads, water user groups and irrigation administrators with a comprehensive 3-tier architecture model framework. WebPIM is the only known tool that is created for double cropping paddy irrigation. This research contribution are as follows:

- An online database management system was developed for paddy irrigation water management in TAKRIS. This provides transparent water accounting for institutional development in water management practices and sharing the database by all stakeholders.
- An online database management system integrated with Participatory Irrigation Management (PIM) process for double cropping rice irrigation is a new tool to the Water User Groups (WUG), decision makers and irrigation administrators.
- The new tool developed will be useful in creating a healthy competition among the tertiary based Water User Groups and prompting strategies to improve their yield and reducing Total Water Use.
- WUG participation in PIM through online activities enhances the ICT literacy, bridging the digital divide between rural and urban population.

1.6 Thesis Organization

This thesis is comprised of 5 Chapters. Chapter 1 introduces the overview of the problem being studied. Chapter 2 reviews the theories and related works to improve irrigation water management, where the relevant schemes and methods conform to the recent challenges are covered. Chapter 3 describes the methodology adopted to develop the WebPIM model for the users. Chapter 4 discusses the outcome from the model which will be best utilized by the decision makers in irrigation water management. Finally Chapter 5 concludes the thesis with its key contributions and highlights some recommendations for further studies.

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