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Knowledge Acquisition for the Design of Flood Management Information System: Chi River Basin, Thailand

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Abstract

Thai people living along the Chi River Basin (CRB), an important river for economic and social development of the Northeast of Thailand, have long been affected by both flood and drought. These problems have not yet been solved due to a lack of knowledge sharing between responsible organizations and researchers who are the experts on CRB to monitor and control the water condition. The knowledge owned by these experts has not been captured, classified and integrated into an information system for decision making. This paper is a part of the research on the development of knowledge-based DSS for water resources management of CRB. It aimed to develop the knowledge domain and to design knowledge-based DSS architecture. The research methods included document analysis and qualitative methods by adopting Liou (1990)’s knowledge acquisition approach. Ten experts in the areas of Environmental engineering, Water resources engineering, and GIS were interviewed. The experts also took parts in the processes of developing the knowledge domain, classifying and structuring the knowledge for flood management of CRB.

The results of this research were the knowledge domain and the knowledge-based DSS architecture. The knowledge was structured by following three processes of disaster management cycle, consisting of 9 domains of forecasting, 10 domains of response, 9 domains of recovery, 16 domains of Historical, 30 domains of GeoInformatic, and 6 domains of Government policy and land use.

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1. Introduction

Freshwater resources are an essential component of the Earth's hydrosphere and an indispensable part of all terrestrial ecosystems. The freshwater environment is characterized by the hydrological cycle, including floods and droughts, which in some regions have become more extreme and dramatic in their consequences [1]. The OECD Environmental Outlook to 2030 has identified water as one of the four critical environmental priorities for the coming two decades. On current trends, 47% of the world’s population will live in areas of high water stress in 2030, and the Millennium Development Goals on water and sanitation will not be met [2].

Water resource decision-making can ultimately affect land use practices and resource allocation, and can identify a need for additional data collection. Scientific data and information have always been important for making decisions related to water resource management. Increasing demands for water have elevated the importance of reliable input data. The confidence with which the outputs of scientific assessments can be used in decision-making is directly related to the availability and quality of the data used [3]. It was found that earlier studies on water resources management system had rather emphasized on using classical approach based on mathematical formulae and models, so as the study of Mikulecky.

However, Mikulecky [4] noted that the system based on mathematical models and simulations was useful but merely playing a supporting role relating to knowledge application. As an ultimate goal, the system should be a complex knowledge-based system, accumulating the most important if not all the necessary that knowledge-based related to the water resources management. Such a system should be able to support the decision making process of river operators intensively, leaving just small margins for erroneous decision [4, 5].

Water Resources Management, or especially river basin management, to be efficiently applied in everyday practice, needs knowledge, as any other knowledge intensive activity. Knowledge is usually possessed only by a narrow group of specialists (experts in the area, e.g. river basin dispatchers) who know when, how, and what must be done in order to provide proper water supply, or to cope with a dramatic consequences of floods. This knowledge, as it happens with experts everywhere, may not be available whenever it is necessary for various reasons: experts need not be always available when necessary, experts can suffer from common human problems, or suddenly their knowledge can be lost because of their mortality, or retirement and experts can differ in their opinions on how to solve a particular situation, etc. [6]

Chi River Basin is an important river for economic and social development of the northeastern part of Thailand. It covers the areas of 49,477 square meters of seven provinces. People living along the basin have had problems affected by both flood and drought every year. Although there are responsible organizations and researchers who are recognized as the experts on the basin to monitoring and controlling the water condition, it is obvious that there is a lack of knowledge sharing between them. In addition, knowledge owned by the experts that shall be used for water resources management of the basin has not been captured, classified and integrated into an information system for decision making.

This paper is a part of the research on the development of knowledge-based decision support system for water resources management of Chi river basin. It aimed to develop the knowledge domain and to design knowledge-based decision support system architecture which integrating information from existing resources and knowledge from the experts in the fields. It is expected that the results will be able to support the decision making process of river operators intensively, help knowledge sharing among the experts, and use as a resource for researches and studies of the basin in the future.
2. Research Concept

The knowledge acquisition process is the key process to build a complete knowledge base, in this case, the knowledge on water resources management. The idea is compiling the whole knowledge necessary to identify the water resources problems and to solve them. The knowledge that must be acquired is not only concerned on how the water managers deal with their river basin real problems but also on how the scientists think that water management could be improved based on knowledge of stream ecosystem structure and functionality. Three types of knowledge can be distinguished: literature, experts, and databases. The general knowledge of the process can be mainly extracted from literature and database, and the heuristic knowledge can be obtained from both water management and domain-experts.

This study used the concept of knowledge acquisition in the context of experts system by Liou [7]. There are three major concerns of the knowledge acquisition task: the involvement of appropriate human resources (including primarily domain experts and knowledge engineers, sometimes end users and managers); the employment of proper techniques to elicit knowledge; and a structured and systematic approach to performing the knowledge acquisition task [4]. A knowledge engineer commonly carries out acquisition the relevant knowledge and expertise. Extracting the knowledge from the expert and representing it in a knowledge base using a proper conceptualization, however cannot take place without first overcoming some obstacles [8].

A review of existing DSS indicated that there are few that have been specifically developed for flood management. Flood emergency DSS have been used by emergency managers for a long time. In the 1980’s and 1990’s these systems were usually in the form of hard copy flood maps, graphs, tables, etc. With recent advances in computer and communication technologies, these systems have been morphing into more sophisticated form; providing much needed real time flood information in more detail, such as computerization of the flood prediction operations and usage of GIS as a platform for interaction with the users [9].

The ICT revolution is increasing the prospect of providing rapid personalized access to weather and flood information and warnings. The technology for collecting (e.g. remote sensing technologies), recording and transmitting (e.g. telemetric system), displaying (e.g. geographic information systems), processing and analyzing data by computer have become very much more powerful [10]. BANCID [11] expressed the opinion that: “Flood forecasting and warning has been identified as a key component that could exert major benefits on numerous aspects of national life, with considerable potential for improving the national economy. As such it is recognized as a highly cost effective, non-structural measure”. In Europe and South Africa a Flood forecast, warning, and response system are implemented to reduce material, human and cultural losses [12, 13]. In Thailand, there are government bodies responsible for providing flood information such as the Thai Meteorological Department, Royal Irrigation Department, Department of Water Resources, and Electricity Generating Authority of Thailand. However, there’s a lack of knowledge sharing between these responsible organizations and researchers who are the experts on Chi River Basin to monitor and control the water condition. The knowledge owned by these experts has not been captured, classified and integrated into an information system for decision making.

3. Research Methods

The research methods used in this study were document analysis and qualitative method. The knowledge acquisition approach by Liou [4] was adopted for acquiring knowledge from the domain experts. The study comprised of 4 steps. 1) Document analysis to identify the concept and domain knowledge of water resources management. The concept of water resources management were drawn from several key sources; Plessis [13], Parker [10], Mikulecky and Ponce [6], Gocic [14], and Tangtham [15]. 2) Drafting the classification of flood information into 4 categories; scientific data, historical data, GeoInformatic, and government policy and land use. 3) Interviews with ten experts of CRB in the areas of environmental
engineering, water resources engineering, and GIS. The experts were asked to take parts in the processes of developing the knowledge domain, classifying and structuring the knowledge for flood management of CRB. And 4) Summarizing the knowledge domain and reconfirming the results by the experts.

4. Research Results

The results of this research were the knowledge domain and the knowledge-based DSS architecture. The knowledge domain was structured by following three processes of disaster management cycle, consisting of 9 domains of forecasting, 10 domains of response, 9 domains of recovery, 16 domains of Historical, 30 domains of GeoInformatic, and 6 domains of Government policy and land use (see example of knowledge domain in Fig 1).

![Fig. 1. Flood management knowledge domain](image-url)
The architecture would consist of three components: Knowledge Management System (KMS) whose function is to acquire data, information, and knowledge from the field of water resources management from the literature, database, and experts using knowledge acquisition methods and knowledge obtained on the basis of knowledge domain into 5 categorizes. Ontology-based System (OBS) whose function is to apply ontologies in the domain of water resources management with supervision of the domain experts. Decision Support Shell (DSS) is integrated with the knowledge-based and ontology-based to assist the user in selecting the appropriate controls of variations and variation orders. The decision support shell provides decision support through a structured process consisting of building the hierarchy among the main criterions and the suggested controls, rating the controls, and analyzing the controls for selection through multiple analytical techniques (Fig. 2.).

The flood management operations involve multiple agencies. In Chi river basin Thailand, Flood coordination typically follows a Government, District, Local layered approach in terms of the communication structure. The majority of flood information coordination is processed at the District Coordination Centre level, and many of the key strategic and tactical decisions are made at this level. District level coordination poses significant challenges as it represents many disparate groups and agencies; these require a great deal of coordination, but often have had little exposure to each other in the past [16].

The general assumption in the flood management is insufficient of information as the basic factor in limiting the efficiency of flood management among organizations [17]. A key challenge is the level and rollout of ICT solutions to enable the team to effectively share information and to communicate the necessary information to others. This challenge is compounded by the sheer number of different stakeholders involved in flood coordination, and the heterogeneous ICT system these organizations already have in place, with which some level of interoperation is desirable [16].

5. Conclusions

It might be said in that there are many research works on water resources and watershed management in the past and consisting of both the basic and applied researches in various fields. They could be beneficial in solving the problem on water resources that are recently and in the future will be more severe in quantity, quality, and timing. Flows that cause of disasters such as flash floods, landslides, drought, and polluted water contaminating water, struggle of water consumption, crop damage and food shortages have been in attention [16]. The researchers have collected the water resources and watershed researches database all over the country. After we analyze and synthesize the content of all previous research works, the knowledge domains can be organize into the 5 main domains: Scientific data, Historical Data, GeoInformatic, Expertise,
and Government Policy and Land use. The gaps in each main domain were then identified of content and can be summarized into 3 main disaster management processes as follows: Forecasting, Response, and Recovery.

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References