A STUDY OF GIS BASED DECISION SUPPORT SYSTEM ON PRIORITIZING YEARLY PLANNING OF DRAINAGE ENGINEERING IN TAICHUNG COUNTY

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Abstract: Due to financial constraints of local governments, budgeting public work projects can be highly politicized affairs. But as the economy grows, people are demanding higher standards of government service and want public works projects performed using only objective and scientific methods. This study uses overall evaluation and Delphi methods as well as non-probability questionnaires completed by county and city governments and village and neighborhood chiefs to set up a decision analysis model for the planning of drainage engineering projects in Taichung County. Furthermore, a management support system can be developed with the aid of geographic information system to provide decision makers with sufficient information to effectively and fairly apportion the yearly budget.

Key words: Multicriteria evaluation, management information system, geographic information system

1 INTRODUCTION

Water engineering projects have always had a close relationship with agricultural development in China. Over the last 5000 years of China's history, the management and upkeep of water projects had a direct impact on the rise and fall of dynasties.

This research will discuss how local governments prioritize budget allocations to drainage engineering projects. Its main purpose is to use scientific methods to establish a quantitative evaluation model based on the special characteristics of the drainage project, to develop an integrated GIS for assisting decision makers in allocating the budgets and assigning priority to drainage projects, and to eliminate political factors in the decision making process and establish a fair, well-adapted and effective means for budgeting drainage projects given the limited public works funding available to local county and city governments.

This research uses questionnaires that employ the general evaluation method and Delphi method to assign priority and weigh the importance of water engineering projects in the annual budget.

1.1 Information system applications

The information system developed for this research was designed by combining enterprise information system (EIS) with geographic information concepts. EIS are classified as an information system and a type of management support system.

Geographic information system (GIS), a new field of research combining geographic information and modern computer technology, has far-reaching applications. Typical geographic information systems incorporate analysis and processing of spatial data, analysis and processing of attribute data, integrated inquiry analysis of spatial and attribute data, and integrated overlap analysis in the planning and design of their applications [3] [4]. Therefore, we can fully utilize these analysis capabilities as long as we have

an ample amount of special and attribute data for integrated analysis. In selecting the site for a distribution center, Wang Yi-Yung used a geographical information system that showed factors that influence site selection such as traffic and land prices as reference to the persons building the distribution center [5] . Wen Tsai-Hong set up an agricultural water use evaluation model for a study site at Baihe Reservoir [6] , Liao Chin-Hsiung mapped the environmentally sensitive regions in the Taipei metropolitan area [7] and Chen Yung-Kuan managed forestry resources [8] using the analysis and planning functions of geographical information systems. J.R. Johnson et. al. geographical information systems and remote technology to do site selection for industrial waste disposal sites [9].

Basically, decision-making analysis is a way to analyze and compare problems with multiple plans and criteria. Due to the diverse and varied nature of the society that we live in, all human activities have multiple criteria. Therefore, the majority of human decision-making activities are aimed at resolving conflicts and contradictions that result from our diverse activities. Up to now, the most common analysis and comparison methods used to resolve multiple plans and criteria are: the analysis stage procedure method, linear programming method, approximation method, multiple criteria integer programming, fuzzy planning method and general analysis method. No single method is clearly superior over the other and each has its own advantages and disadvantages.

1.2 General evaluation method and Delphi method

1.The General evaluation method

The general evaluation method uses human methods to isolate and evaluate the relative importance of multiple criteria. This method assumes that a professional manager with his or her own subjective opinions and experience does the general evaluation of the relative importance of each plan. Therefore, this type of evaluation takes the professional level and the scope of the manager into account, so the results of its evaluation process are more authoritative. The first step to this method is to combine the results of the expert's evaluations into an evaluation framework. The second step combines the results of these general evaluations. The third step adds a weighted average to each plan and a variance to each expert and combines them to obtain new valuation for discussion. This is repeated until a relatively consistent opinion is reached [10].

2.The Delphi Method

The Rand Corporation developed the Delphi Method in 1948. Its name comes from the site of a temple of Apollo in Ancient Greece where people went to seek divination and guidance. The Delphi Method is a type of intuitive forecasting developed by a small group of specialists to solve strategic military problems.

The Delphi method is a type of systematized process to collect expert opinions. Its chief goal is to obtain a consensus from experts using questionnaire surveying and compilation methods . [11] This method is useful in eliminating doubts concerning over-subjectivity [12]. Currently, the Delphi method is used frequently in weighting evaluation items for research goals in the field of construction management. The procedure of this method is shown as the flow chart below:

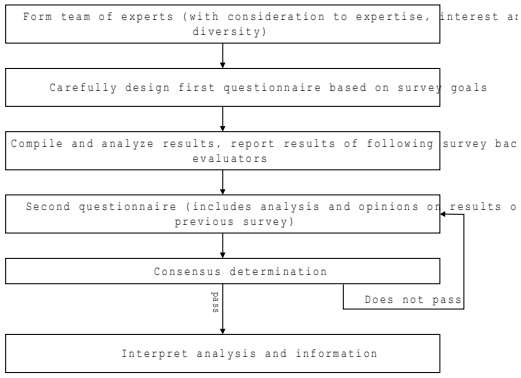


Figure 1. Use of Delphi Method

This research uses one of the principles of the general evaluation method and combines it the analysis research of the Delphi method.

2 SETTING UP A DECISION-MAKING MODEL FOR ANNUAL PLANNING OF DRAINAGE ENGINEERING PROJECTS

In the following sections, the paper will discuss which items can be included in the annual budget decision-making index for small and medium water drainage projects and which decision-making items will be taken from the replies to the first-stage open-question questionnaires. Those items that were

repeated will be acted as decision-making evaluation index for this research's targets (eight consideration factors have been prepared for this research). The second-stage closed-question questionnaire is used to weigh the decision-making evaluation index by combining the questionnaire replies with techniques taken from general evaluation method and Delphi method to set up a decision-making evaluation model for annual drainage project planning.

2.1 Determining decision-making rules for drainage projects

To prioritize drainage projects, it is first necessary to examine the relationship and potential bottlenecks in the drainage system, assign a priority to the project using subjective evaluation rules and methods, and then make a final determination by taking into account real life conditions. Therefore, the criteria for selecting the decision-making index must be determined before choosing which factors should be included into the scope of this research.

A questionnaire survey was used to select the evaluation criteria for water engineering project to achieve objectivity. For this research, a judgmental sampling was designed using two-stage, non-human determination to obtain a non-probability sampling. Though there is a risk of bias in determining a representative sample using this method, the results are useful in understanding the problem. Therefore, this method is very suitable for initial and primary research [15].

From related other research and analysis of this research, it was found that village chiefs play an active role in government decision-making and communicating local requirements during the planning of public work projects. Village chiefs in Taichung County were selected as the target of this questionnaire sampling to make the questionnaire more representative and universal.

2.2 Weighing method of the decision-making criteria

2.2.1Criteria weighting questionnaire

The purpose of the second-stage questionnaire survey was to weigh the decision –making criteria for drainage projects. The questionnaire used a closed question grading method (Yan Yue-Chu, 1996) and was performed twice. The second questionnaire was used to obtain a consensus on the evaluation results. The evaluators were then asked to make a second evaluation based on the statistical analysis of the first questionnaire results using the principles set forth in the Delphi method. The source of the data for this stage was the data collected and compiled from the first questionnaire. Recipients were asked to select and rank five (in order from 1 to 5 with 1 being the most important) of the eight agreed-on consideration factors when planning and constructing drainage improvement projects. The research also included an open question (other part) to modify and amend the consideration factor. If the difference in the answers selected by the village chiefs were too great, the content of the answers would have to be amended, a new questionnaire written and a new sample taken.

2.2.2 Consensus determination

To determine if a consensus has been reached in this research, a random sample was taken of samples with the same score. A Sing test was done each evaluation criteria and survey result from the second questionnaire to determine whether a consensus had been reached on the second questionnaire.

In determining the results using the Sing test, when there is no significant statistical difference between the two questionnaires, the village chiefs have reached a consensus, dummy hypothesis was accepted and there is no need to perform another survey.

2.2.3 Evaluation methods for various drainage projects

After prioritizing the consideration factors collected and compiled from local government agencies and discussing them with experts.

2.3 Weighing decision-making criteria for drainage projects

A weight percentage was calculated for each criterion (consideration factors) that was compiled from the second part of the second questionnaire using the general evaluation method and Delphi method to determine the relative importance of each factor. This research uses proportional scale concept from the AHP method [11] to determine the relative weight of the priority index.

The weight proportion was calculated from the questionnaire statistics using the following formula:
(1) Weighted proportion

$$W_i = E_{ij} * S_j \qquad (2.1)$$

Of these, E_{ij} is the number of times a consideration factor is selected in the questionnaire and S_j is the weighting based on its priority. For this research, i=1~8，j=1~5。

（2）Standardization:

$$\overline{W}_i = \frac{W_i}{\sum_{i=1}^{n} E_{ij} * S_j} \qquad (2.2)$$

For this research, i=1~8，j=1~5, and

$$\sum_{i=1}^{8} \overline{W}_i = 1 \ 。$$

After combining together the values obtained from the above quantification calculations, the relative weight of each consideration factor (see Figure. 2) is obtained with the unit weighing value for the second stage consideration factors by using the Delphi method. In this way, the decision model for this research as shown in 2.3 is obtained.

$$(S.I)_n = \sum \overline{RW}_i \times P_i \qquad (2.3)$$

$$\overline{RW}_i = \overline{W}_i \times 10 \qquad (2.4)$$

Of these, $(S.I.)_n$= The evaluation index for the n^{th} drainage section

$\overline{RW}_i$ = Relative weight of the evaluation criterion for the n^{th} drainage section. The number 10 is the magnification factor. Its purpose is to highlight this value and reduce error.

P_i= 0 or 1 added to evaluation score for evaluation criteria I. See explanation in chapter 4. After calculating with formulas （2.1） （2.2） （2.3） （2.4） , a criteria weight can be set up for this research.

3. THE EXAMPLEOF INFORMATION SYSTEM APPLICATIONS

3.1 Collection of background information and regional surveys

The research scope of this project is the administrated regions in Taichung county. For the small and medium drainage ditches portion, the data was collected from the 1990 to 1994 surveys of drainage systems commissioned by Taichung county government and discussions with Taichung county government officials involved with these projects.

Other similar relevant data was obtained by the Taichung County Water Conservancy Bureau. Since the administrative structure of the other 20 county and city governments is similar, this research model is suitable for use with them. The only difference is that each agency must set up their own data sheets with their existing data.

3.2 Comparison of planning methods used for individual drainage projects

Previously, local governments used procedures and regulations drafted by the Taiwan Provincial Water Conservancy Bureau to assign priority to drainage maintenance and improvement projects. This research attempts to use objective and fair principles to improve these past planning procedures to minimize the difficulties experienced in planning these projects. Using the general evaluation method and the Delphi method to set up a fair weighing system for the consideration factor in the decision-making process to establish a decision-making analysis model for Taichung county's annual drainage project planning. The purpose is to improve the labor-intensive model currently in use and to raise administrative efficiency and results.

This research uses the same eight consideration factors in the project application forms submitted by local government to obtain funding from the provincial government. By using the consideration factors from actual application forms, government officials do not need to translate over to another evaluation system when using this research model. an outline was made using the decision-making factor modeling and evaluation method shown in Figure 2.

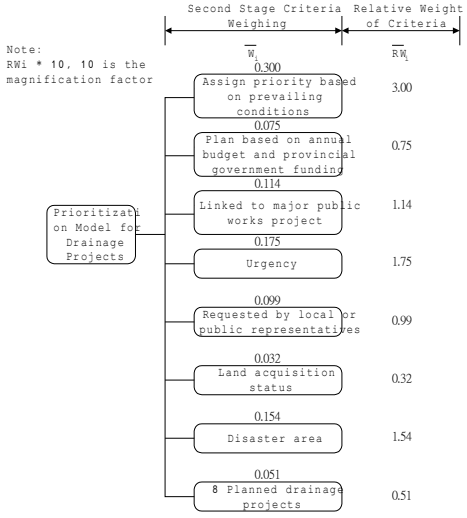


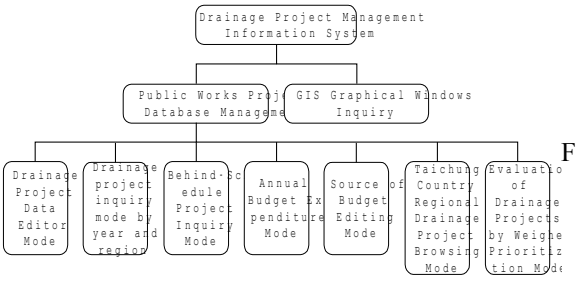
Figure 2. Criterion Weighting for the Evaluation

System

3.3 Developing procedures and applications of drainage project information systems.

A Delphi software package was used to set up the information system for this research because it offered the fastest and most efficient way to set up window applications for interface design tools, offers a medium for dynamic data exchange of field data in databases and attribute data from the GIS. For the software portion of the database, an Access software package was used to organize the data from the system maintain and manage the database with intuitive controls and customized design by the user. To simplify operations and improve user-friendliness, map display and drainage project inquiries were done with another widely-used retail software package MapInfo.

This research was used on a regional drainage project within Wufeng Hsiang. A drainage information system was set up in a windows environment. Items such as the project name, construction date, project location, funding, source of funding and contractors were used to set up a linked database for developing information system with a personal interface equipped with index and inquiry functions to help managers increase their work efficiency. This system has a total of eight modes as shown in Figure 3. They are a GIS image windows inquiry mode, water project data editor mode, water project inquiry mode by year and region, behind schedule project inquiry mode, annual budget expenditure mode, source of budget editing mode, Taichung county regional drainage project browsing mode as shown in Figures. 4 and 5.



igure 3. MIS Framework for Drainage Projects

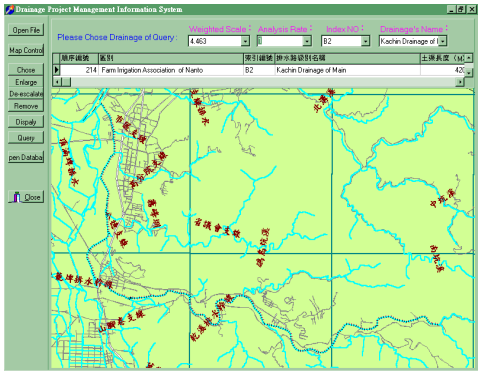


Figure 4. View of GIS Map

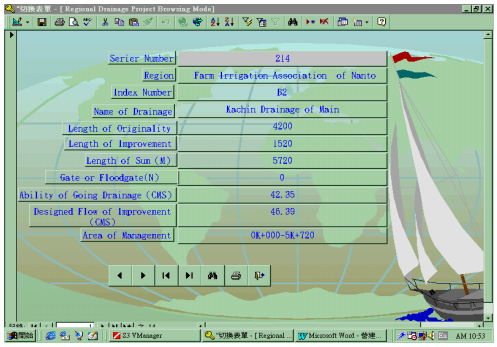


Figure 5. Table of Drainage Systems in Taichung

4. CONCLUSION AND RECOMMENDATIONS

This research used the general evaluation method and Delphi method to develop an evaluation model for prioritizing the yearly planning for drainage projects. In theory, this research attempts to find the most suitable decision-making prioritization for drainage project management information systems given the differing viewpoints of government agencies and village chiefs and the funding application procedure for the Water Conservancy Bureau. This research uses a geographic information system with powerful spatial and attribute integration, inquiry and analysis capabilities to perform graphical decision analysis of databases, evaluation models and graphic interfaces for creating a theoretical model that can be applied in real working environments.

Also, the government can consider ending the current funding assistance model and set up a funding assistance agency that has experts set up evaluation criteria and their weightings. This research can also used the speed and precision of GPS systems to increase the administrative efficiency

in the measuring and design work (such as surveys of water conservation land and water rights management) for water and drainage projects.

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