

Research Article

Research and Development of Water Resources Management System Based on GIS

¹Zhang Hong-Yi and ²Ke Yun

¹The High-Tech Institution of No. 12, Fangongting South Street, Qing Zhou 262500,

²Wuhan Yangtze Business University, Wuhan 430065, P.R. China

Abstract: Water is the basic material for human to survive. How to allocate the limited water sources is a big problem. This study designed a set of water source management system by using Geographic Information System (GIS). Experiments results showed that this system could provide functions for the users, such as local water sources prediction analysis, water sources dispatch analysis, information index and search, simulation and decision, etc. The development of this system will provide a new way in water sources management.

Keywords: Geographic Information System (GIS), water, water resources management system

INTRODUCTION

Water resource is the key resource for human living and production, however, nowadays ecological environment has suffered from severe damage and water has been polluted heavily also, such that, water resource protection and water pollution management shall be the hot topic of modern society.

China is a country with serious water shortage and drought, whose total quantity of fresh water resource is 2.8 trillion m³ covering 6% of global water resource and ranks the fourth of the world being next only to Brazil, Russia and Canada. While, the per capita of fresh water resource is just 2200 m³, which is only a quarter of world average level and 1/5 of America, so China has been one of the 13 countries of the world with the poorest per capita water resource (Shushu and Rui, 2012). The fresh water of China that can be actually used shall be much less after deducting the flood runoff difficult to be utilized and groundwater resources scattering in remote area, which can only be about 1.1 trillion m³ with the quantity of per capita available water resources of 900 m³ and distributes disproportionately severely. By the end of the 20th century, there have been more than 400 cities exist water shortage problem among more than 600 cities throughout the country, in which, nearly 110 cities have severe water shortage problem and the total quantity of water scarcity can be 6 billion m³. China confront with water resource shortage, grievous water pollution, serious soil erosion, critical low water price and grave waste of water resource (Ling *et al.*, 2012). Besides, the water of south China is more than that of north China and water of west China is less, but coastal water is more. With the development of urbanization and economic society, large quantity of

land has been covered and the demand of non-agricultural irrigation water is increasing rapidly, therefore, multiple water usage contradictions between agriculture and industry, rural and urban, production and life, production and ecology, intensify further. Though China has taken the most rigorous cultivated land protection measures, the decreasing trend of cultivated land resource shall still be difficult to be reversed and the pressure of water shortage shall be larger further, due to that plenty of farmland and agricultural irrigation water resource have been occupied by the city and industry (Feld *et al.*, 2003). How to utilize and exploit water resource reasonably has been the focus issue of various countries in modern world.

Geographic Information System, simply known as GIS, has received extensive attention and rapid development being the important tool, technology and science for obtaining, handling, managing and analyzing geospatial data in recent years (Akbar and Ha, 2011). From the angle of technology and application, GIS is the tool, method and technique for solving space problem; in aspect of subject, GIS is a discipline developed on the subject basis of geography, cartography, geodesy, computer science and so forth, which possesses independent disciplinary system; in aspect of function, GIS has functions of acquiring, storing, displaying, editing, processing, analyzing, outputting and applying spatial data; from the angle of systematic, GIS is provided with certain structure and function, which is a complete system. In short, GIS is an information system based on DBMS for controlling spatial objects, furthermore, the basic difference of GIS from other information systems lies in its spatial analysis function which regards geographic data as operation objects.

Corresponding Author: Zhang Hong-Yi, The High-Tech Institution of No.12, Fangongting South Street, Qing Zhou 262500, P.R. China

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This study designed and developed a suit of water resource management system based on geographic information by employing GIS system, which shall carve a new road for the rational utilization and development of water resource.

METHODOLOGY

Water resource management is about the quantitative analysis and comprehensive integration on systematic level for regional water resources in aspects of development, utilization, management, configuration, conservation and protection. On the one hand, it shall provide water resource basic for basin land planning and economic layout planning; on the other hand, it can coordinate the relation between the specialized planning's of flood protection and water logging control, water-saving irrigation, urban water supply, hydroelectric power, water and soil conservation, by readjusting the space-time distribution of water yield and formulating the standard of water environment, so, it plays an important role for mankind in the whole process of developing and utilizing water resource (Badmus *et al.*, 2013). Owing to the mobility character of water, the disturbance of one point of drainage basin shall affect the circum and down stream areas, therefore, during the process of comprehensively managing basin water resource, one should make an analysis of the environmental influence of various management strategies and development plans by basing on the corresponding environmental model, at the same time, synthesize, analyze and compare the demands of different parts to the functions of water resource by integrating the local natural and social conditions, finally, map out the optimal decision of water resource management in drainage basin.

Then it follows that various kinds of environmental process models are emphasized in the process of managing and planning basin water resource, which includes steady state and dynamic state water-flow models, multidimensional water quality model and pollution diffusion model, etc. Most of these models have obvious spatial characteristic, but they still have difficulty in operating spatial data and especially in aspect of result display. However, spatial analysis and spatial data management are just the superiority of GIS. GIS can provide integral spatial operation specification based on GIS logical theory for these environmental models, so as to reflect the movement, diffusion, dynamic change and interaction process of model research objects which have spatial distribution characteristic. The basic conceptions of GIS are spatial location, spatial distribution and spatial relationships, while its basic research objects are spatial entities being abstracted as dot, line and face and their association attributes. In correspondence with it, about environmental model, the basic conceptions are substance, energy and its conversion and movement, while its basic research objects are environmental elements, such as water and population that possess

obvious spatial distribution characteristics. The similarity and complementarily of GIS and environmental model in aspects of conceptions and research objects allow the combination of them to be reasonable and have practical value (Peilong, 2013).

In aspect of software selection, GIS development software makes use of ArcGIS series manufactured by American Environmental Systems Research Institute Inc. It consists of three major parts:

- ArcGIS desktop software, which is an integrative advanced GIS application
- ArcSDE access, which is a connector used for managing spatial database by RDBMS
- ArcIMS software, which is GIS based on Internet distributed data and services

ORACLE9I, one of the most popular large database systems at present, is chosen as DBMS (Saneifard and Abbasi, 2012). The whole system applies the method of three-layer-model, C/A/S and windows Server2000 is chosen as operation system (Fig. 1).

On the basis of the construction of GIS information analysis platform, it makes use of the basic electronic map of 1:250000 in the whole irrigated area, drainage map of 1:10000, as well as DEM map of 1:50000 in irrigated area and 1:2000 locally.

The following main functions can be realized on the basis of GIS water resource management system.

Predictive analytics: It can timely draw the contour map of underground water level by inputting dynamic monitoring data and calculate the storage capacity of underground reservoir through the spatial analysis model of the system, so as to make a prediction to the variation trend of future groundwater resources by employing the water resources prediction model in auxiliary decision analysis module.

Analysis of water resources scheduling: In accordance with the proportion of agricultural and industrial departments covered in national economy and their production status at that time to make index analysis, so as to determine reasonable output of supplying water, allow the limited water resources to have optimal distribution and give play to maximum economic benefit.

Information retrieval and query: It can search the hydrologic data annually observed in research area, such as annual precipitation and runoff volume, annual variation and monthly variation of underground water level, storage volume of water reservoir, emission load of waste water, etc. It also can inquire the internal memory of the system or various kinds of picture files derived from system analysis, such as cultivated land, channel, river system, reservoir topographic contour, typical annual rainfall isoline, etc.

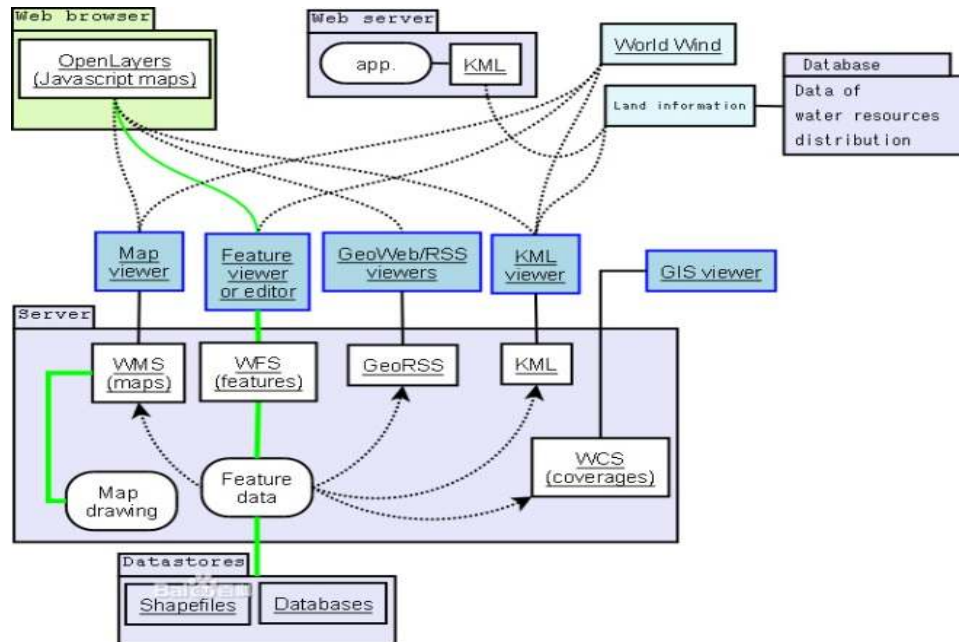


Fig. 1: Water resource management system data flow diagram

Simulation and decision-making: Perform simulation to the implementation effect of the proposed feasible water resource management plan by means of water yield calculation model and water quality evaluation model, so as to make a direct evaluation to the alternative schemes. Furthermore, the prediction results can be inputted to Decision Support System, so as to obtain the optimal solution of the planning scheme.

At present, the first stage of design and development of the system has been completed, which allows the realization of water resources information query under GIS platform, water transfer scheme simulation and multiple visual management functions.

EXPERIMENTS AND RESULTS

After the system imports the information data of China Hubei Water Resource, it makes experiments to the data acquisition, transmission, storage and management of basic information platform in the system, which has proved that the system can achieve the following functions.

Information query system: Information query system is to carry out water resource management and analysis work by applying GIS into water resource management and analysis, integrating the current undertaking demand of water resource with GIS function and taking advantage of GIS function. This system has realized quick index query of water resource information and created convenient conditions for the information sharing of water conservancy and water resource.

Decision support system: DSS is man-machine interactive system, which is to evaluate and predicate

the quantity and quality of water resource by water resource analysis, evaluation, prediction model, as well as calling database materials based on GIS technology.

Service management system: SMS is mainly to achieve office automation of declaration, examination and approval and certificate issue of water resource items requiring administrative approval. In the process of project examination and approval, DSS and GIS platform shall be equipped to make aid decision; meanwhile, it also has the functions of classified statistical query, subtotal and report printing.

Business handling platform for water user: Business handling platform for water user mainly allows water user to submit the approval projects on the net. Its functions involve project declaration, declaration query, advice and notice, user information modification and system using help.

Database management system: Database management system is responsible to the storage, retrieval, handling and maintenance of mass data referred by the system and it also shall extract data from various information resources coming from different channels, so as to convert them into data needed by the system. And it mainly includes two large divisions of spatial database management and information database management.

CONCLUSION

The experiments and practical tests indicate that GIS water resource management system can visually exhibit water conservancy operational data, make correct aid decision by intelligent judgments in

accordance with industrial standard and historical database, allow users to monitor different problems confronted in water conservancy working more accurate and efficient, as well as decrease the labor intensity of the staff. In the end, it can attain the objective of guaranteeing water resource system to distribute reasonably.

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