Information System of the Wetlands on the Qinghai-tibet Plateau

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***Abstract*—This study establishes an information system of the wetlands and lakes on the Qinghai-Tibet Plateau. We sort up on the wetlands and use Visual Basic 6.0 for the management and development of MapObjects, and the ArcSDE pattern to place the spatial and attribute data into the Microsoft SQL Server relational integrated database. We demonstrate how this Wetland Information System, containing all the characteristics of the Qinghai-Tibet Plateau, can be applied to help manage the lakes and wetlands of the Qinghai-Tibet Plateau in a sustainable manner.**

***Index Terms*—Qinghai-Tibet Plateau; wetland; information system; MapObjects**

I. Introduction

Wetlands are a precious natural resource forming the transition zone between land and water. It is a unique ecological system and, with economic and technological development, the exploitation of wetlands has increased. The destruction of wetlands has caused increasingly serious environmental and resource issues and, as a result, the international wetland research community has agreed that stronger protection of the wetlands is needed.

Governments have begun to pay attention to wetland protection and management, and use different types of technology for scientific research of the wetlands [1, 2]. Along with the wide application of the Geographic Information System (GIS), establishing a wetland resources database, to cover a certain country or to monitor the economic development of a wetlands area, has become the focus of wetland research [3].

This study combines data from previous wetland research to establish the Qinghai-Tibet Plateau Wetland Geodatabase Model by analyzing and summarizing the characteristics of wetlands on the Qinghai-Tibet Plateau.

We introduce a method to develop the GIS database by applying ArcSDE (Spatial Database Engine) and Geodatabase techniques. We also demonstrate how to establish, operate and backup the spatial database. Using component technology and the MapObjects method, we establish an information system of the Qinghai-Tibet Plateau wetlands, which provides a scientific basis for the protection and sustainable use of the Qinghai-Tibet Plateau wetlands.

II. General Situation Of Study Region

The Qinghai-Tibet Plateau, known as "the roof of the world", is the highest, largest, and youngest plateau in the world. It is bordered to the north by the Kunlun, Altun and Qilian mountains, to the south by the Himalayas, to the west by the Pamir Mountains, and to the east by the Loess Plateau and the Sichuan basin, including Qinghai, Tibet, and the Gansu, Sichuan, and part of the Xinjiang provinces (See Figure1).

Wetlands, consisting of different types and covering large areas, are widespread in China and rich in resources. The Qinghai-Tibet Plateau wetland is a unique wetland in

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China [4]. The wetland types on the plateau include lakes, and lake, marsh, river and peat wetlands. The marsh wetland located in TangGuLa Shan at an elevation of 5,350 m is the highest wetland in the world. The Yangtze, Yellow, Lancang, Nujiang and YarlungZangbo rivers all originate from a river wetland that is the most important source of freshwater for the region. The Qinghai-Tibet Plateau wetland is distributed mainly in three types of area: the exterior drainage of large rivers; the central plateau region with high elevation or in the flows of mountain basins; and low-lying regions with moderate topography [5].

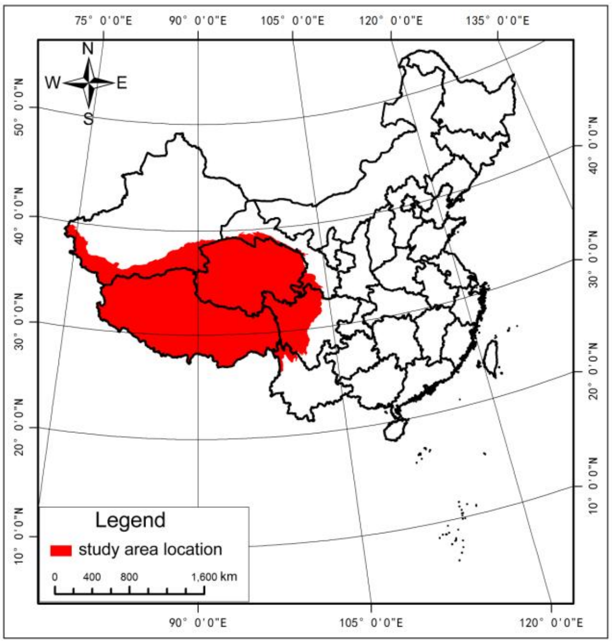


Figure1. Location of Qinghai-Tibet Plateau of China

III. Wetland Information System

GIS is an emerging interdisciplinary and comprehensive technology integrating the disciplines of information and computer science, modern geography, remote sensing, and space, environmental and management science. It is capable to handle many semi-structured and none-structured problems, and can provide accurate and scientific information for system users [6].

GIS operates on two data elements: spatial and attribute data. Spatial or geographical data refers to a known location on the Earth's surface. Attribute data means the statistical and non-location data associated with a spatial entity [7].

A wetland management information system can be established with the application of intelligent and automated GIS technology. This entails collating GIS vector data, documents and other data in a specific format, and applying the advantages of GIS technology (an objective, accurate, economical and efficient program) to achieve dynamic monitoring and real-time updates of wetland information to provide leadership and information for decision-makers.

With the extensive application of GIS databases, wetland resource databases have become the focus of wetland research worldwide. The first Wetland Information System (APIRS) was established at the University of Florida in 1979. Subsequently, a number Wetland Information Systems have been established. According to the function of a Wetland Information System, it can be divided into query service-oriented and decision support-based information systems. The former focuses on transforming wetland data into a wetlands database for use as a public service query system for wetland information. The latter has the ability to process integrated wetland data and produce new information, and also take advantage of the integrated information to evaluate the status of the wetland, and to assist decision-makers in formulating scientific wetland protection and development planning.

IV. Study Platform

Within many emerging IT concepts and products, component software technology has become one of the most popular technologies and the main direction of GIS development [8-10]. The component characteristics for software development include release in binary form, independence of development tools and languages, reusability, high efficiency, expansion and redevelopment capacity [11-14].

MapObjects has a powerful function in projection transformation, address matching, data access, map query, display and drawing output, to meet the demands of the user for data publishing, application development and business requirements. MapObjects includes a map control, and over forty Object Linking and Embedding (OLE) objects with properties, events and methods [15-16]. ArcSDE is a type of middleware technology offering an open interface between the GIS application procedures and the space database on a relational database management system (RDBMS) [17, 18]. Data formatted as Coverage, Shapefile, INFO table, Dbase table, or Computer-aided design (CAD) can be imported using ArcCatalog. The SQL (Structured Query Language) Server 2000 is used as the data backup tool, because it provides four options (Database Backup, log, differential, and group-of-files backups) to effectively preserve the safety and integrity of the system [19].

V. Design And Implementation

The system has, proceeding from the exterior to the interior, the human-computer interface, database, module base, and decision support. It provides a practical system for the Qinghai-Tibet Plateau wetland data. The system has been designed based on the following principles: completeness, standardization, systematization, compatibility, versatility, reliability, practicality and scalability. Completeness mainly refers to the system functionality. GIS is generally applied in functions, such as data collection, management, processing, query, edit, display, drawing, conversion, analysis and output. Standardization has two meanings, the first states that the GIS design should meet the basic requirements and standards, and the second states that data types, coding, and drawing symbols should be consistent with existing national standards and industry norms. Systematization states that the property database management, the graphics and database management, and application model subsystems must be naturally combined into one so that various parameters can be transmitted between them. Compatibility ensures that the data have interchangeability and can be shared with different GIS, CAD and other types of databases. Versatility states that the system must be able to promote the use of different ranges, without geographic restriction. The reliability of the system consists of two aspects; the security of the system operation, and the reliability of the data and the integrity of the symbol content. Practicality refers to a system of data organization flexible enough to meet different application analysis needs. The system is clearly able to solve queries posed by the user, and provide services for production, research and teaching. Scalability of the system is a continuous process of improvement, to facilitate system development and expansion.

A. *Data Sources*

The data in the system can be divided into spatial and attribute data. The spatial data include vector data on wetlands extracted from topographic map data from the 1960s, Multispectral Scanner (MSS) data from the 1970s, Thematic Mapper (TM) data from the 1990s and Enhanced Thematic Mapper (ETM) data from 2000. The spatial data also contain vector data on administrative regions, water systems and landform boundaries, and raster data of remote sensing images. The attribute data include information tables for lakes, and marsh, river, and lake wetlands, and an information table of geographical elements.

B. *Import Data*

If the data is stored in the format of Converage, Shapefile, INFO table, Dbase table and CAD, we can import the data with ArcCatalog(Figure.2). In addition, if there is few data or no data for creating database, we may create feature class, feature set and table with utilizing “New” operation of ArcCatalog and then input the data (Figure.3).

C. *Backup and Recovery*

The role on the backup of the database is to build the copy of the structure and the data on the database in order to recovery the data when the database is destroyed. SQL Server 2000 provides the backup on four kinds of objects (including database, loggings, differential files and file groups). It will improve the safety of the database greatly and lower the risk on the loss of the data to take advantage of different kinds of methods for the backup of the database. The recovery of the database means that retrieving the data with the backup after the database is loss or destroyed, where the enterprise manager will provide the simple GUI (Graphic User Interface) for the recovery operation. We can ensure the security and the integrity of Qinghai-Tibet Plateau wetland database effectively through the backup and recovery of database.

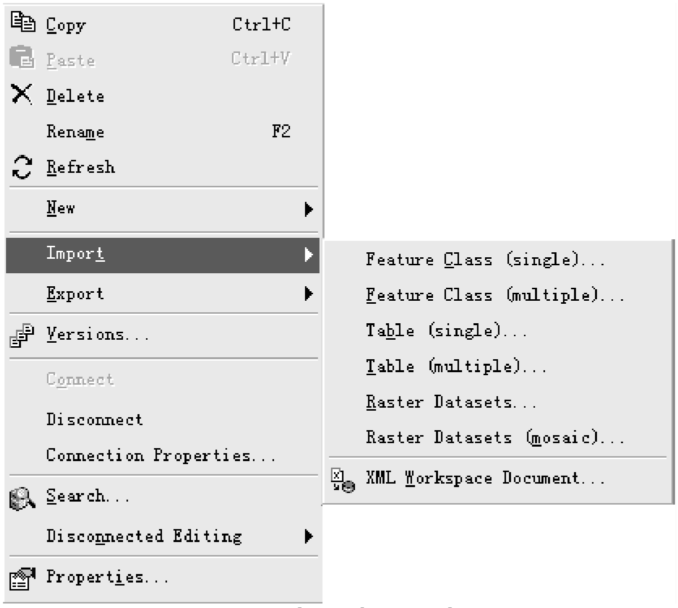
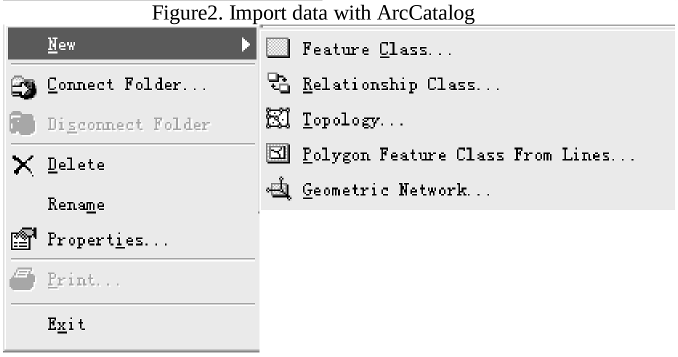


Figure2. Import data with ArcCatalog



Fiure3. Import feature class, feature sets, tables with ArcCatalog

D. *Function*

The functions of the system include data presentation, retrieving, information statistics, thematic map-formatting and system maintenance. In the thematic map-formatting module, we adopt models of the strength of wetland change and relative wetland change.

1. Model for strength of wetland change: the values of n reflect the characteristics of the wetland changes in different areas.

$$n = \frac{K_b - K_a}{S_i} \times 100\%$$

where K_a is the wetland area at the start of the research and data logging, K_b is the wetland area at the end of the research, and S_i is the area of the research

2. Model for rate of relative wetland change: the wetland changes substantially in different regions. The values of R reflect the differences of wetland changes in different areas [20]:

$$R = \frac{K_b - K_a}{K_a} \Big/ \frac{S_b - S_a}{S_a}$$

Where K_a is the wetlands area at the initial time of the research area, K_b is the wetlands area at the final time of the research area,

S_a is the wetlands area at the initial time of the whole research area,
and S_b is the wetlands area at the final time of the whole research area

The changes in large lakes (area > 500 km^2) provide important insight into the ecological environment of the Qinghai-Tibet Plateau. There are 13 large lakes on the Qinghai-Tibet Plateau, and using this system, we are able to monitor their changes.

VI. SYSTEM VALIDATION

The interface of the system includes three modules: the information query, information statistics and the key lakes monitoring modules. The information query module provides "Click inquiries", "Name inquiries" and "Criteria inquiries", which are three ways to query the system for information on the lakes and wetlands. This module also supports commands such as map zoom-in, zoom-out, pan, browsing and find out. Figure 4illustrates how the user is able to select the area and wetland type they want to query, and information on the objects, such as text, images and graphs, will be displayed.

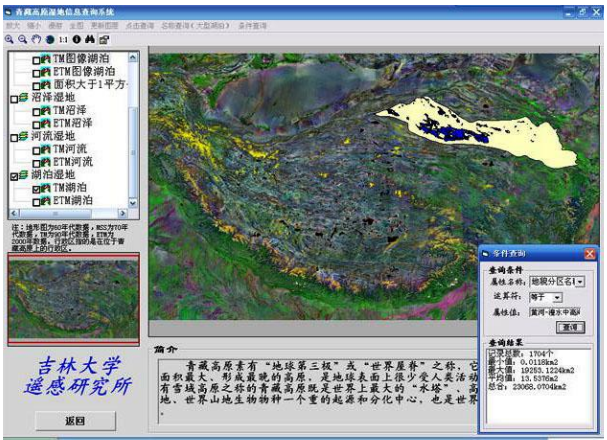


Figure4.Criteria inquires of the information query module

The information statistics module includes four sections: lake, river, and swamp wetland information statistics, and all wetlands information statistics. Using this module, we can study the dynamic changes in lakes and wetlands. As shown in Figure 5, by selecting a specific parameter, we can draw a map of the dynamic changes in the river wetlands divided by district on the Qinghai-Tibet Plateau. Figure 6 displays the dynamic changes of the lake wetlands information statistics on the Qinghai-Tibet Plateau.

Using the key lakes monitoring module, we can observe the dynamic changes and images of large lakes, and use the toolbar to look up positions and ranges of interest. As can be observed in Figure 7, there is a clear atrophy change in the northwest corner of Zhari Namco Lake and its area has decreased substantially.

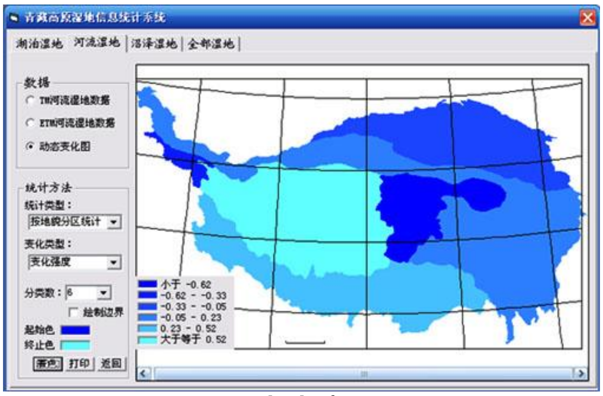


Figure5.River wetland information statistics

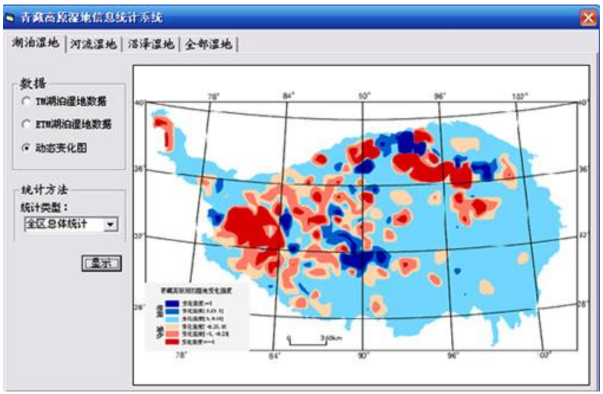


Figure6.Lake wetland information statistics

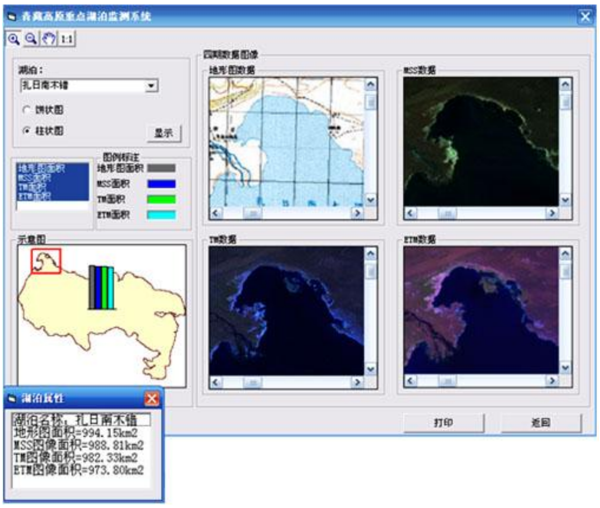


Figure7.Key lakes monitoring

VII. CONCLUSIONS AND RECOMMENDATIONS

The spatial and attribute data of the wetlands can be comprehensively managed using the “MapObjects” method.

We have created a scientific management plan of the Qinghai-Tibet Plateau wetland data, which is a convenient way to show different regional characteristics. It is a helpful tool for understanding the reasons for spatial variation and for providing scientific information for decision-making on environmental protection issues.

This paper introduced models of the strength of wetland change and relative wetland change in the thematic map-formatting module. The system analysis and manage wetland data, which can effectively organize wetland data and information management.

Data on peat wetlands are needed to complete the system. Using these data, we will be able to improve system performance and speed up the space data display and operation.

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