An Integrated Information Service Platform for Wetlands Based on WebGIS

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***Abstract*—Wetland resource management is an important task in the protection and utilization of wetlands. Given the environmental interests in these wetlands, there is urgent need for a centralized repository and mechanism to share geospatial data, information and maps of wetlands. Our objective is to develop an interactive WebGIS and geodatabase for wetlands providing mapping and data services. This paper represents an integrated information service platform based on WebGIS using spatial statistics and analysis method based on ArcGIS Server to manage and utilize wetland resources. The system adopts the Browser / Server architecture, dot NET framework, and ArcGIS Server component to improve the performance of current system. The functions of this system are map distributing, query and display, spatial statistics and analysis, scientific education, remote management, and wetland resource sharing. It has much superiority like good compatibility, convenient data maintenance, high efficiency, and code security, etc. The system scalability and database stability have been improved greatly. Practical application shows that the system can fully satisfy the requirement of wetland resource management and achieves expected goals.**

***Index Terms*—wetlands, information service platform, ArcGIS Server, WEBGIS, ArcSDE**

I. Introduction

Wetlands are not only an unique ecological system formed by interaction of water and land, but also is an important living environment for human beings, and one of natural landscapes that have the richest biodiversity. Wetlands tied with forest and ocean are called the world's three major ecosystems. Wetlands are also known as "the kidney of the earth", "the cradle of human civilization", and "species gene pool". Wetland resources have mass data, whose data types are complex and diverse, and the current management methods are difficult to efficiently manage and fully utilize. The structures and standards of wetland data are not uniform so that they are difficult to be shared, which lead to the duplication of data collection and waste of manpower, materials and financial resource. There are many problems such as chaotic management, poor data sharing, weak protection sense of the public, unreasonable exploitation, and the difficulty of information dissemination, etc. in the protection and utilization of wetland resources.

The current situation of data management of wetland resources is as following:

(1) The wetland resource data cannot be shared effectively, because the structures of data storage are not uniform in different departments. They use various ways to collect and store wetland data according to their own requirements [1]. Since wetland data cannot be stored and managed efficiently by relevant departments, some of them may be ruined. Exchanges of wetland resource data are difficult between departments, which has resulted in the serious waste of wetland resources.

(2) Wetland resource data updates are not timely. Because of the slow speed of updating and having nonstandard formats, wetland resource data cannot achieve real-time updates. At present manual management or stand-alone information system is used to manage wetland resource data. Their consolidation and standardization cannot be handled timely and the use time of data is seriously lagging behind.

(3) The conservation of wetland resources was not extensively propagated among the public in the past, and the public are not strongly aware of the significance of wetland resource conservation. At present, the ways of wetland propagation are not efficient and outdated. With the developing of network and GIS, WebGIS is a good way to propagate wetlands.

(4) Under the low utilization rate of wetland resources, investigation and management departments have paid a lot of manpower, financial, and material resources to get

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wetland resource data. But the wetland resource data are stored separately in their own database and formats which cannot be used by other users (such as other departments, researchers, and institutes).

Thereby, in order to strongly protect and reasonably utilize wetland resources, a wetland resource information system should be established to achieve uniform management. It can manage, organize, maintain and share wetland resource data. In recently years, with the popularity of Internet technology and the development of Geographical Information System (GIS) technology, integrated management of spatial and attribute data of the wetland resources (maintenance, update and sharing, etc.) become possible according to common spatial ordination and uniform data standards. To construct wetland integrated information service platform based on Internet technology is a development of GIS application in wetlands. On the one hand, it can realize wetland resource data sharing; provide wetland resource data for most scientific researchers; avoid data duplication collection; build a wetland resource management platform for administrators; enhance management efficiency and level; on the other hand, it can realize wetland research and education, and raise people’s awareness of wetland conservation.

Based on the above analysis, to construct a wetland resource information system is necessary and urgent. It aims to realize wetland resource data sharing, remote management, attribute and spatial analysis, standardized data and archives, publishing information on the Internet.

Considering the above problems, some scholars have already carried out some researches. A wetland resource information sharing system of Dongting Lake was established based on MapServer. It has realized data remote sharing [1]. Huanghua wetland information system can realize Map basic manipulation, query, and basic analysis [2]. A map publishing and query system was constructed using C# programming language, it shows that C# programming language is more efficient to establish a wetland geographical information system [3]. An eco-tourism information system based on WebGIS has been constructed combined wetland tourism with WebGIS [4]. WebGIS is a special application field of GIS; it turns global scale geographical information sharing into a reality. Users can get all kinds of functions served by wetland geographical information system based on WebGIS through Internet browser without extra client software [5]. Web based GIS system allows multi-scientific collaborators to easily access to the last updated data and to monitor and validate their works easily [6]. Planning and management of forest land use is easily and effectively conducted using GIS. However, the integration of remote sensing and GIS for the development of mangrove forest management plans by natural resource managers and planners is necessary [7].

These scholars have studied wetland resource information system from different angles. They have provided some solutions for data sharing, information query, and the basic structure of information system. However, some problems emerged in the current studies of these scholars.

(1) These solutions should be integrated to achieve wetland resource comprehensive management through a uniform geographical information system platform.

(2) Current solutions need some extra functions, such as science and education, remote management.

(3) Some functions need to be strengthened, such as spatial analysis and statistics, security.

(4) Design and implementation of wetland resource information system need to be planned uniformly.

(5) The technologies of current systems are relatively backward. To solve these problems, this paper presents an integrated information service platform for wetlands using spatial statistics and analysis method based on ArcGIS Server, and practical application shows that the expected goal has been achieved.

The outline of this paper is as follows: Section 2 introduces basic theories of the study; Section 3 presents wetland resource integrated information service platform based on ArcGIS server to manage and utilize wetland resources; Section 4 validates the system through practical application and analysis; Section 5 concludes this paper and describes the future work.

II. BASIC THEORIES OF THE STUDY

A. Spatial Statistics and Analysis Method

Spatial analysis or spatial statistics includes any of the formal techniques which study entities using their topological, geometric, or geographic properties. Complex issues arise in spatial analysis, many of which are neither clearly defined nor completely resolved, however, they form the basis for current research. The most fundamental problem is how to define spatial location of the entities being studied. For example, a study on wetland resources could describe the spatial position of birds with a point placed where they live, or with a point located where they hunt for food, or by using a line to describe their migration trips; each choice has dramatic effects on the techniques which can be used for the analysis and on the conclusions which can be obtained. Other issues in spatial analysis include the limitations of mathematical knowledge, the assumptions required by existing statistical techniques, and problems in computer based calculations.

A mathematical space exists whenever we have a set of observations and quantitative measures of their attributes. For example, we can represent individuals' income or years of education within a coordinate system where the location of each individual can be specified with respect to both dimensions. The distances between individuals within this space is a quantitative measure of their differences with respect to income and education. However, in spatial analysis we are concerned with specific types of mathematical spaces, namely, geographic space. In geographic space, the observations

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correspond to locations in a spatial measurement framework that captures their proximity in the real world. The locations in a spatial measurement framework often represent locations on the surface of the Earth, but this is not strictly necessary. A spatial measurement framework can also capture proximity with respect to, say, and interstellar space or within a biological entity. The fundamental tenet is Tobler's First Law of Geography: if the interrelation between entities increases with proximity in the real world, then representation in geographic space and assessment using spatial analysis techniques would be appropriate.

The types of spatial analysis mainly include spatial autocorrelation, spatial interpolation, Spatial regression, Spatial interaction, Simulation and modeling, and Multiple-Point Geostatistics (MPS).

The quantitative assessment of spatial autocorrelation has played a fundamental role in ecological analysis, soil analysis, 1andscape analysis and social science analysis. Spatial autocorrelation exists when there is a significant similarity or dissimilarity between the values of a variable *z* at all pairs of adjacent locations *i*, *j*. Moran's Index (or Moran's *I*) has been used to detect spatial autocorrelation and analyze spatial relationships among analysis unit. Global Moran's I is defined as

$$I = \frac{N}{W_{ij}} \bullet \frac{\sum\sum W_{ij}(x_i - \bar{x})(x_j - \bar{x})}{x_i - \bar{x}} \quad (1)$$

where, W_{ij} is the binary spatial weight matrix. x_i and $\bar{x}$ are the attribute value. The max va1ues of Moran's I is 1, which means absolute positive spatial autocorrelation.

The binary contiguity matrix is defined as

$$W_{ij} = \begin{cases} 1 & i \text{ and } j \text{ are adjacent} \\ 0 & i=j \text{ or } i \text{ and } j \text{ are not adjacent} \end{cases} \quad (2)$$

where *W* is the binary spatial weight matrix.

In literature [12] the loca1 Moran’s I is used to understand the spatial clustering process. Local Moran’s I is defined as

$$I_i = (z_i / m_2) \times \sum_{j=1}^{n} W_{ij} z_j \quad (3)$$

where z_i and z_j are deviations from the mean value of variable *X*, $m_2 = \sum_i (z_i^2 / n)$ as a second moment, W_{ij} is a binary spatial weight matrix in which each pair of neighbors is assigned a one and each non—neighbor pair is assigned a zero. Local Moran's I is large and positive when x_i is similar to adjacent values x_j. Local Moran's I is large and negative when x_i and neighboring values x_j are dissimilar. Local Moran’s I is approximates zero when no spatial autocorrelation exits between x_i and neighboring x_j .

Geographic information systems (GIS) and the underlying geographic information science that advances these technologies have a strong influence on spatial analysis. The increasing ability to capture and handle geographic data means that spatial analysis is occurring within increasingly data-rich environments. Geographic data capture systems include remotely sensed imagery, environmental monitoring systems such as intelligent transportation systems, and location-aware technologies such as mobile devices that can report location in near-real time. GIS provides platforms for managing these data, computing spatial relationships such as distance, connectivity and directional relationships between spatial units, and visualizing both the raw data and spatial analytic results within a cartographic context.

Our wetland WEBGIS adopts spatial statistics and analysis method to implement spatial map distributing, query and display, spatial data statistics and analysis, scientific education, remote management, and wetland resource sharing..

Spatial Decision Support Systems (SDSS) take existing spatial data and use a variety of mathematical models to make projections into the future and to help managers to make decision. Our wetland WEBGIS is a simplified SDSS which can provide aided decision information for management departments. This allows planners to test intervention decisions prior to implementation.

B. ArcGIS Server

ArcGIS Server gives people the ability to create, manage, and distribute GIS services over the Web to support desktop, mobile and Web mapping applications [8]. ArcGIS Server simplifies access to GIS services for GIS professionals, mobile workers, as well as knowledge workers without any GIS experience. With ArcGIS Server, people stay in control of themself content through centralized management of spatial data, including imagery. In addition, ArcGIS Server provides people with a scalable GIS server platform that can be deployed on a single machine to support small workgroups, or it can be distributed across multiple servers for supporting enterprise applications. People can also deploy ArcGIS Server on Cloud infrastructure. Fig. 1 shows the architecture of ArcGIS Server.

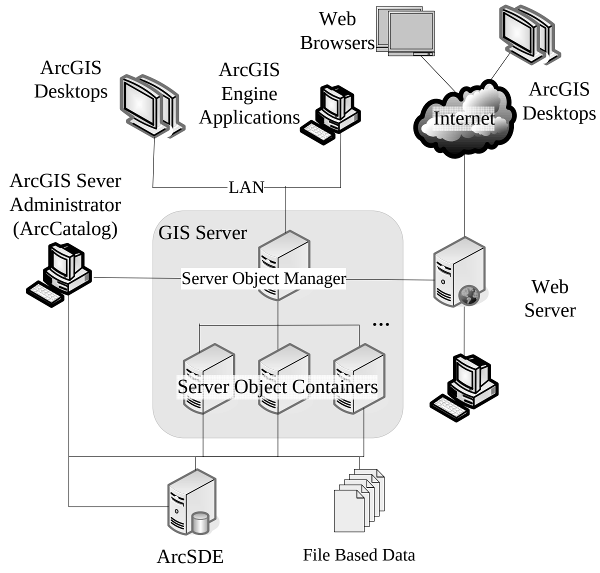

Figure 1. The Architecture of ArcGIS Server.

The map of wetland resources should be distributed on the Web to server all the users. In our information service platform, the ArcGIS Server is used to publish map information of wetland resources. It provides spatial data display, management, analysis and statistics functions of wetland resources.

C. ArcSDE Technology

ArcSDE technology is a core component of ArcGIS Server. It manages spatial data in a relational database management system (RDBMS) and enables it to be accessed by ArcGIS clients. It is this very technology that provides the framework to support long transactions, which facilitates the versioned editing environment in multiuser geodatabases.

ArcSDE technology serves as the gateway between GIS clients and the RDBMS. It enables you to store, access, and manage spatial data easily within an RDBMS package such as DB2, Informix, Oracle, PostgreSQL, SQL Server and SQL Server Express. ArcSDE technology is critical when you need to manage long transactions and versioned-based workflows such as support for multiuser editing environments, distributed editing, federated replicas managed across many RDBMS architectures, and managing historical archives. The responsibility for defining the specific RDBMS schema used to represent geographic data and for application logic is retained in ArcGIS, which provides the behavior, integrity, and utility of the underlying records.

On our integrated information service platform, the ArcSDE is used to manage spatial data of wetlands based on Microsoft SQL Server. The data of wetlands is stored in the Microsoft SQL Server and accessed through ArcSDE.

D. Geodatabase Technology

The geodatabase is the primary data storage model for ArcGIS; it provides a single central location to access and manage spatial data. A multiuser geodatabase utilizes a multitier architecture that implements advanced logic and behavior in the application tier (e.g., ArcGIS software) on top of a storage tier (e.g., relational database management system [RDBMS] software). The responsibility for managing geographic data in a multiuser geodatabase is shared between ArcGIS and the RDBMS software.

A relational database management system provides a straightforward formal structure for storing and managing information in tables. Data storage and retrieval are implemented with simple tables. The multiuser geodatabase utilizes the power of the RDBMS. Certain characteristics of geographic data management, such as disk-based storage, definition of attribute types, query processing, and multiuser transaction processing, are delegated to the RDBMS.

The geodatabase is the common data storage and management framework for ArcGIS. It combines "geo" (spatial data) with "database" (data repository) to create a central data repository for spatial data storage and management. It can be leveraged in desktop, server, or mobile environments and allows you to store GIS data in a central location for easy access and management. The geodatabase offers you the ability to store a rich collection of spatial data in a centralized location, apply sophisticated rules and relationships to the data, define advanced geospatial relational models (e.g., topologies, networks), maintain integrity of spatial data with a consistent, accurate database, work within a multiuser access and editing environment, integrate spatial data with other IT databases, easily scale your storage solution, support custom features and behavior and leverage your spatial data to its full potential.

III. WETLAND RESOURCE INTEGRATED INFORMATION SERVICE PLATFORM

A. Functional Modules of the System

The integrated information service platform of wetland resources is made of some modules including system management, basic manipulations, data analysis, information publishing and management, science and education, and data sharing (Fig. 2). Specific functions of each module are as follows:

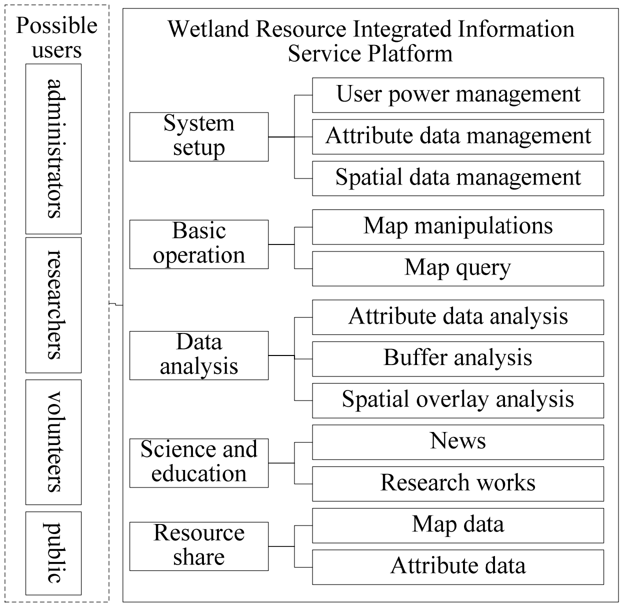

Figure 2. Function modules of the platform.

a. System Configuration Management Module

The first work of system configuration is to grant users privileges. There are four types of users in the system including wetland administrators, wetland scientific researchers, wetland conservation volunteers, and the public in the world. The system administrators have rights to set up and manage other user's accounts and privileges.

In additional to the above functions, the module which is oriented all kinds of users can realize the following functions: (1) collecting, inputting, and editing wetland resource space and attributes data; (2) vector, publishing, and storing graphic and attribute data; (3) System administrators can timely update graphic and attribute data; (4) changing database structures timely; (6) discriminating and assigning reasonable privileges to users; and (5) all kinds of users can edit and update wetland resource data remotely by Internet anywhere at any time. The basic data processing software platform is ArcGIS Desktop of ESRI which can support a variety of spatial data formats.

b. Basic Manipulation Module

Basic manipulation module includes map manipulations and map inquiries. Map manipulation (that is GIS standard manipulations for map) includes map display, distance measurement, area measurement, zoom in, zoom out, pan, flying, legend management, and layer management, etc. Map inquiry function mainly provides a variety of data retrieval operation for users, including a simple query, composite query, print, output graphics, and other operations. The module also provides interactive inquiry, display, and output thematic graphics and spatial information.

The module also provides a function for a variety of spatial information retrieval, such as direct hitting a spatial object on the map to get attribute information of it; drawing a rectangle on the map to obtain information of spatial objects within it; and using SQL query.

Attribute data query is to obtain attribute data through spatial objects and Query results in tabular or statistical graph display, specific as follows: (1) Condition query. According to the requirement of users, the system creates a query clause to achieve the query goal and shows it on electronic map. (2) Multimedia data query. The system searches multimedia information on the table according to key words entered by users. The system downloads and plays the multimedia or pictures from the location of the searched results. (3) Graphic display of attribute data of spatial object. Attribute data of Spatial object is displayed as graphics on electronic map, such as pie charts, bar charts, and three-dimension charts. Electronic maps can be used to browse attribute data with visual and dynamic ways.

c. Data Analysis Module

This module includes attribute data analysis, buffer analysis, and spatial overlay analysis. Attribute data analysis and statistics includes wetland area, vegetation species, and animal quantity, etc. Buffer analysis is used for identifying areas surrounding geographic features. The process involves generating a buffer around existing geographic features and then identifying or selecting features based on whether they fall inside or outside the boundary of the buffer. There are three types of buffers; they are point-based, polyline-based, and polygon-based in turn.

The point-based buffer is an area built around a point object within a certain radius (c in Fig. 3). The polyline-based buffer is an area built around polyline objects within a certain radius (b in Fig. 3). The polygon-based buffer is an area built around a polygon object within a certain radius (a in Fig. 3). Buffer analysis is an important function of geographical information system applications. On studies of wetland resources conservation and utilization, many buffer analyses are needed to create, such as querying objects of riversides within a certain distance, or analysis of nature and human environment for a certain residential point. The following steps can realize a buffer analysis: (1) select one or many objects of a layer; (2) set up a certain distance for buffer analysis; (3) select all layers needed to use; (4) show the analysis results with different colors, and list all results on the bottom of web page. For instance, a researcher who wants to obtain all the residential points of riversides within a distance, he can select a river firstly, then set a certain distance from riversides, and overlay residential layer, lastly create a buffer with river layer and residential point layer.

a. polygon based buffer b. polyline based buffer c. point based buffer

Figure 3. Three types of buffer.

Main functions of the data analysis module include buffer analysis, overlay analysis, spatial distance computation, spatial area computation, and data mining of spatial and attribute data, estimate and forecast, and providing aided decision information for management departments.

d. Science and Education Module

For strengthening conservation and reasonable use of wetland resources, the science and education module is set up. Its functions include information publishing, wetland news management, wetland scientific research dynamics, propagation and education. Information publishing includes wetland news management and wetland scientific research dynamics management. Wetland resource information mainly comes from management departments of wetland nature reserves, related government, media, scientific institutes, Universities or colleges, wetland reserve volunteers, international organizations, and so on. Wetland resource news management is mainly used to publish wetland scientific projects, research results, and the frontier information of wetland research. The purpose of propagation and education is mainly to exhibit wetland multiple benefits and functions, tourism resources, wetland reserve documents, laws, and so on. The data of this module are texts, pictures, videos, and so on. A user can leave words or comments and realize intercommunication with other users. A user can intercommunicate with other users by leaving words or comments, which will help Ordinary citizens, scientific researches, students, and others know the importance of wetlands, and inspire them to take actions timely to conserve wetlands, and hopefully reach the goal that all the people take actions to protect wetlands all over the world.

e. Resource Data Sharing Module

This module provides data (all kinds of styles) upload and download function for users. All kinds of users can query or download wetland resource data remotely in the integrated information service platform of wetland resources through Internet when users login in the system.

Data provider (the users who uploaded data to the system) may earn chances to copy or download wetland resources in the system. User can download some important or sensitive data when he got the privileges from the administrators.

B. Integrated Information Service Platform for Wetlands

Based on actual survey, documentations reading, and discussion with related persons, this paper presents an integrated information service platform of wetland resources based on WEBGIS (Fig. 4). The system architecture has three sides: client side, application server side, and database server side.

On client side, users can send application request to application server side (such as ArcGIS Server) through web browser (such as Internet Explorer, Firefox, and Chrome), also receive and show results from application server side. Application server side mainly responses to web publishing, map publishing, data analysis, data processing, and so on. Database server side is mainly used to store, manage, and maintain spatial database (based on relational database management, such as oracle, mysql, sql server) and files (such as .doc and .xls). In the architecture, data services and application services are separated. Thus system performance is improved greatly. Database servers that provide the Database Management System functionalities include query optimization, query processing, transaction management and database management. It is responsible for searching the database and retrieving the results from it [9].

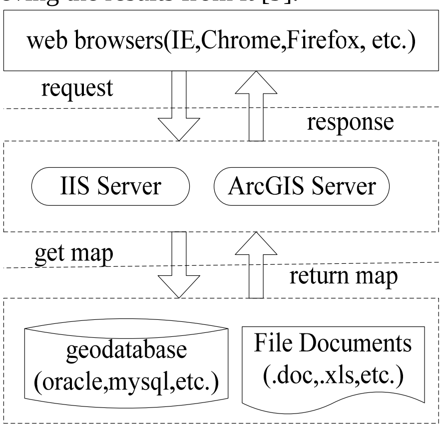

Figure 4. The architecture of the integrated information platform

C. Wetland Resource Data and Accessing Mode

Data of wetland resources WETGIS mainly includes basic geographical data, water resource data, biological data, documents, multimedia, and so on. The system adopts different data accessing method according to different data type. Spatial data is accessed and organized through ArcSDE component of ESRI Corporation. Guohui Li use ArcSDE to achieve the geographic data pretreatment, geographic information management, visualization, inquires the statistics, the terrain analysis, navigation and positioning, information output, and other functions, improve the level of automation in the civil air defence command [10]. Ordinary attributes data are accessed through ADO.NET component of Microsoft Corporation. Documents data are accessed through File System Object Model. Multimedia data are processed and accessed through streaming media technology. Data and access method are as showed in the Fig. 5. This data access method can fully take the advantage of every data access model to optimize data, and improve data access efficiency.

Specifically, wetland resources data are as follows:

(1) Basic geographical data. Basic geographical data includes range of regionalization (core area, buffer area, experimental area, and so on), management station location, roads (such as geometric parameters, and dynamic indicators), land use situations, administrative division, and so on. Basic geographical data mainly exists in SHAPEFILE styles, and a small amount of attributes data.

(2) Water resource data. Water resource is an important part of wetlands. Health situation of water resources plays a very important role in wetland ecological system. Lakes and rivers are the two major water resources in wetlands. So an attribute table is designed to store water resource data of wetlands. The main attributes of the table include river name, fluvial fluidity, water saline and alkaline, water covering area, river length, river area, and so on. Wetland pollution mainly comes from water body pollution, so the information of pollution source is important to rivers around wetlands and wetland data are stored in database too. The attributes of potential pollution source data include pollution source name, pollution type, pollution source distribution, and so on. Water resource data are stored in SHAPEFILE formats.

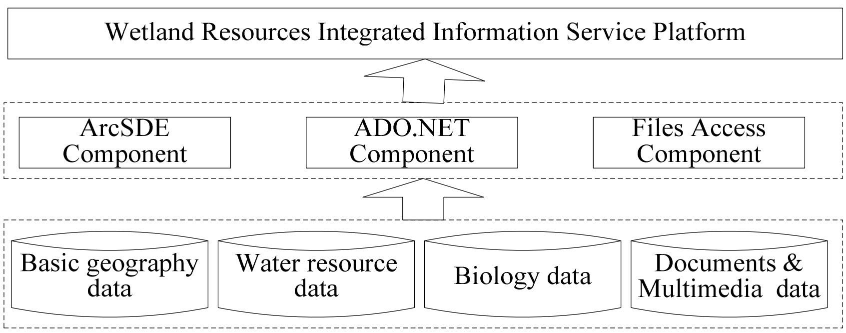

Figure 5. The data accessing manner of wetlands

(3) Biology data. Most wetland biology data are plants and animals. Plants attributes data include Chinese name, Latin name, family name, order name, ecological characters, distributions, and so on. Animal's data include Chinese name, Latin name, family name, order name, season type, protection level, ecological characters, distributions, and so on. Bird monitoring of important wetlands is emphasized because birds have indicative effect to wetland health. Monitoring and researching of birds of important wetlands is long-term and special. Biological data mainly stores in formats of attributes and a small amount of graphics.

IV. Practical Application and Analysis

This paper has been applied to the design of Lashi Lake wetland nature conservation district; Fig. 6 shows the application result.

The integrated information service platform of wetland resources adopts ESRI ArcGIS Desktop to manage, organize, and process the spatial data of wetland resources. It was developed under Microsoft .NET Framework platform with ArcGIS Server component using C# programming language. Microsoft SQL Server 2005 database management system is used to store and manage wetland resource data. Table I. lists the main tools used in the practical application.

TABLE I.
Main Tools Used in the Practical Application

Id	Name	version
1	ESRI ArcGIS Desktop	9.3
2	Microsoft .NET Framework	2.0
3	ESRI ArcGIS Server	3.0
4	Microsoft SQL Server	2005
5	C# Programming Language	3.0
6	ESRI ArcSDE	9.3

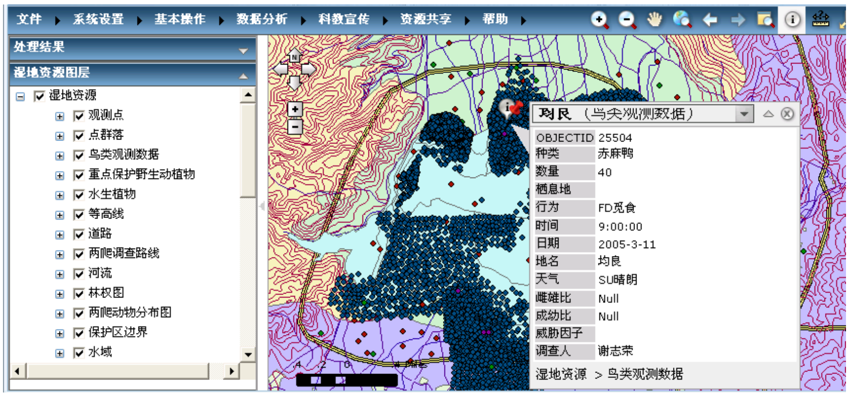

Figure 6. Practical application result.

This application presents a lot of advantages compared with a traditional paper bulletin. Tables, graphics and maps are built online based on end-user criteria (Web queries). All the data are continuously updated and can be consulted anywhere at any time. The contrast of this study and Lashi lake wetland nature reserve management information system in 2008 [11] shows the following advantages and features: (1) the integrated information service platform of wetland resources has better stability, generalization, applicability, and real-time performance. (2) wetland source attributes data are fully expressed by graphics and text. Wetland resource spatial data can be queried, analyzed, and added up through web, showed on map by visual ways. The public can access wetland resource multimedia data through Internet at their home, office, and so on. (3) wetland resource data can be easily publicized on the Internet shared by all kinds of users such as public, researchers, and so on. (4) wetland knowledge and news is conveniently delivered through the system, and users can get real-time and accurate information from the system. The system also can promote wetland protection and tourism propagation.

V. Conclusions

We presented the implementation of a WebGIS and geodatabase for wetlands using ArcGIS Server, which was extended by using a Microsoft SQL Server database, C#, and ASP.NET to provide data and map services. This is the first repository for wetlands and we expect that the sharing of previous, current, and future geospatial wetland datasets will reduce costs, avoid funding of redundant research projects, and secure continuous documentation of environmental health in wetlands adopting our WebGIS in the decision-making process of restoring wetlands. There is need to develop more Web-based tools to share environmental datasets and information. Decision-makers and administrators often have limited expertise in GIS and complex spatial analyses. WebGIS has the potential to share data, provide easy access for users with limited GIS knowledge, and assemble data and information customized for specific topics, such as wetlands, that support informed decision-making.

Our integrated information service platform of wetlands adopted ArcGIS Server, ArcSDE, and GeoDatabase technology to implement wetland resource management. Functions of the system include wetland resource data management, query, analysis, sharing, science and education, and remote management. The system can facilitate the management and utilization of wetland resources and provide aided decision support for administrators. The system makes wetland resource management and utilization more systematic, scientific and comprehensive. Our Integrated information service platform of wetland resources has some advantages as following:

(1) It can promote sharing of wetland resource data; provide more accurate, vivid, and abundant wetland resource data for the public, administrators, and researchers through web page; and provide real time and precise information support for all kinds of users.

(2) Updating and maintaining wetland resource data more fast and conveniently; all kinds of users can upload, download, update, and maintain wetland resource data through WebGIS by Internet anywhere at any time.

(3) WebGIS can be used to propagate wetland knowledge in efficient, visual, and global ways, and raise wetland ecological tourism awareness. And it also can effectively promote the wetland resource management level and efficiency. This should be introduced to other wetland nature reserves to use.

Although the system has the above advantages, there are some aspects need to be improved, such as spatial analysis, remote access speed for spatial data, map data, streaming media data transferring, and visualization function.

In the future work, the study will further strengthen the spatial analysis function, visualization function, and web streaming media play function, etc. The cloud GIS will be integrated into our study.

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