Enhancement of Urban Spatial Data Infrastructure to Support Land Administration in City Sanya, China

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Key words: digital earth, e-government, GIS, land database, Land Based Service

SUMMARY

Digital earth and e-government have significant impacts on the development of different land information systems in China in the recent decade. There was a tide of building up electronic land databases upon the traditional urban cadastral and land information management systems in wealthy cities. Most of these systems lack coordination, inter-operation, data sharing or exchange functions. They are built basically for departmental internal uses. Many investments were duplicated and wasted. There are hindrances on further development of Land Based Services and the applications on e-government are much limited. This paper reports on the investigation of the developments of urban land cadastral and land information systems in Sanya, Hainan, the Peoples' Republic of China in the recent decade, and discusses ways for enhancement of these systems particularly in the aspects of data ownership, copy right arrangement, data contents and quality control.

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1. INTRODUCTION: E-GOVERNMENT & DIGITAL EARTH

In the 1980's, government offices went through automations with the advent of mini-computers. In the mid 1990's, websites became available and by 1999 the Chinese Government started the government online program. According to [Zhao, 2004], the National Information Leading Group which consisted of members from the Central Committee of the Communist Party of China and the State Council set policy on the implementation of e-government. China's e-government market is a multi-billion yuan business, and, over 90 central government portals and 10,000 local government websites are now running [UNESCO, 2007].

The e-government projects have progressive aims. First, the setting up of the hardware and software for enabling the technology are usually completed in one to two years. Then, information sharing is gradually implemented and eventually a paperless government operation is achieved. The second and third aims are largely unaccomplished [Lovelock and Ure, 2002].

In land administration departments, e-government not only means the website services providing land related services but also uses other non-internet based technologies including the use of WiFi, Bluetooth, CCTV, GPS, GIS, etc in road traffic monitoring and any form of Location Based Services.

Digital Earth was the label given to a visionary concept, made popular in 1998 by former US vice president Al Gore, for describing a virtual representation of the Earth on the Internet that is spatially referenced and interconnected with the world's digital knowledge archives. The concept continues to evolve into two distinct organizational groupings. The first batch could be seen as the global digital earth community which includes non-government organizations, universities, government departments and companies, where they promote cooperative uses of standards, databases, software and hardware development. The second batch is the group of commercial applications which gradually become highly visible and popular. This group includes business guru like Google, MSN and Yahoo.

The top Chinese government has supported Digital Earth projects, from the inaugural meeting of the International Society of Digital Earth in 1999, to a wide spread of digital earth cities extending to provincial and municipal levels. Maps and positional information are traditionally treated as protected and restricted information in China. In the recent decades, with the top-down e-government policy and the growing economy of China, and under the direct influence of e-government and Digital Earth programs, different levels of provincial and municipal governments have accumulated significant investments on the production of digital maps and related land databases. At the national level, the National Geomatics Centre of China of the Survey Bureau has accomplished 80% coverage of the nation at the scale of 1:50000 [NGCC,2006]. That means the populated areas of the nation have all been covered. At provincial level, the survey bureau is responsible for the data gathering and map production. Land administration and construction departments may use the basic digital mapping data to further develop their own operation maps and databases. The level of sharing data is still not widely achieved.

2. GIS DEVELOPMENT IN SANYA

The city of Sanya has the total areas 1919 square kilometers, population of 500,000, and the planning urban area of 54 square kilometers. It is a city in the southern region of Hainan province which has a beautiful coast with international fame for tourism. In recent years, with the rapid development of tourism, real estates, and other related industries, the increased workload on land management in Sanya became critical. There was an urgent need to improve the land management system to cope with the rising demands on competing user interests and detailed handling of the planning and land administration rules.

The Sanya GIS started developing in 2003. To improve efficiency on the traditional paper maps and manual operation system, the office automation with a computer network system and updated GIS were thus timely to build. The system is mainly for administration, auditing and internal controls. The system adopts an approach of integrating management information system (MIS), geographic information system (GIS), and office automation (OA) and workflow. It maintains the land information databases, and provides internally the electronic (paperless) model of land management and externally needed information for clients. The aim is to establish e-governance in land management.

To support the complicated land management activities, the basic step was the development and integration of various land information databases. GIS technology of the 1990's came in handy for the database building and integration. The traditional land surveys and management were manual operations, and thus were limited to computer aided drawings. There was a lack of integrated operations from data acquisition, database building, and management to data application, updating and dissemination. In the traditional manual system it was difficult to keep information and data current and consistent.

2.1 Sanya land Databases

Data is of fundamental importance to a workable GIS. In Sanya, a set of specialized land spatial graphics and attribution databases was planned and built. These graphical databases include the 1:500, 1:2000, 1:10,000 basic topographic maps, the so called red-line maps of land use, land use master plans, current and alteration maps of land use, property right and cadastral maps (divided into cadastral maps and house-base maps), land transaction records, mortgage records, the maps of land frozen by laws, house-demolished maps, land pricing base maps, land classification maps, and land reserve maps. In these maps and records, the basic topographic maps are the base for the others. While land-use master plans and current land-use maps are the basic data for land use and cadastral administration. The red-line maps of land use and property right and cadastral maps are the main maps.

In building of the specialized spatial graphics bases, the links between these spatial graphics bases and their corresponding attribute databases needed to be established accordingly. These attribute databases consist of cadastral attribute database, land-use attribute database, current land-use database, land-use planning database, land transaction database, and land market database, etc..

The building up of the Sanya land databases was not limited to digital data conversions of paper maps. A detailed design on data modeling and data re-construction from the original data generated at production stage was implemented. Before data input into a database, the data were be carefully checked with GIS software under the following standards:

— Checking the mathematic precision: data coordinate check; projection check; the coherence check of marginal point coordinates against its theoretical values; the precision of joint point matching (including control point etc.).
— Checking the attribute uncertainty: checking of the type, length, order and etc. of attributes in the different attribute tables; the coherence check between graphics and attributes.
— Checking the quality of graphics: object overlap check; the checking of suspended lines, false joint points, U-turning lines, and redundant joint points; the closed polygon check (see if it is closed).
— Checking the logistic coherence: edge match check; the coherent check of the map number and file name; the coherent check of the street number and parcel number; and the coherent check between the factual areas and the labeled areas.

Particular attention was paid to the integrating of basic survey and mapping and GIS from the beginning of land information building. Following the idea on the integration of many kinds of maps, emphasis was placed on unified coordinate system, scale precision and data format. Three map databases have been established. One is the basic geographical database, including 1:500 digital maps, 1:10,000 digital maps, 1: 10,000 ortho-images and 1:10,000 DEM. The second database is the basic data for land management, composed of 1:500 administrative district maps, 1: 10,000 current land use maps, 1:10,000 land use planning maps. The third is specialized database, consisting of 1:500 red-line maps of construction land, the red-line maps of land used for building a rural house, cadastral parcel maps, the maps of land frozen by laws, other property right maps, trading maps, repertory maps, house-based maps, and 1:10,000 land base price maps, classification maps, geologic hazard maps, etc. These map databases can be seamlessly overlapped and integrated, and administrative databases are interrelated in updating operation. It accomplishes the aim of integration of various maps, which improves greatly the land management of Sanya.

Under the new system, the updating of basic survey data is performed using both CAD and GIS software; and, the updating of land management information is performed under direct process of case handling by different levels of authority. The improved office automation provides capability of handling large volume of digital data with set user-defined functions.

3. FUNCTIONS OF THE SANYA GIS

The land information system of Sanya city started developing in July 2003, and now it has been in normal operation. The system, which combines GIS with MIS, has implemented the so called “window office” to clients. For all cases the files are collected at the so called service window, and then these files are transmitted to various departments via network. These departments handle the files step by step according to the system flow. The completed cases are finally sent back to the window office for the clients to collect. The advantage of the windows office is it handles only the case, not involves clients. With this model the work efficiency is improved and the chance for corruption is reduced.

The system adopts the standard Client/Server model that is easy for operation management and information distribution. It has an advanced GIS operation interface. The system maintains the merits of GIS software platform. It uses the seamless technology so that sea volume of data can be managed. The system uses various ways to minimize graphical errors, and has over twenty projection transformations, and zooming, full roaming, and classifying functions enable perfect graph management. The system keeps the consistence between graphs and their attributes, and completely overcomes the weakness of other information systems that pay attention to graph management, but less attention to attribute management.

The system is divided into nine subsystems. They are the cadastral management subsystem, construction land use subsystem, monitoring subsystem, window office subsystem, land use subsystem, land use planning subsystem, land evaluation subsystem, files management subsystem, and integrated maintenance subsystem. The system has changed the situation of manual operation management and brings a lot of social and economical benefits. The main functions of the system are as follows

3.1 Spatial & Attribute Data Input

The system provides many ways for spatial data input, such as, direct transformation of files into cadastral parcel maps, map generation by direct input of the coordinates of boundary points, generation of maps directly with the field surveys, and direct input of other GIS formatted data and the data of national standard formats. When building the databases, the attribute data can be imported into the system by the SQL Sever database, or with the input tools for batch attribute data that the system provides, or through the workflow step by step in routine administrative activities.

3.2 Inquiry

The system provides rapid, convenient, and flexible inquiry modes as follows.

— Inquiring graphs with data or vice versa: It is two-way inquiry.

— From graph to data: Given a graph, it is convenient to query its various related attribute information (such as, questionnaires, approval tables).

— From data to graph: Given some information about a cadastral parcel, we can quickly find the cadastral parcel map and its location. Having found the cadastral parcel map, we can find out the other related attributes about this parcel.

— History inquiry: The system has a special and unique inquiry management function of the history data to maintain the continuity of the spatial and temporal data. It supports historical inquiry for the whole area or a part of area and in a continuous time period. Not only can the entire management system be traced to a designated history state, but also the historical evolution of a single cadastral land parcel. Moreover, several historical states can be displayed and compared with each other.

— Fuzzy Inquiry: The system provides the powerful fuzzy inquiry function. The users can do inquiry by choosing a street or block, or by choosing the user representative, place name, the neighboring objects, cadastral land number, etc.. When users fill in the keywords and use the mouse to tick the "inquiry", the information system will display the cadastral land parcel which satisfies the specific conditions in the computer windows, and twinkling frame. On the contrary, users also can conveniently carry out the inquiry from graph to data, such as coordinate positioning inquiry, intersection inquiry, bordering inquiry, occupied land inquiry, inclusion inquiry, overlap inquiry etc. All these make the system convenient to the public, for open inquiry and charged services, so that the industrialization of land information can be realized.

3.3 Statistics

As the land management information system is a dynamic system that includes the data in processing and the processed data in files. The system provides statistics function for above-mentioned two kinds of data. The conditional inquiry statistics, the rectangular inquiry statistics and the block-based inquiry statistics are the functions for the filed data, i.e. the data in databases; while the block-based statistics is the function for the data in processing.

3.4 Buffer Area Analysis

We often come across the situations, like old city reconstruction, building new roads, and expanding existing roads. It is needed to analyze the effects of these activities on the existing land parcels – which land parcels are affected. The system has a spatial analysis functionality, which makes the above analysis easier. What we need to do is to inquire the land parcels within a buffer area. Buffering analysis does not change the data, but can provide information on affected land parcels.

3.5 Outputs

The system provides various output formats as follows:

— Cadastral land parcel output – the system can select the best scale to output the maps.

— Standard sheet of maps output

— Arbitrary area map output

— Table and account output

4. APPLICATONS OF THE SANYA GIS

The recent advances in computer sciences and related disciplines have provided a sound foundation to build the land resource management information system. It helps handle new land management laws, policies, regulations and standards for land use control by facilitating land protection, land use master plan and land use administration operations. Furthermore, the development of computer technology, 3S technologies, and network technology provides the technical support for building the land information systems. In land management, matured and advanced GIS information technologies were employed to accomplish the integration of graphical and textual land information and to perform efficient management of cadastre, current land use, land use planning, construction land use approval, land transaction, etc.

The cadastral management primarily uses the GIS information technology and the related technologies to study the cadastral parcels. It’s designed for land registration and especially for the management and application of urban and sub-urban cadastral data. The cadastral management system has the functions of inquiry, statistics, alteration, input and output of land parcel information. It accomplishes the maintenance of cadastral maps and provides the support for decision-making. At the same time, there is a complete database of cadastral files for parcels. So that the system can interrelate the graphics with the corresponding parcel files for inquiry and display.

Completely and accurately understanding of the land property right and existing land use for a land development project is of the main purpose of the current land use management. This is based on the information of land registration, current land use investigation, land alteration investigation, and plough land resource data. With GIS technology we can plot onto large scale current land use maps the precise boundary of the project and information on ownership, classification and area of each parcel within the project area and produce the reports on the rights and current use of the land in the project area. The current land use maps can be generated and output with GIS-based land information system or GIS software.

Furthermore, the investigation results of the current land use and land use alteration are imported into the information system with GIS technology to accomplish the store, management, inquiry, statistics, analysis, and maintenance of the current land use data and graph files. Therefore the digitization and automation of the current land use management and land use alteration investigation can be realized.

In land use planning management, the system helps to establish and manage all kinds of land planning data, especially the data on the approval of construction land. In the aided land planning aspect, the GIS technology has accomplished the related functions of land use, planned information inquiry, statistics, file management, input and output. In the plan implement aspect, the information system can check if it follows the planned and provide aided decision-making, and output the corresponding files and maps.

The sharing of basic spatial data based on the GIS technology is one of important aspect in the management of construction land approval. The data sharing is mainly the sharing of basic topographic maps, cadastral maps and red-line land use maps. The system can carry out the approval of land use by the workflow and perform the aided analysis of land use condition with special GIS tools.

Land transaction is an important element in the land management. In the transaction management, the mission is to guarantee that the property right of transacted land is clear; especially the transaction must accord to the laws and regulations. In order to provide the accurate and effective land property information in the process of land transaction, the GIS-based land property management information system was built. This property information includes the status regarding the payment of management fee and other fees, tax fee, mortgage, rental, legal aspect, any serious geologic problems, etc.

5. SANYA GIS ESTABLISHMENTS

— With the land information system, the 1:1000 topographic maps for various tourism projects were provided. It has wide uses on the project design, and saves much investigation funds and time.
— The system of detailed land surveys not only provides the data for compiling the needed maps, but also saves time in the new round of land use master plan.
— The information system completed filing of historical land use certificates in one year, which makes the information in the system more complete and more accurate. In addition, it makes the public feel easier and more confident to use the system. The system has highly appreciated by the users.
— The construction-land system provided maps of the Sanya Bay new town that is an important project of Sanya city. The finished maps are normative, remarkable and accurate, and not comparative by the manual operation.
— The system provides a great amount of statistics data, including the time spent for processing each task, the work efficiency, the rate of increased efficiency and overtime rate of individual or each office, and total work load of every department. These statistics data provide the scientific foundation for quantifying objective management, analyzing the work bottleneck and optimizing the office mode.
— In the routine of land management, the system can rapidly, flexibly, accurately and directly provide the various needed information for the land management departments, construction departments, land use departments, decision-making institutions, and social circles.

6. CHALLENGES FOR FURTHER DEVELOPMENT

Given the advent of advanced computing and GIS hardware and software, Sanya grasped the opportunity to produce digital maps and GIS databases. No doubt Sanya has achieved the installation of the GIS technologies which greatly improves the operation efficiency. With the updated and detailed digital spatial data on hand, more open services and applications could be provided to the general public. Nevertheless, given the traditional government control of the access of data, the advantage of easy dispersion of electronic data on website is not yet fully materialized. At least, there are two main concerns on further opening use of the digital spatial data. The restriction on the access of spatial data by different users and the unwillingness to release spatial data sets with no satisfactory preventive measure on violating the copyrights are the two main factors for the further uses of established valuable spatial data sets by the general public and other institutions.

Firstly, it is the security of the content of the positional information. For national security sake, it is necessary and thus a considerable restriction on the access of spatial data is implemented. Secondly, essentially cost recovery, and to a lesser extent, implementing digital copyrights may have difficulties such that spatial data holders who have invested a great many resources in building up the database may not like to share or open their digital data for public access. Trying to use protective technology in digital data is thus in great need. The authors argue that it had better establish and rationalize the policy on the supply of digital mapping data to the general public, and relax on the protective measures which inevitably restrict the full rate of use of the product.

As a spatial data policy review, the supply of spatial data should be considered as the first principle that a government organization is serving the general public for the improvement of human well-being. The land related departments are building up an acceptable urban environment by providing appropriate services and facilities. Further on, for the effective management of information concerned with infrastructure and services, these departments are thus obligated supply data and service to other departments and the society at large. In another words, it is to enrich government-to-business (G2B), government-to-client (G2C) and government-to-government (G2G) operations.

To tackle the access right problem, the government departments need to restructure the service of providing spatial data. Usually a department has to invest a great deal of resources into the acquiring and producing of mapping data. When there are new users of the mapping data, there is no direct or easy access to the data, particularly when the user is the general public. Sanya is taking a change of the service attitude and to launch studies on the cost, benefits and danger assessment of releasing digital mapping data to the general public. When there is solid proof on the benefits of further opening of spatial data to the general public, a top-down policy on the release of mapping data to be freely shared on the boundless web environment would then be implemented.

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ACKNOWLEDGMENT

This paper is supported by the PolyU Research Project G-U131

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