A SELF-DEVELOPED AND WEB-BASED GEOGRAPHIC INFORMATION SYSTEM FOR WATER RESOURCE PROTECTION

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Abstract

Taipei Water Resource Management Commission (TWMC) is in charge of water resource protection in order to provide sustainable water for a population about four millions in Taipei. Two watersheds covering an area of 717 square kilometers have to be managed day by day at TWMC. Although there are only five townships under its jurisdiction, TWMC has to run more like a county government rather than a water resource protection agency. Zoning enforcement, garbage management, tree plantation, illegal land use enforcement, housing management, water quality and quantity protection, soil and water conservation, sewage management, watershed management, village reallocation, game boat buy-out, hot spring resort management are typical tasks to be performed efficiently such that sustained water supply will not be jeopardized. A geographic information system has been developed at TWMC for more than seven years to pursue water resource protection. Databases consisting of all types of digital maps provide very good infrastructure for integrated watershed management at TWMC. Web-browsing capabilities were introduced into the self-developed GIS mainly because of a new map file format, scalable vector format (SVG), was adopted for all digital maps at TWMC. The SVG file format is an official standard that was set up by the World Wide Web Consortium recently.

The objective of this paper was trying to demonstrate how a GIS can be developed without too much programming effort. All digital maps in the databases are stored in SVG file format that can be displayed on web pages for manipulations such as layer on or off, zoom in or out, print, hyperlink, and inquiry. More than ten application modules have been developed to solve each particular type of problems encountered in water resource protection. The databases can provide common digital maps and attributes for all application modules such that water resource protection can be performed smoothly and efficiently. The SVG file format is one type of text file that is very easy to manipulate with x and y coordinates generated by a hand-held global positioning system device. A hand-held GPS and a notebook personal computer will make a GIS integrate with GPS in the field as a standard procedure in the practice of water resource protection. All relevant maps and attributes can be extracted on a color monitor in the field right away for further manipulation. Although the self-developed GIS can work alone without commercial GIS packages, it can work with commercial GIS packages side by side and extend web-browsing capabilities for them. Minimum programming, web pages oriented, text-based map file format are major ingredients that make a water resource protection GIS work at TWMC. Further studies have been designed to generate more general public involvement in water resource protection in Internet using the self-developed GIS.

1. INTRODUCTION

Taipei Water Resource Management Commission (TWMC) was a government agency under Taiwan Provincial Government. All areas within jurisdiction of TWMC are part of Taipei County. TWMC has to supply water for about four millions people. However, more than 90% of water has to supple people living in Taipei City. People living in TWMC are subjected to restrict zoning codes, and soil and water conservation code. There are two major watersheds, one reservoir, and five townships in TWMC. In general, TWMC is more like a county government rather than a water resource protection agency.

Zoning enforcement, garbage collection management, tree plantation, illegal land use enforcement, housing management, water quality and quantity protection, soil and water conservation, sewage management, watershed management, village reallocation, game boat buy-out, and hot spring resort management are typical tasks to be managed efficiently in order to supply water at a sustainable basis at TWMC. Remote sensing,

geographic information systems (GIS), and global positioning systems (GPS) have been implemented for more than 10 years to pursue water resource protection at TWMC. Simplicity, efficiency, user-friendly, limited functions, and solving specific problems are the concept for development of GIS at TWMC.
The objectives of this paper were to discuss how a geographic information system was developed and what can be done for water resource protection at TWMC.

2. A SELF-DEVELOPED GIS

A geographic information system consists of hardware, software, data, people, and institutional arrangements for collecting, storing, analyzing, and manipulating about areas at given regions. A GIS for water resource protection can implement commercial GIS software as its major components. It is efficient but can be more powerful when additional software was developed as working companion. Commercial GIS software is not good for solving problems irrelevant with spatial content such as word processing, spreadsheet processing, calculating, and engineering drafting. To develop a GIS is not an easy task but can be done. Open data structure, providing source codes and task oriented are major components of the whole developing process.

2.1 Operating Systems

Personal computers and their peripheral are major hardware. When Windows 3.1 was the dominant operating system for personal computers, the major computer was not personal computer but Sun Sparc Station. In the first stage, Unix was the major operating system running in X-window. Since Windows 2000 Professional, Sever, and Advanced Server were popular, the operating systems have been changed accordingly. Personal computers running windows 2000 became the key component of hardware implemented. No workstations, such as Sun, Silicon Graphics are required. A high speed CPU say, one giga Hertz, 256 mega bytes of RAM, a powerful VGA card with 32 MB of RAM on board and 3D capability are recommended.

2.2 Databases

Databases creation are time consuming and expensive. The first step of GIS development is to create databases that cover areas in TWMC. Topographic maps, cadastral maps, land uses, sewerage, and their attributes have been created in the databases. Access 2000 and Microsoft SQL Server are the two data base management software been implemented to manipulate all text types of attributes. Maps were stored as scalable vector graphics (SVG). Because SVG is an application of XML, it

has several nice properties for hyperlinks, map layer operations, accessibility and scalability. Images are also stored as SVG images such that they are zoomable without the need for special magnification tools. Web surfing is one of several properties that SVG can bring a GIS into new territory, Internet.

2.3 Software

Traditional GIS functions have to develop from nothing. The lesser the better is the key concept of programming. Visual Basic is the most important programming language. A little bit of web pages programming is necessary. Hyperlinks among map elements and attributes can not be done efficiently without computer programming. Database manipulations are two steps process. The first step is done in Access 2000 and SQL Server. The second step is a process of ODBC (open database connection) and ADO (ActiveX Data Objects). Once a database has been created, then it is almost a process consisting of Visual Basic programming only. That is, all databases manipulations can be done with several Visual Basic programs. Databases manipulations on web pages are mainly consisting of ASP (Active Server Pages) programming using Visual Basic. Statistical charts generating capabilities are necessary and essential. Commercial statistical charting object modules for Visual Basic (VB) are cheap and efficient. Three dimensional terrain modeling and animation are good for water resource protection. Commercial software for terrain animation is not cheap but affordable. Manipulations of terrain modeling and animation output can be done easily using Visual Basic. Tables and reports generating is essential for water resource protection such as house construction certificate, zoning codes, and fine for illegal land uses. Using OLE (object linking and embedding) to control other applications such as Word objects (Word 2000) and Excel objects in Visual Basic is not difficult and quite efficient. That is, an inquiry about ownership of a given piece of land can be done using VB and issuing some sort of certificate can be done automatically. GIS functions and some additional paper working functions are provided with a series of VB programming in terms of application modules. Remote sensing, GIS and GPS integration has been done with several VB programs. Remote sensing techniques are mainly focus on image manipulations such as image display and overlay with its associate maps. Because images are stored in SVG format, they are good for zoom in and zoom out, layer on and off types of GIS manipulations. GPS manipulations are very simple. A palm-size GPS device will give the required x and y coordinates for a given location. Then, a GPS application module will bring relevant attributes, images, and maps for further reviewing process in the field and it is only required to type the x and y coordinates. Preprocessing is necessary to add x and y coordinates for a given attribute and map.

2.4 People and Institutional Arrangements

People and institutional arrangements are the most important issues that will make a GIS successful or not. People and institutional arrangements come first and GIS is nothing but one type of computer tools. All problems encountered in water resource protection can not be solved efficiently by GIS alone. People have to pin point what kind of problems are good for GIS implementations. Then, application modules will be developed accordingly.

3. APPLICATION MODULES

"Build to order" is the key concept for application modules development. More than ten application modules have been developed in TWMC. All application modules will contribute something for water resource protection. It is not a good idea to go through application modules one by one in detail. Some application modules that will make significant impact on water resource protection are discussed as follow.

3.1 A Web-based GIS

This application module provides basic database manipulations. All vector maps can be extracted automatically by index maps or by watershed. Satellite images and aerial photos can be extracted on web pages either in personal computers or Internet. Printing maps is a mouse clicking process. Slope maps, aspect maps, contour maps, cadastral maps, river, road, land uses, orthophoto maps, and house site maps are ready for automatic extractions.

3.2 A GPS Application Module

A palm-size GPS device provides x and y coordinates for a given location in the field. Then, a GPS application module takes x and y coordinates as the only required input. The rest of processes are a series of mouse clicking. All required information in the databases can be extracted for real time reviewing on a color monitor, both personal computers and lap-top computers. Cadastral maps, house maps, and topographic maps are three types of maps that can be implemented in a GPS application module. More types of maps can be added in the databases for GPS manipulations. But people and institutional arrangements in advance
are necessary. An inquiry of attributes for a given location with x and y coordinates can be manipulated by other application modules based on ownership, land parcel number, address and so on. GPS implementations can be done in batch mode as well.

3.3 A Reservoir Management Application Module

A reservoir provides more than 90% of water supply for Taipei City. There are four townships in the reservoir watershed. A reservoir management application module was developed to provide information for water resource protection in the whole reservoir watershed basis. All databases for the reservoir have been transferred to the reservoir authority. Further implementations of a reservoir management application module pave a smooth way for water and soil conservation coding process. Huge amount of map layers are the major difficulty for implementation of a reservoir management application module. A simplify process for the reservoir databases have been taken for those databases open for general public in Internet.

3.4 Water Quality and Quantity Protection Application Module

Water quality and quantity has to be monitored carefully in TWMC. A water quality and quantity protection application module was developed to manage water in a more efficient way. Water quality and quantity statistics for a given year, season, and month were posted on web pages. Reviewing and inquiry processes are as simple as a mouse clicking.

3.5 Sewerage Systems Application Module

There are two large sewage treatment facilities in TWMC. More than 90% of houses and buildings have been managed by sewerage systems. This application module by no means needs more budget and effort in the future. For the time being, only basic information has been created in the databases. The sewerage systems application module needs to develop more sub-application modules in order to solve problems encountered in sewage treatments.

4. CONCLUSION

Geographic information systems are good for water resource protection at Taipei Water Resource Management Commission. Remote sensing, GIS, and GPS integration is not difficult when a self-developed and web-based GIS was implemented. Two of the major ingredients of web surfing capabilities of a self-developed GIS are SVG (scalable vector graphics) file format and ASP (ActiveX Server Pages) web pages. System design process is very critical in the whole process for water resource protection GIS development. Application module approach will make the developing process more easy and acceptable. People and institutional arrangements are also very important factors that can make a GIS successful or not. The lesser the better is a very practical and useful guideline when almost everything

has to be programmed. At last, user-friendly and simplicity are two other ingredients that a GIS is successful and operational for water resource protection at TWMC.

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