DESIGN AND OPERATION OF SPATIAL DECISION SUPPORT SYSTEMS FOR WATER RESOURCE PROTECTION

Mu-Lin WU[a], Chiou-Hsiung CHEN[b], Chih-Hsin CHEN[b]

[a]Civil Engineering Dept., National Pingtung Univ. of Science and Technology,
39-13 TongZong Road, Dali, Taichung County, 41244, Taiwan
mulinwu@tpts6.seed.net.tw
[b]Taipei Watershed Management Bureau, WRA, MOEA,
5, Lane 45, Sec. 1, Peihsin Road, Hsien-Ten, Taipei 231, Taiwan
cccc3333@ms15.hinet.net

Commission II, WG IC II /5

KEY WORDS: Spatial decision support systems, Water resource protection

ABSTRACT:

Spatial decision support systems for water resource protection at Taipei Watershed Management Bureau (TWMC) have been pursued for more than a decade. There are five townships and two watersheds under jurisdiction of TWMC. The whole area under management of water resource protection is 717 square kilometres. The management objective is to provide sustainable drinking water for a population about four millions in Taipei. Management prescriptions for water resource protection at TWMC are not confined to traditional approaches. Design of spatial decision support systems for water resource protection was mainly focused on integration of techniques such as remote sensing, geographic information systems (GIS), and global positioning systems (GPS).
The major ingredients of spatial decision support systems are web-based GIS which can bring relevant information for management of water resource protection for a given location say, x and y coordinates, a single sheet of map, a township, even a watershed. All maps, satellite images, and orthophoto maps were stored in scalable vector graphics (SVG) format. Integration of remote sensing, GIS, and GPS on Internet is then not difficult. Data bases were manipulated such that they can be extracted on web pages by township, by watershed, and by task. Visual Basic was the major computer programming language to make the spatial decision support systems acceptable and operational. Active server pages (ASP) with JAVA scripts provided server applications on web pages when tasks needed to be solved on Internet as well as on Intranet. Task-oriented application modules were designed to solve problems encountered on daily operations and long-term management of water resource protection at TWMC. A hand-held GPS device can provide x and y coordinates for a given location and a GPS application module can bring relevant attributes and maps on a notebook computer. Management prescriptions for spatial decision support can be issued right away, in office or in open field. The whole systems are simple and easy such that all level of government employee would like to use.
Application of spatial decision support systems for water resource protection at TWMC is simple a series tasks of implementation of self-developed application modules. All modules were built to meet special and spatial orders for a given type of task. More than ten application modules have been developed and implemented for solving problems encountered in water quality and quantity protection, soil and water conservation, watershed management, zoning enforcement, garbage management, illegal land use enforcement, housing management, sewage management. A GPS application module can make integration of x and y coordinates with relevant attributes smoothly. Inquiry is not the only function provided by the application modules. A two-way communication between user and databases can be done by any government employee if they can identify with proper permissions. Software source codes were provided such that certified users can modify application modules to meet their special requirement. Update of databases can be done by users when they were granted this privilege. Not all application modules are necessary for Internet browsing. More Internet browsing capability for a given application module to serve general publics in Internet in order to make spatial decision support on water resource protection at TWMC more smoothly will be pursued in the near future. Sustainable supply of high quality drinking water in Taipei in the past decade may be the best evidence of successful design and operation of spatial decision support systems for water resource protection at Taipei Watershed Management Bureau.

1. INTRODUCTION

Taipei Watershed Management Bureau (TWMC) is in charge of water resource protection in order to provide sustainable drinking water for about four millions population in Taipei. There are five townships, two major watersheds, and 717 square kilometres under its jurisdiction. Management prescriptions of water resource protection at TWMC are not confined to traditional approaches. Spatial information is the one of many key components for water resource protection. Adequate spatial information can be extracted on the right spot with finger touch in real time is a must for management of water resource protection at TWMC. Daily operations and long-term management of water resource protection at TWMC have to look into the whole area, a single watershed, a given township, and a single spot simultaneously. Integration of remote sensing, geographic information systems, and global positioning systems provided very nice functions such that design and operation of spatial decision support systems for water resource protection at TWMC may be simple and efficient.

Integration of remote sensing, GIS, and GPS can be a tough task and complicate for every technician at TWMC. Simple and easy to implement is the top priority of design and operation of spatial decision support systems at TWMC. However, web browsing capability of spatial information is also a must of the whole systems. Application modules were developed to make the whole systems more user-friendly and to make every technician of TWMC happy. Source codes of the all developed systems were provided to encourage more people involvement and also to meet the requirement of build-to-order. Databases were updated constantly by the right person of TWMC once they were created.

2. DESIGN OF SPATIAL DECISION ING SYSTEMS

Design of spatial decision support systems for water resource protection at TWMC is simple a sequence of tasks consisting of integration of remote sensing, GIS, and GPS; web-based GIS as the basis; all Chinese-menu driven and easy to use; task-oriented application modules to solve problems encountered in management of water resource protection more easily; databases updated by authorized users. Spatial decision support systems are consisting of pieces of programs or web pages to bring relevant spatial information to solve problems on day to day operations and long-term planning. Programs were mainly written in Visual Basic. Active server pages (ASP) with JAVA scripts provided server functions on web pages when tasks to be solved on Internet as well as Intranet (Siler and Spotts, 1998). Remote sensing and GIS integration can be done in scalable graphics format (SVG). SVG is one type of extensible markup language (XML) which can deliver structured information on the World Wide Web such as images, vector maps, and attributes (Light, 1997).

2.1 Integration of Remote Sensing, GIS, and GPS

Integration of remote sensing, GIS, and GPS is a task consisting of images, vector map files, and databases manipulations. Usually, it can be done with several brand-names software packages. Although the whole systems can work alone without those brand-names software, the spatial decision support systems will take advantage of commercial software whenever it serves. The SVG file format can bring images and vector map files together on web pages. Hyperlink capabilities of SVG web pages provide very nice functions to link among attributes, images, and vector maps. With a little computer programming, an X and Y point information given by a hand-held GPS device can make integration of remote sensing, GIS, and GPS easily. Digital images were rectified and overlaid with relevant vector maps first. Then, they were converted into SVG format which can be manipulated by Visual Basic or by web page editors.

2.2 Web-based GIS

Web-based GIS usually can provide server functions on Internet. Several large and expensive web-based GIS software are available on the market. Simple and small scale functions were needed on Internet for water resource protection at TWMC. Active server pages (ASP) provides server functions on Internet for attribute manipulations of databases. The SVG provides overlay of orthophoto images, satellite images, and vector maps. Spatial information was manipulated in several types such as by a single map sheet, a township, and a single watershed. However, spatial information of several villages can be summarized to manage the sewage system for a large sewage treatment plant. Web pages consist of ASP and SVG can provide simple and nice remote sensing, GIS, and GPS functions on Internet. This may be not a full-function web-based GIS but it serves for water resource protection well enough at TWMC.

2.3 All Chinese-Menu Driven

Web pages with SVG components can be manipulated with all Chinese-menu driven. However, a little bit of XML programming is required to make web pages provide some sort of GIS functions such as layers on or off. A free SVG viewer plug-in for Microsoft Explorer can be downloaded on Adobe website (Adobe, 2002). This plug-in provides very nice GIS basic functions such as zoom-in, zoom-out, map attributes searching, and printing, all in Chinese-driven menu.

2.4 Task-Oriented Application Modules

Application modules were developed according to tasks performed for water resource protection at TWMC. There are five departments at TWMC. Each department has their own jobs to be done in order to protect water resource at TWMC. Task-oriented application modules were developed on a build-to-order basis to solve problems encountered at every department. It is not practical to provide web browsing capabilities for all application modules. The GPS capability is not required for every application module as well. Application modules can be modified by authorized technician with a little bit of programming to extend their functions and to show more personal flavour.

2.5 Databases Updated by Authorized Users

Databases creation has been done in a process of more than eight years jobs. Almost all spatial information such as orthophoto maps at scale of 1:5,000 and 1: 10,000, satellite images, aerial photos, vector maps, and attributes were created in the databases. Databases can be updated at a daily basis by authorized users is the first concern of the whole spatial decision support systems. Every technician of the five departments has to maintain their own databases whenever it is possible. Only those authorized technicians can modify certain databases directly on some of the application modules.

3. IMPLEMENTATION OF APPLICATION MODULES

Management prescriptions of water resource protection at TWMC consist of a wide range of tasks such as water quality and quantity protection, soil and water conservation, watershed management, sewage management, garbage management, zoning regulation and enforcement, tree planting, illegal land use enforcement, and housing management. Implementations of application modules can be performed on some of the developed modules together, with or without the GPS application module. Not all application modules will be discussed here.

3.1 Garbage Management

Garbage is one of the several components that will deteriorate water quality at TWMC. Garbage collection is managed by private company to achieve higher efficiency. However, garbage management is still a job to be monitored closely. Collection sites and collection routes were managed with GIS and GPS. Hand held GPS devices have been implemented in the open

field to locate all collection facilities and their relevant attributes were also stored into databases. Household garbage collection is now well managed. Huge amount of garbage at some tourist attraction sites in the weekends usually was the major problem encountered in garbage management. How to manage, where is the garbage, and how much are the three components that can be decided with the help of GIS and GPS. Spatial information for garbage management can be extracted right away using personal computers or notebook computers, both in office and in open field.

3.2 Zoning Regulation and Enforcement

Every house and land parcel at TWMC has its own zoning code. Zoning regulation and enforcement are two different types of tasks. An application module for zoning regulation was developed to indicate the exact zoning code for a given piece of land parcel. Zoning certificate is then issued automatically. This module was made by Visual Basic programs and active server pages (ASP). Zoning code for a given piece of land parcel now can be extracted in Internet by typing land section and parcel number. Inquiry of zoning code for a given piece of land and then generate official zoning certificate in Microsoft Word are now only taking few minutes.

Zoning enforcement is a more complicate task that requires computer inquiry and field check processes. The GPS application module is good for field identification to decide location of the exact piece of land parcel. The zoning application module is then implemented to inquire the exact zoning code for the piece of land parcel. Further management prescriptions can be done accordingly.

3.3 Housing Management

Every house is subject to housing enforcement according to the law at TWMC. In order to pursue water resource protection, it is a very serious job to manage all houses at TWMC. A house application module was developed to manage houses at TWMC. There are 5364 houses have been managed by the house database. It can extract detail information for a given house with computer mouse clicking. Address, land parcel, owner, material, base map, house photos, and when it was build were displayed on a colour monitor. Only those houses build before certain year entitled for repair maintenance. New houses construction permit is a very strict review process at TWMC. Further sewage management for a given house can take advantage of this house application module. Zoning regulation and enforcement of a given house are more efficient when two application modules work together.

3.4 Sewage Management

There are two major sewage treatment systems to manage two major watersheds at TWMC. The whole system consists of three large sewage treatment plants and nine small plants. More than 80% of households have their sewage collected to one of the three plants. Sewage databases consist of large scale layout and construction maps. Sewage application modules have been developed to depict the collection systems rather than geographic locations. Those sewage-to-be-collected houses locate in remote areas and away from business quarters are the major targets of the next stage sewage management. Decision making for sewage-to-be-collected houses can take advantage of the existed databases. Day to day operation of sewage management has to look into one house by one house. Maintenance of sewage systems is also a very delicate process. More special application modules are under development to solve series of problems encountered in sewage management.

4. CONCLUSIONS

Taipei Watershed Management Bureau (TWMC) is responsible for water resource protection of two watersheds. Its area is 717 square kilometres. However, its management prescriptions can not confine to traditional approaches because the four millions population in Taipei demands sustainable supply of high quality drinking water. Watershed management is the typical top priority of water resource protection when traditional approaches were implemented. Design and operation of decision support systems for water resource protection at TWMC was mainly focused on integration of remote sensing, geographic information systems, and global positioning systems. Visual Basic programs and scalable graphics format (SVG) have made integration of remote sensing, GIS, and GPS smoothly and easily. Active server pages (ASP) and JAVA scripts bring all spatial information for water resource protection into Internet such that decision support systems can be done in the frame work of simplified web-based GIS. Task-oriented application modules were developed to solve problems encountered in watershed management, soil and water conservation, sewage management, garbage management, zoning regulation and enforcement, housing management, illegal land use enforcement, tree planting, and so on. Operation of decision support systems for water resource protection at TWMC have been discussed on garbage management, zoning regulation and enforcement, housing management, and sewage management. Sustainable supply of high quality drinking water in Taipei in the last decade may be the best evidence of successful design and operation of spatial decision support systems for water resource protection at Taipei Watershed Management Bureau.

REFERENCES

Adobe Systems Inc., 2002. *Adobe SVG viewer 3.0*. http://www.adobe.com/svg/viewer/install/main.html (accessed 15 June 2002)

CHANG , K, 2002. *Introduction to Geographic Information Systems.* McGraw-Hill Companies Inc. 348 pages.

Light, R. 1997. *Presenting XML*. Sams.net Publishing. 414 pages.

Mikhail, E. M., J. S. Bethel, and J. C. McGlone, 2001. *Introduction to Modern Photogrammetry.* John Wiley & Sons, Inc. 479 pages.

Siler, B. and J. Spotts, 1998. *Special Edition Using Visual Basic 6.* Que, pp. 687-718.