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REMOTE SENSING APPLICATIONS IN WATER RESOURCE PROTECTION

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ABSTRACT: Remote sensing applications in water resource protection at Taipei Water Resource Management Commission (TWMC) has been pursued for more than 12 years. Remote sensing applications were not easy as it should be in the first several years because of satellite image resolution and limitations of computer software and hardware. Above all, remote sensing has to depend on its basic maps in order to make practical implementations reliable and operational in water resource protections. TWMC is not simple a water resource protection agency but more like a county government. There are two watersheds and five townships in its jurisdiction and the area is about 717 square kilometers. Illegal land uses as small as five meters by five meters have to locate and identify for land use enforcement. There are more than 320,000 landowners subject to law enforcement for water resource protection. The objective of this paper is to demonstrate what have been done and how to adapt to the Internet age on remote sensing applications at TWMC. This is not a description of history. Soil and water conservation, house management, zoning, sewerage system management, and land use enforcement are some tasks to be performed daily for water resource protection at TWMC. High-resolution image is one of the several critical components that make remote sensing applications for water resource protection acceptable at TWMC. Satellite images, digital orthophoto maps at scale of 1:5000, and aerial photos are the three types of images have been implemented. Databases in cadastral information, house maps, zoning, and sewerage system maps have been created and their application modules are suitable for daily implementations on water resource protection. Global positioning system integration with remote sensing and geographic information systems provides nice functions that attributes for a given small piece of land can be extracted on a color monitor for further examination in the open field. Remote sensing alone is not good enough for water resource protection. At TWMC, remote sensing, GIS, and GPS integration has provided nice infrastructure for water resource protection.

1. INTRODUCTION

Remote sensing applications in water resource protection at Taipei Water Resource Management Commission (TWMC) has been pursued for more than 12 years. Image resolutions are very important factors that made remote sensing applications reliable and acceptable. Computer software and hardware were also critical in operational remote sensing applications in water resource protection at TWMC. Remote sensing applications usually provide information on what are on ground only. More detail info rmation such as landowner, housing content, sewerage, zoning, and so on are required for water resource protection. TWMC is not only a government agency for water resource protection but also more like a county government. There are 717 square kilometers under its jurisdiction include five township and two watersheds. TWMC is the only government agency entitled with legal authority to manage the two watersheds in order to provide sustainable water for a population about 4 millions in Taipei. There are more than 320,000 landowners subject to law enforcement for water resource protection. Illegal land uses as small as five meters by five meters have to locate and identify for land use enforcement.

The objective of this paper is to demonstrate what have been done and how to adapt to the Internet age on remote sensing applications at TWMC.

2. DATA BASES

Data bases creation is the first step that operational remote sensing applications has to take care. Images, maps, and attributes are the three types of databases have been developed for more than 12 years at TWMC. Satellite images, aerial photos, digital orthophoto maps at scale of 1:5,000 have been created in the image database. Usually, two meters resolution satellite image was not available in Taiwan. The major reliable and operational remote sensing images are the digital orthophoto maps. A digital orthophoto map has to overlay with its relevant house map, sewerage system map, parcel map, and topographic map for further implementations. Application modules have to be developed to extract and manipulate remote sensing images for practical implementations.

Images that can surf in Internet for general public have to condense as small as possible. An image large than one megabyte (MB) is usually considered as too large for Internet browsing. Several image formats can be accepted for Internet browsing such as GIF and JPG. However, the scalable vector graphics (SVG) file format provides very nice property for vector and raster files implementations on Internet. All images that overlay with its relevant vector maps are stored in SVG file format. In the mean time, all vector maps are also stored in SVG as well. Attributes, images, and maps are three types of information that remote sensing applications required for Internet implementations. They are ready for web pages implementations whenever they were edited by web page editing software such as FrontPage 2000. With a little bit of JAVA programming, GIS and GPS functions can be integrated with remote sensing applications on web pages.

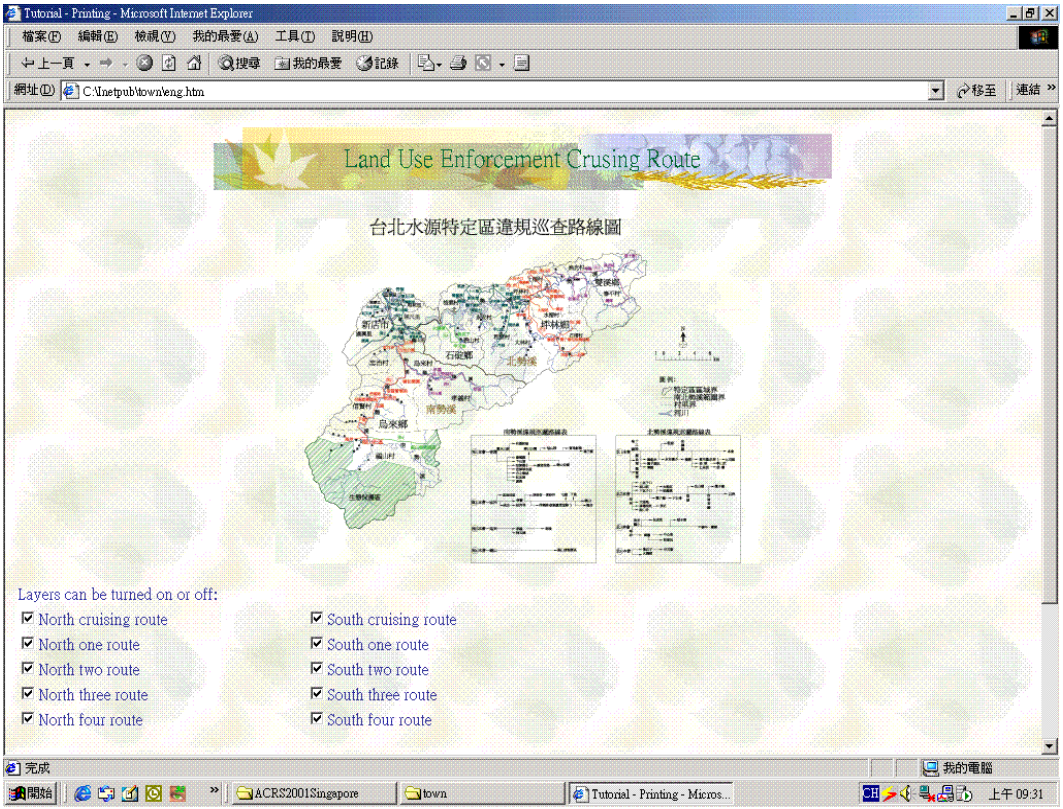

Fig. 1. The web page for land use enforcement cruising route.

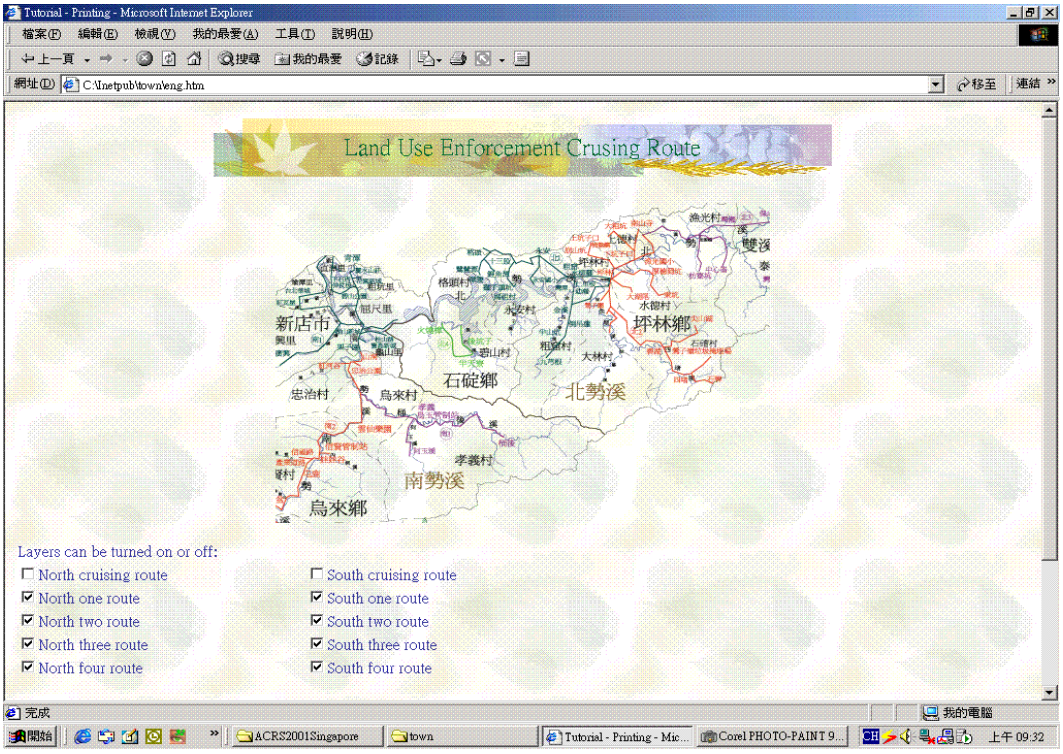

Fig. 2. Layers off and zoning in for partial enlargement.

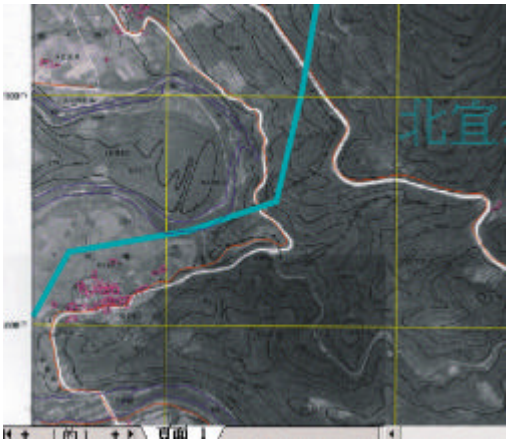

Fig. 3. Orthophoto map overlay with house map.

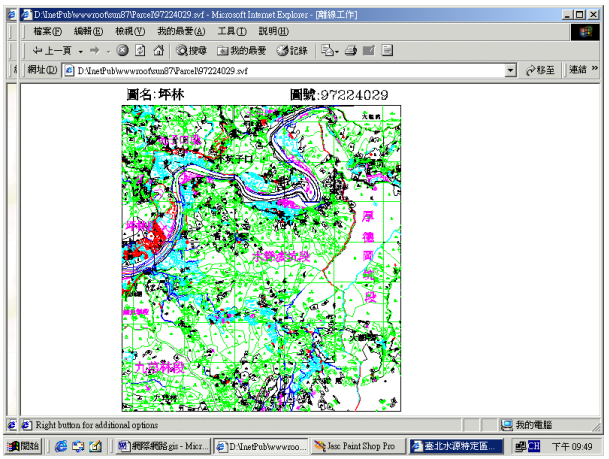

Fig. 4. One sheet of parcel map at scale 1:5,000.

3. APPLICATION MODULES

Remote sensing applications for water resource protection usually required commercial software packages. At developing stage, remote sensing software packages can be implemented. But at the operational stage, no commercial remote sensing software packages are needed. User-friendly and all Chinese-menu driven are two major ingredients for application modules at TWMC. There are more than ten application modules have been developed to take care problems encountered in daily operations and long-term management on water resource protection at TWMC. Illegal land use enforcement, zoning, housing management, garbage management, and cadastral information with GPS integration are some of the application modules.

All application modules were written in Visual BASIC. Visual BASIC programs are not suitable for web browsing except they are in active server pages (ASP). Zoning information for a given piece of land parcel can be extracted on a color monitor and its zoning certificate can be issued right away. Zoning information for general public inquiry in the Internet requires ASP web page. Fortunately, visual BASIC provides very nice function for ASP programming. To write application modules for zoning management in the office and in the Internet is not difficult. However, all databases have to be manipulated by Microsoft SQL server first.

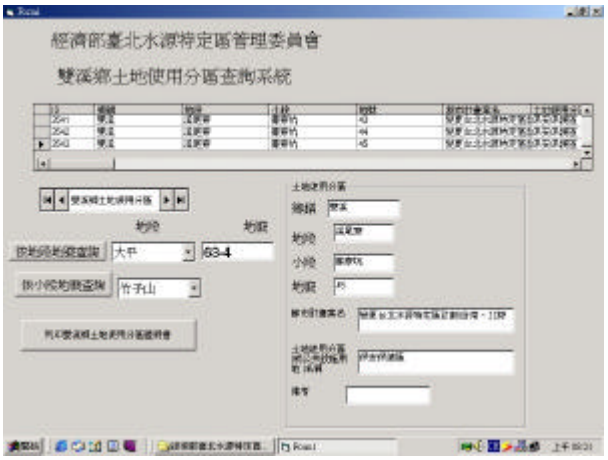

Fig. 5. Zoning information module for a given township.

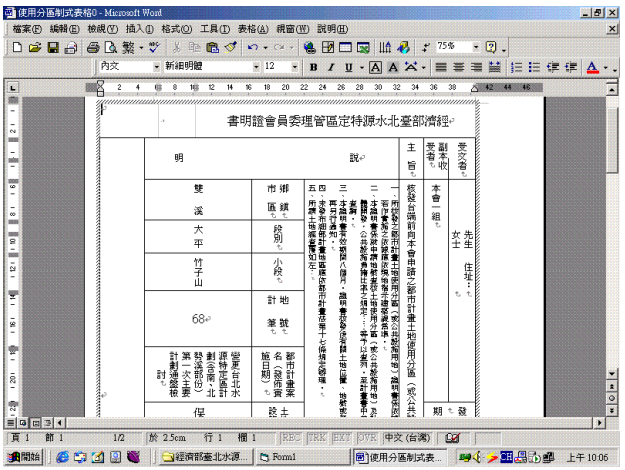

Fig. 6. Zoning certificate is ready for printing.

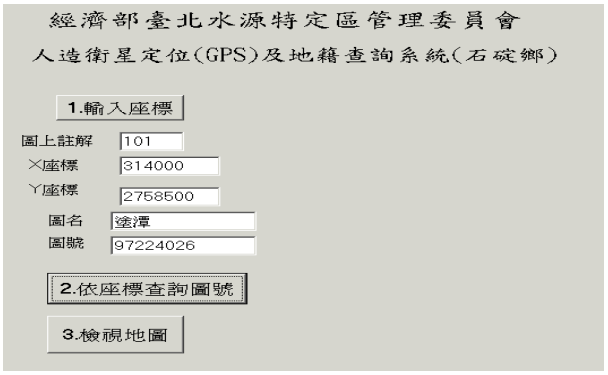

Fig. 7. Input X and Y coordinate in GPS module.

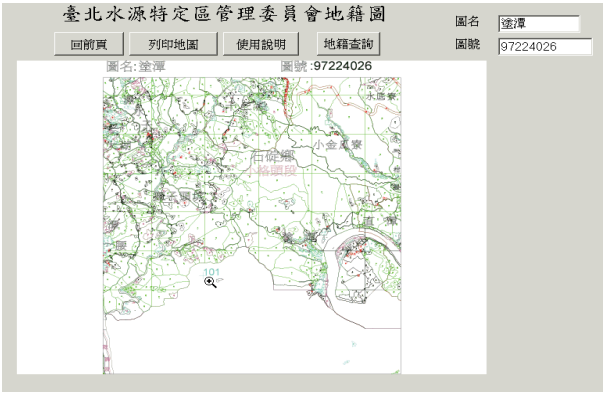

Fig. 8. The GPS module extract the right parcel map for further inquiry and manipulations.

4. INTEGRATION OF REMOTE SENSING, GIS, AND GPS

Remote sensing is good for land cover and land use monitoring. It can provide very good information on where it was. But more detail information such as zoning for a given house or land parcel, sewerage information for a given house, and when was a house built will be given by GIS and GPS. Remote sensing images were geometrically corrected and overlay with relevant vector maps. The SVG file format can give background information such as a satellite image or orthophoto maps and foreground information such as house maps, and sewerage maps. In the mean time, these vector maps provide very good GIS functions such as layer on and off, attribute inquiry, zoom-in and zoom-out, map printing. Visual BASIC programming is required to write an application module that provides input function for the X and Y coordinate acquired by a palm-size GPS device into the computer. Then, the GPS module automatically extract the right maps such as a house map, a cadastral map, a sewerage map and so on for further inquiry and manipulations. All attributes can be extracted either by parcel number, by landowner, by house address, or by X and Y coordinate. Figures 7 and 8 indicated one type of GIS and GPS integration. In figure 8, an orthophoto map can be overlaid as its background, and then remote sensing, GIS, and GPS integration is operational.

5. CONCLUSION

Remote sensing applications in water resource protection at Taipei Water Resource Management Commission requires very nice image resolution such as two meters resolution. However, digital orthophoto maps at a scale of 1:5,000 provides very nice property for practical implementation of remote sensing images with other types of data, say, vector maps and attributes. Remote sensing applications require application modules for every single type of task in water resource protection such as illegal land use enforcement, zoning, house management, sewerage management, and garbage management. Remote sensing applications have to be implemented in the office, in the Internet, and in the open field. The X and Y coordinate provides by a palm-size GPS device makes it possible and operational for integration of remote sensing, GIS, and GPS. Application modules can be integrated by landowner, by X and Y coordinate, by township, or by address. At Taipei Water Resource Management Commission, remote sensing, GIS, and GPS integration has provided nice infrastructure for water resource protection.

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