Development of River Environment Evaluation Technologies Using Remote Sensing, GIS Etc.

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1. Introduction

In order to manage rivers appropriately, it is essential to recognize environments that must be preserved and environments that must be restored. To do this, we have performed a census of river environments and prepared river environment information maps, but there is now a growing need to obtain information related to the environment in detail over wide areas; for example, the networks of water and greenery at rivers and their surrounding land and the micro-topography that have a great impact on the lives of plants and animals. Technologies such as laser scanners and other technologies used to measure micro-topography over wide areas and classify vegetation using hyperspectral technology, etc. have progressed in recent years, and at the same time, data bases of numerical national land digital information, detailed digital information, and other information related to environments are steadily provided by the Geographical Survey Institute, etc.

The goal of this research is to develop environmental evaluation and analysis support systems using remote sensing data and GIS (Geographical Information System) data bases in order to contribute to daily river management and to make various kinds of plans considering the environment; for example, river improvement plans, river environment management plans, and plans for water and green networking, and to effectively apply them to conduct censuses of river environments. The following is an outline of this research.

2. Past use of remote sensing and GIS to evaluate river environments

(1) Remote sensing

The merit of using remote sensing on aircraft or a satellite lies in their ability to repeatedly obtain surface data over wide areas . The following are examples of its use related to river environments.

① Land cover

Vegetation is often classified using the reflectance or luminance of various wave length bands of visual data. Because sensors with multiple bands including the near infrared band are necessary, hyperspectral sensors with many bands are often used. They are now in regular use to monitor the state of restoration of vegetation or to learn the distribution of exotic species. The distribution of riverbed materials (from sand to gravel) has been estimated by analyzing pictures taken by high spatial resolution digital cameras mounted in helicopters.

② Ground surface elevation

The distance between the ground surface and an aircraft is measured by measuring the time taken by a laser pulse transmitted towards the ground from the aircraft to be reflected back from the ground to the sensor at the same time as GPS and IMU (Inertial Measurement Unit) are used to measure the location and the attitude of the aircraft, and the difference in elevation between them is used to measure the ground surface elevation. With this method we can measure elevation accurately by about ± 15cm.

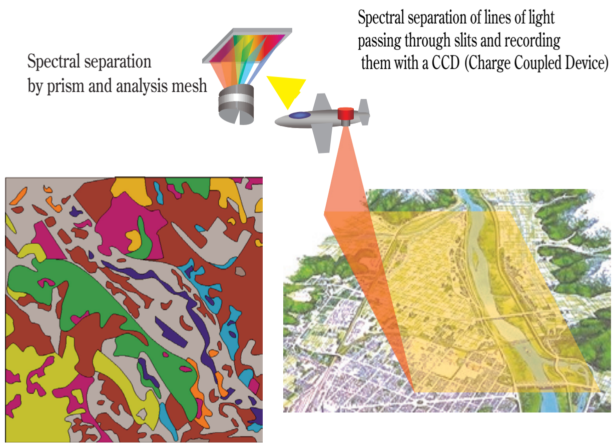

Figure 1 Vegetation classification using a hyperspectral sensor

③ Water quality and water depth

Water quality is surveyed relatively often. For example, the relationship between the reflectivity on water surfaces measured by hyperspectral sensors and water quality (turbidity, SS (suspended solids), chlorophyll a, etc.) has been analyzed. Thermal infrared sensors can measure electro-magnetic waves radiated from the ground surface in the thermal infrared range, and in recent years, a rise in its spatial resolution has permitted its use to measure river water temperature.

Water depth has been measured by laser scanning of green, near-infrared, and Raman scattered light.

(2) GIS

The two-way exchange of data is now underway as, for example, vegetation and soil information obtained by remote sensing is used to update geographical information, and GIS data is used in the process to analyze and evaluate remote sensing images. For example, the distribution range of a species of vegetation communities has been estimated by analyzing GIS vegetation maps obtained by the census of river environments and spectral images obtained using aerial hyperspectral sensors.

3. Focus of the research

As stated above, remote sensing and GIS have often been used to analyze each element related to river environments. On the other hand, it is known that there are various correlations among these environmental elements; the frequency of submersion of the river area and vegetation for example.

The aim of this research is to improve environmental prediction and evaluation methods by, as shown in Figure 2, combining these findings and making the best possible use of the characteristics of remote sensing, spatial analysis functions of GIS (overlay, buffering, etc.) and their good correlation with various analytical, prediction, and evaluation models to clarify environmental elements and the mechanisms of their interrelationships.

For example, when we obtain wide area data concerning river shape and soil distribution that have big impacts on the growth and life of plants and animals by using aerial laser measurements and other remote sensing techniques, or analyze the interrelationships between those data and the distributions of plants and animals by using GIS data; for example, river environmental information maps, and analyze and predict the changes of river shape caused by the change of river flow volumes and quantity of supplied sediment from dams, it will probably also be possible to predict the impacts of dams on plants and animals.

4. Content of the research

(1) Present efforts

In 2003 that was the first year of the research, using laser scanners, hyperspectral sensors, thermal infrared sensors, and three-line sensors we made aerial surveys to measure and analyze ground elevation, tree height, soil grain size distribution, land cover classification, and water quality (water temperature, turbidity, chlorophyll a). This was done on the Ara River, Tama River, and the Nakatsu River (Sagami River System). At the same time, we measured water quality etc on site. Using these data and the results of past surveys of lateral river measurements, river environment information maps, and other related surveys to environments, we will evaluate the various environmental elements. And using these data we will analyze correlations of vegetation with submersion frequency distribution (based on ground elevation data etc. obtained by laser scanners) or with grain size distribution. On the Nakatsu River that was one of the districts studied, and the location of the Miyagase Dam, through this research we will try to apply the method using remote sensing to predict and evaluate the various impacts of a dam on river environments.

(2) Future plans

Based on the achievements of 2003, we are scheduled to apply remote sensing and GIS to develop an environmental evaluation and analysis support system, and improve the system through applying it in the field. For example, using remote sensing and existing GIS data, we may develop the system to evaluate the diverse of vegetation and continuity of greenery and analyze the correlation between these results and animal distribution. And we are scheduled to evaluate and analyze environments including areas around rivers using existing data such as the results of basic surveys of natural environment conservation provided by the Ministry of the Environment. And finally, we aim to develop the river environment prediction system that applies remote sensing and GIS described in 3. The fruits of this research are expected to apply to various kinds of planning and daily management as explained in 1. Introduction. We will conduct a study to prepare a guideline for river environmental evaluations using remote sensing and GIS, which can be utilized by construction offices in the field.

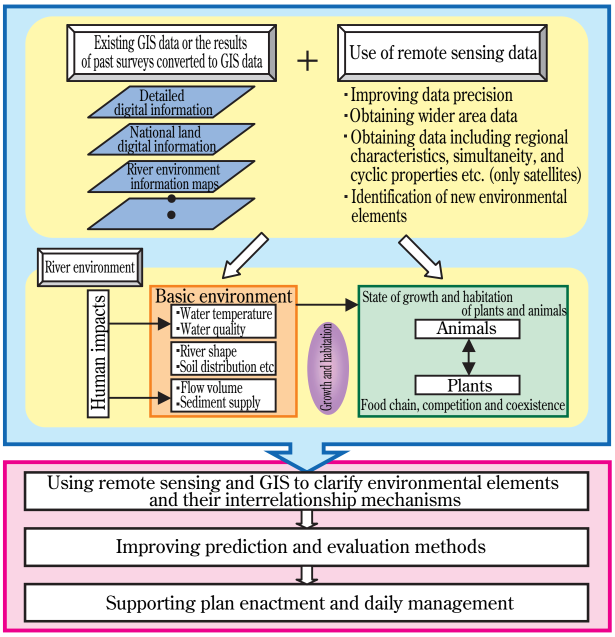

Figure 2 Overall image of the research