Data Collection

DEVELOPMENT OF GLOBAL LAND COVER CHARACTERISTICS DATABASE

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1. Introduction

Information regarding the spatial distribution of the biophysical characteristics of the earth's land surface is critical to global change investigations and environmental quality assessments. The quality and quantity of existing land cover/use data are not sufficient to deal with the range of issues. Clearly there is an urgent need to develop geo-referenced global and regional land cover and use data sets, using standardized definitions, classification systems and data management structures. Also in Agenda 21 numerous references can be cited which illustrate this need for more, better and standardized information on land cover and use: Chapters 10 (Land resources), 11 (Deforestation), 12 (Desertification), 14 (Agriculture and rural development) and 18 (Water Resources), all referring to the need for land cover and use information and assessments; Chapters 35 (Science) and 40 (Information) focussing on the needs for harmonized database development and data sharing. Changes in land cover and land use are also significant components of the problems addressed by the agreements negotiated for UNCED, such as the climate change and biodiversity conventions and the declaration of principles on forests.

2. Land Cover Characteristics Database

The U.S. Geological Survey (USGS) and UNEP has formed a partnership, along with other agencies, to collaborate in the development of a 1-km global land cover characteristics database from Advanced Very High Resolution Radiometer (AVHRR) imagery and other ancillary data including elevation, ecoregions, climate, and soils. The main goal is to produce a global land cover and land use database that can be used in a wide range of global environmental applications and research programmes, using satellite data, existing country data and other ancillary data including topography, hydrology, eco-regions, climate, soils and the like.

The U.S. Geological Survey's (USGS) EROS Data Center (EDC), has developed a prototype land cover characteristics data base for the conterminous United States. in cooperation with the Canadian Center for Remote Sensing and plan is to expand this activity to other regions of the world (Loveland, 1994). The data base, developed using multi-temporal, multi-source classification techniques, contains land cover regions with 1-km resolution and attributes describing vegetation, seasonality, spectral properties, terrain, and climate characteristics. Translation tables, linking the regions to several classification systems, are also part of the data base. The land cover characteristics data base was designed to permit tailoring to specific applications requirements.

3. Analysis Summary

The development of a global vegetation layer based on AVHRR and ancillary data will follow a five stage process.

3.1 AVHRR Time Series Data Assembly

The initial step will be the production of monthly 1-km AVHRR time series composites for periods spanning 1992-94 for each continent. The International Geosphere-Biosphere Programme (IGBP), NASA, NOAA, and the European Space Agency (ESA) are cooperating with the USGS in this function.

3.2 Ancillary Data Collection and Assembly

Before starting each continental land cover characterization, an intensive effort will be undertaken to collect, process, and ready an ancillary data set for each continent. The minimum digital data set will include digital elevation, climate, ecoregions, and soils. In addition, an extensive literature and map search will be undertaken to collect reference materials needed to develop, understand, and validate the vegetation layer.

3.3 Interpretation

This step includes the development of an unsupervised AVHRR classification for each continent, the preliminary identification of vegetation types for each unsupervised class, stratification of classes representing multiple vegetation types, and the development of the final "draft" classification. In addition, statistical summaries of each class identifying seasonal components, elevation conditions, and climate trends will be generated. Extensive comparison of the preliminary class labels to available reference data will also be completed. Teams of regional ecology/vegetation experts are needed to assist in the development of class descriptions.

3.4 Validation/Evaluation

The validation of data sets will follow a two part process. First, the "draft" classification will be compared to available continental and national land cover statistics to develop an approximate understanding of regional strengths and weaknesses. Secondly, regional assessment workshops will be convened to bring experts together to evaluate the vegetation layers.

3.5 Product Generation

Attributes for each region in the final classifications will be generated, and the data base will be formatted to insure consistency between continents. Documentation describing the methods, source data, classification strengths and weakness, and validation conference findings will be provided.

The developed global 1 km databases (and regional subsets) will be widely distributed through an easily accessible medium (e.g. CD-ROM). The datasets will be designed such that they can be easily linked to other relevant information using geographic information systems. In this way multi-source and cover/land use datasets can be compiled, which will be extremely useful for many different users/applications. Using the database, global and regional assessments will be made of land cover and land use.

References

Loveland, Thomas, R. (1994), Strategy for a Fast-Track 1-km Global Land Cover Classification : Unpublished Summary report of IGBP-DIS Land Cover Working Group Workshop, Las Vegas, Nevada, Feb , 23-24.

CIESIN'S ACTIVITIES OF DATA COLLECTION ON LAND USE AND COVER

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The Consortium for International Earth Science Information Network (CIESIN) mission is to provide access to and enhance the use of information worldwide, advancing understanding of human interactions in the environment and serving the needs of science, and public and private decision making. To carry out its mission CIESIN is:

- Developing the Information Cooperative, a network for sharing data and information among major archives and resource centers worldwide, and

- Collecting and integrating georeferenced social data and land use data.

Both of these topics will be addressed here.

The Information Cooperative is a distributed archive that allows major national and international data resource centers to catalog and share information electronically. The common denominator which makes this possible is that every site, at the very least, will participate in a common catalog system, either by hosting their own local directory (and perhaps, inventory) server or by loading their metadata onto another server within the Information Cooperative network. Selected sites support more robust links that provide on-line access to selected data sets, and they may also support the development of data set or country-level guides. The development of the Information Cooperative has been in progress for three years. The emphasis during this initial phase has been on well established data centers in government, nongovernment, and intergovernmental organizations. Table I lists participating organizations. Agreements have been developed (or will be developed) with these organizations and their metadata and data have begun to become available through the system. This effort builds the base of socioeconomic and environmental information necessary to understand global environmental change.

The Information Cooperative is also taking initial steps to expand the network so as to make information resources available from developing nations and nations with transitional economies. These nodes are referred to as Country Nodes and are presently being developed in Central Europe (Estonia, Poland, Latvia, Lithuania, and Ukraine), and in Southeast Asia (China and Thailand). The development of Country Nodes is being done in partnership with the United Nations Development Program Sustainable Development Network and other government and intergovernmental agencies.

Population dynamics and distribution have been consistently identified as key elements in understanding human interactions with the environment and in considering possible responses to environmental change. It has also been pointed out that georeferenced social data plays a key role in improving understanding of land use change and in accessing impacts, vulnerability and adaptation to global changes.

With this in mind, CIESIN has been collecting georeferenced demographic data to integrate with land cover, soils, elevation and emissions data. These efforts initially have been concentrated on Mexico, the United States, and Canada. This project is being done in cooperation with the EROS Data Center.

Another project to be presented involves integration of environmental and socioeconomic data for Rwanda. This will illustrate how multi-disciplinary data helps in the understanding of man-environment interactions.

Table I

Information Cooperative Partners and Provisional Partners

Agency for Toxic Substances & Disease Registry (ATSDR), Atlanta, GA, USA

Center for Indigenous Knowledge for Agriculture & Rural Development, (CIKARD), Ames, IA, USA

Center for International Research (CIR), U.S. Bureau of the Census, Washington, DC, USA

Centers for Disease Control and Prevention (CDC), Atlanta, GA, USA

Centre for International Research and Advisory Networks (CIRAN), The Hague, The Netherlands

China in Time and Space (CITAS), Seattle, WA, USA

Coordination of Information on the Environment (CORINE), Brussels, Belgium

Earth Resources Observation System (EROS) Data Center (EDC), U.S. Geological Survey, Sioux Falls, SD, USA

Economic and Social Research Council Data Archive (ESRC), Essex, United Kingdom

Food & Agriculture Organization (FAO), Rome, Italy

Great Lakes Commission, Ann Arbor, MI, USA Harris Center, Institute for Research in Social Science (IRSS), Chapel Hill, NC, USA

Institute for Public Policy and Social Research (IPPSR), East Lansing, MI, USA

Interuniversity Consortium for Political & Social Research, (ICPSR), Ann Arbor, MI, USA

International Centre for Research in Agroforestry (ICRAF), Nairobi, Kenya

International Development Research Center (IDRC), Ottawa, Ontario, Canada

IUCN-The World Conservation Union, Gland, Switzerland

Joint Research Centre, (JRC), Ispra, Italy

LEAD, Institute of Cultural and Social Studies, University of Leiden, Leiden, The Netherlands

Michigan Department of Natural Resources, (MDNR) Lansing, MI, USA

National Institute of Public Health & Environmental Protection (RIVM), Bilthoven, The Netherlands

Norwegian Social Science Data Services (NSSDS), Bergen, Norway

Organization for Economic Cooperation and Development (OECD), Paris, France

Organization of American States, (OAS), Washington, DC, USA

Roper Center for Public Opinion Survey, (ROPER), Storrs, CT, USA

Social, Labor, and Institution Statistics, Statistics Canada, Ontario, Canada

Statistical Office of the European Communities (Eurostat), Luxembourg

The World Bank, Washington, DC, USA

United Nations Environment Programme/Global Resource Information Database (UNEP/GRID), Nairobi, Kenya

World Conservation Monitoring Centre (WCMC), Cambridge, United Kingdom

World Health Organization (WHO), Geneva, Switzerland

World Resource Institute (WRI), Washington, DC, USA

Zentralarchiv fur Empirische Sozialforschung (ZA), Cologne, Germany

GLOBAL MAPPING
- Global Geographic Information Data Set in support of Global Environmental Research -

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1. Introduction

Today, many scientists and government administrators are undertaking a variety of studies to understand and solve global environmental problems. These studies need basic geographic information which describes and detects changes in the present condition of the earth's environment. It is, therefore, the responsibility of the surveying and mapping community to develop a Global Map, an integrated geographic data set which covers the entire landmass of the earth. Featuring consistent specifications and a spatial resolution of at least 1 km on the ground, it is to be provided to the international community. In this regard, the Geographical Survey Institute of Japan and the Ministry of Construction of Japan have proposed the creation of global maps, a basic integrated geographic data set for research into global change conducted under international cooperation. Last year we made a study of the specifications of a Global Map with scholars and specialists from related fields.

2. Specifications of the Global Map

The Global Map needs to include the data on such elements as rivers, shorelines, roads, place names, terrain relief, vegetation, hydrological conditions, land use, soils, geology, climate, population, and various economic indices. More detail specifications of the Global Map are as follows.

(1) Data Types

Data Types

Grid Data	Graphic Data	Data Currently Available
Vegetation Hydrological conditions Elevation Geomorphology Land use	Boundaries of plant ecosystems Watershed boundaries Boundaries of landforms Rivers, shorelines Administrative boundaries	Basic geographic data (USA) Elevation (USA)

(2) Forms of Descriptive Data
Descriptive data are defined at each grid of the Global Map Standard Grid System at a ground resolution of approximately one kilometer.

(3) Grid System
The Global Map Standard Grid System is constructed by dividing the ITRF-92 geodetic coordinate system into 30-second sections for latitude and 30 to 180-second sections for longitude, depending on latitude as shown below.

Definition of Latitudinal Zone

Latitudinal zone	Latitude	Spacing in a longitudinal direction
I	0-50 degrees	30 sec. (0.5 min.)
II	50-70 degrees	60 sec. (1 min.)
III	70-75 degrees	90 sec. (1.5 min.)
IV	75-80 degrees	120 sec. (2 min.)
V	80-90 degrees	180 sec. (3 min.)

(4) Forms of Graphic Data
Boundary data are defined by dividing the lines of data into segments in which the necessary accuracy can be retained, and by recording the coordinate values of the start and end points of each segment and its attributes.

(5) Coordinate System of Graphic Data
Coordinate values of the start and end points of a segment are recorded in longitude and latitude of the ITRF-92 geodetic coordinate system. The references for elevation should follow the national datum of each country. Coordinate values should have sufficient accuracy so that the data points are clearly defined for the Grid System within the accuracy range of the original data.

(6) Definition of Vegetation and Hydrological Conditions
Vegetation and hydrological data are classified using a seasonal change pattern in plant activities (i.e., vegetation indices) derived from meteorological satellite images and hydrological conditions for low plant activity periods as shown in the following table. These data are defined at each grid point of the Global Map Standard Grid System. The horizontal accuracy of vegetation and hydrological condition data must be within 500m.

Classification of Vegetation and Hydrological Conditions

Class (Plant Activity)	Subclass (Low Plant Activity Periods)	Corresponding Vegetation and Climate Class
Constantly High		Tropical rain forest, Evergreen broad-leaved forest
Changed with temperature and precipitation	Dry land	Coniferous forest, Deciduous broad-leaved forest, Deciduous coniferous forest, Steppe, grassland, farmland, Savanna
	Water (temporary dry land)	Paddy field
	Ice and snow	Tundra
Constantly Low	Dry land	Desert, urban areas
	Water	Lakes, rivers and oceans
	Ice and snow	Glaciers

(7) Definition of Geomorphology
Geomorphological data constitute a landform class defined at each Global Map Standard Grid point. Landforms are broadly classified as higher, medium, lower, or lowest relief energy areas. These last are further classified as moderate slope, slight slope or flat surface. The horizontal accuracy of geomorphological data must be within 50m.

Classification of Geomorphology

Major Landforms (Relief Energy Area)	Micro Landforms	Typical landforms in humid and temperate zones
Higher		Mountains
Medium		Hills
Lower		Plateaus
Lowest	Moderate slope Slight slope Flat surface	Alluvial fan Natural levee Delta

(8) Definition of Elevation Data
Elevation data is defined at each Global Map Standard Grid point and recorded in meters. The accuracy of elevation data must be within 50m horizontally and 10m vertically, considering semi-automatic production of geomorphology and watershed boundary data, and consistent with existing global and national elevation data sets.

(9) Definition of Land Use
Land use is the state of the earth's surface defined at each Global Map Standard Grid point. The earth's surface is classified as water, ice and snow, barren land, wetland, forest land, forest plantation, grassland (including range land), agricultural land, and urban or built-up land. If possible, it would be desirable to include subclasses, as shown in the table below. Subclasses may be added or eliminated within the range of classes depending on regional characteristics. The horizontal accuracy of land use data must be within 50m.

Classification of Land Use

Class	Subclass
Water	Man-made river and lake, natural river and lake
Ice and snow	Perennial snow, glacier, tundra vegetation
Barren land	Mining site, beach, unused land, barren land
Wetland	Forested wetland, non-forested wetland
Forest land	Thick forest, thin wood
Forest plantation	Forestry land, wooded field
Grassland	Range land, unused grassland
Agricultural land	Pasture, confined feeding operations, upland field, Paddy field, other agricultural land
Urban or built-up land	Densely populated urban area, Urban area of low density, park, transitional area

(10) Definition of Boundaries of Plant Ecosystem
Boundaries of the plant ecosystem are lines enclosing sections of nearly homogeneous vegetation, hydrological and climatic conditions. The class of each section should be determined by consulting experts when the boundary data is developed. Sections smaller than 100 x 100 km are ignored except for especially important ones. The horizontal accuracy of the boundary data must be within 500m.

(11) Definition of Watershed Boundaries
Watershed boundary data consists of lines dividing catchment areas. Watersheds smaller than 10 x 10 km are ignored except for especially important ones. The horizontal accuracy of the boundary data must be within 50m.

(12) Definition of Landform Boundaries
Boundaries of landforms are defined as the lines enclosing sections having uniform geomorphological characteristics and proximity, and are drawn based on geomorphological data. The class of each section should be determined by consulting experts when the boundary data is developed. Sections smaller than 10 x 10 km are ignored except for especially important ones. The horizontal accuracy of the boundary data must be within 200m.

(13) Definition of Rivers and Shorelines
River and shoreline data include the properties of river banks and shores classified as natural or artificial at intervals of 3 km. Riverbanks are merged into a single line when the width of the corresponding river is less than 100m. The horizontal accuracy of the boundary data must be within 50m.

(14) Definition of Administrative Boundaries
Administrative boundaries are defined as the lines dividing administrative sections, and are drawn by considering their correspondence to statistical data. Administrative sections smaller than 10 x 10 km are ignored except for especially important ones. The horizontal accuracy of the boundary data must be within 50m.

3. Toward the Development of the Global Map

The following two methods are considered practical in implementing Global Mapping.

A: Mapping information developed from satellite data provided by a select number of organizations.

B: Information which would be more efficiently developed from existing maps and other materials, or which could be provided by cooperating countries from existing materials and satellite data. A country might develop the data for its own territory, or it might provide an organization with the necessary access and input to develop the data on its behalf.

By combining these two methods, the Global Map can be successfully developed using presently available materials and technologies. At present, data items such as vegetation, hydrology and land use are considered to be applicable to method A. On the other hand, elevation, geomorphology, watershed, landforms, and rivers and shorelines are considered to be applicable to method B. However, there is the possibility of developing the latter items from satellite data by method A once more advanced satellite data acquisition systems become available. In the future, if should be possible to take advantage of such technological tools as a stereo imaging satellite sensor of 5m ground resolution, multi-spectral image data of 20m ground resolution, multi-spectral image data of 250m spatial resolution with repeat cycle of less than a day, interferometric SAR images of 5m spatial resolution, and real-time index data to measure the intensity of plant photo-synthetic activity of 1 km ground resolution.

APPLICATION OF REMOTE SENSING TO MONITORING LAND COVER CHANGE
- Why do we need Remote Sensing ? -

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1. Introduction

Deforestation, desertification, and land degradation have become very critical environmental issues during the past decade. Monitoring earth surface conditions (land use/cover) and their changes is essential to the proper management of these global environmental isssues. As most global issues originate from local events such as shifting cultivation, extensive logging or rapid urbanization, monitoring earth surface changes requires that observation of land use/cover should embrace the terrain from local to global on a spatial scale, and periods from short to long on a temporal scale. It is, however, difficult to continuously observe the environment over a large area only by means of ground surveys. Remote sensing from space can provide an effective tool for observing a wide range of environmental variables.

There have been several attempts to apply remote sensing to environmental monitoring, in particular, to the monitoring of land cover and its change. In this presentation, examples of monitoring land cover distribution and its change by using remote sensing are introduced with special emphasis on vegetation monitoring in Japan and South-East Asia. These include:
- National Survey on the Natural Environment (Green Census)
- Vegetation Mapping in South-East Asia
- Global Wetland Monitoring.

2. National Survey on the Natural Environment (Green Census)

The Japan Environment Agency, in compliance with the Nature Conservation Law of 1972, undertakes a National Survey on the Natural Environment every five years. The Survey is popularly known as the "Green Census", and it covers actual vegetation, animals, natural landscapes, etc. This data base provides an important and essential tool for nature conservation in Japan.

As for actual vegetation, the surveyed results are presented on 1,250 sheets of a 1:50,000 scale map for the entire Japan. The total number of vegetation classes is 766. At the highest level they are aggregated into twelve classes for 1km spatial mesh, and at this level digital format data is available. The survey had been carried out based primarily on ground surveys by around 100,000 voluntary experts. Since 1988, however, as for actual vegetation, remote sensing has been applied to update data because of shortages in the budget and a dearth of experts in vegetation survey. In updating the actual vegetation map, the multi-temporal satellite images from the last survey and from the latest are compared merely to detect land cover change areas. However, the ground survey is carried out to actually investigate the changes in the surveyed areas. Detection of land cover can be done by both visual interpretation and digital image processing. This updating procedure can greatly reduce the cost and the length of the survey.

3. Vegetation Mapping in South-East Asia

The decrease in forested areas of South-East Asian countries is now critical, causing serious environmental impacts on society from both a physical and a social viewpoint. It should, however, be pointed out that the deforestation rate of the area has not yet been precisely estimated. Monitoring of vegetation change in South-East Asian countries is now urgent. The National Institute for Environmental Studies started a research project on monitoring vegetation distribution and its changes in South-East Asia using remote sensing since 1990.

The objective of the study is, first, to develop a method for monitoring vegetation distribution and its change by using NOAA AVHRR LAC images, and secondly, to develop an operational monitoring system for it. First, NOAA AVHRR images with low cloud-cover from January to March (dry season) each year since 1986, were retrieved, and a cloud-free mosaic map was produced by composing the images after geometric and radiometric correction as well as cloud removal. In addition, to evaluate how the area is covered by vegetation, a vegetation index map was produced from the mosaic image for each year. In this evaluation, the Normalized Difference Vegetation Index (NDVI) was used. The NDVI is given by

$$NDVI = \frac{N2 - N1}{N2 + N1}$$

where N1 and N2 denote the image density of band 1 (visible) and band 2 (near-infrared), respectively. The NDVI takes the higher value for the vegetated area because vegetation shows high spectral reflectance in the near-infrared spectral range. Furthermore, the NDVI changes from year to year were calculated to evaluate vegetation changes in the area, and vegetation change maps were produced (Fig.1).

4. Global Wetland Monitoring Project

The necessity of monitoring wetland distribution and its changes has been pointed out because of their importance as habitats of migratory birds as well as major emission sources of methane which is one of the predominant green house gases. Changes in wetlands are rapid because such areas are sensitive to the environmental impact of human activities. It is urgent to monitor wetlands and their surrounding environment from physical, biological and social viewpoints. A ground survey of wetlands is, however, difficult and time-consuming, and for this reason there have been very few wetland distribution maps on either a regional or a global scale. Globally, for example, there is only one wetland map with a spatial resolution of one degree (around 100km) produced by Dr. Matthews.

NIES started a project for monitoring wetland environments on both a local and a global scale. In this study, new approaches to global wetland mapping using monitoring with satellite remote sensing are investigated. The study consists of two phases covering both local and global approaches. The first phase takes the local or regional approach. In this phase, the detailed land cover maps, including vegetation maps in and around wetlands, are produced by using spatial high resolution satellite data such as LANDSAT TM, SPOT HRV, MOS MESSR or J-ERS SAR imageries. This approach has been applied to several typical wetlands around the world. The second phase is global. In this phase, wetland-type maps are produced on a global or continental scale by using rather low resolution data such as NOAA AVHRR imageries. The current objective area covers the Asian-Pacific region.

In this representation, the outline of the project is first described, and the results of preliminary studies of Kushiro Mire in Japan (Fig.2) and Western Siberia in Russia are then presented as regional case studies.

5. Conclusions

The potential advantages of remote sensing in environmental monitoring are summarized as follows:

(1) The measurement system does not disturb the object.

(2) The system can measure the land cover conditions over a wide area in a short time.

(3) The system allows for the measurement of environmental variables in the same spatial and temporal scale and resolution in any area of the earth's surface.

and finally,

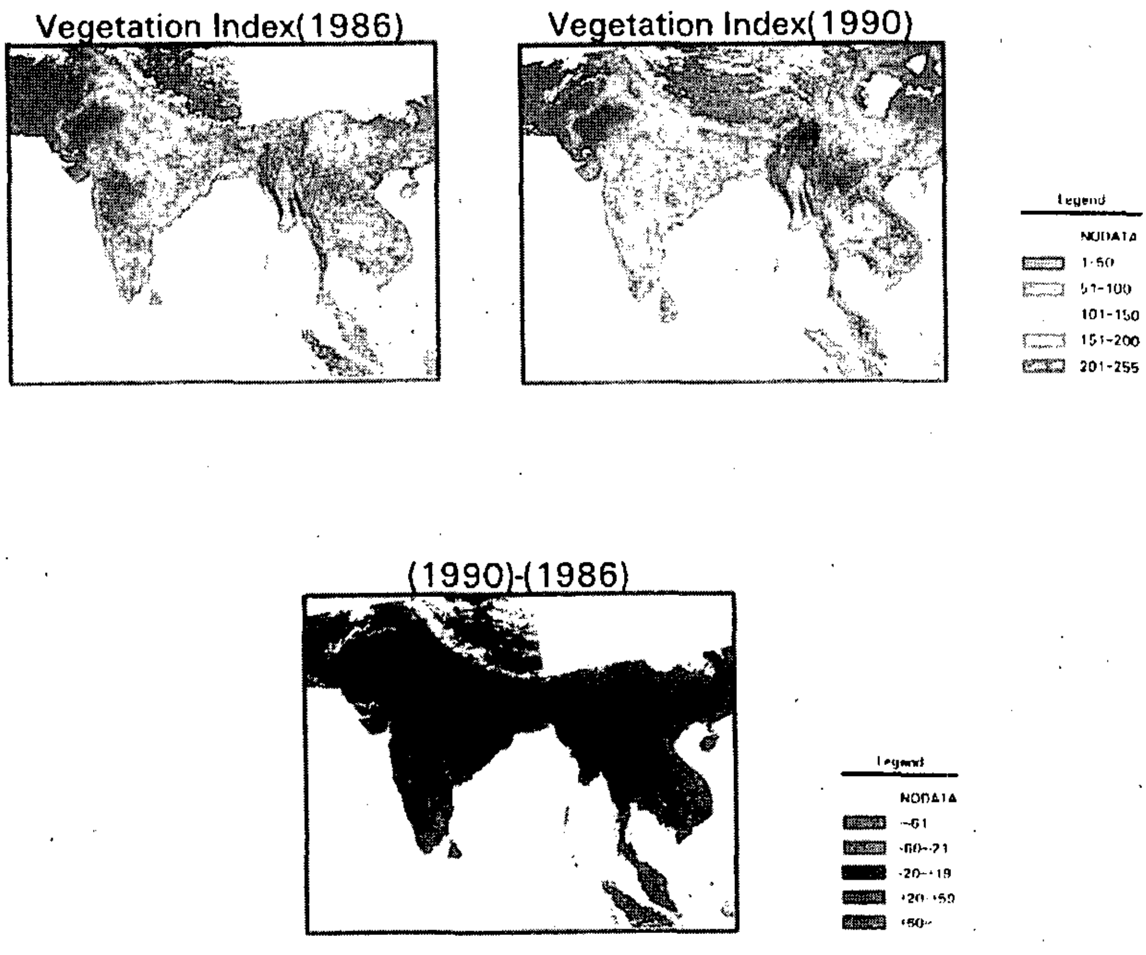
(4) The system can extrapolate local level events to a global scale by combining and

integrating different sensor data (sensor data fusion).

At the same time, however, there are several problems in applying remote sensing to land use/cover mapping. Basically, although remote sensing can observe land cover conditions, in order to derive land use information from such data, higher level processing ability including pattern recognition or artificial intelligence is needed. This ability is not yet fully available. A remote sensing validation process is also needed to ensure that classification results are really correct. This process is usually troublesome and time consuming.

However, the fact remains that remote sensing from space can provide a powerful tool for monitoring environmental variables on both the local and the global scale, and a highly practical operational remote sensing system, is expected to eventually be realized.

Fig.1



Vegetation Index (CVI) maps and associated change maps in South-East Asia

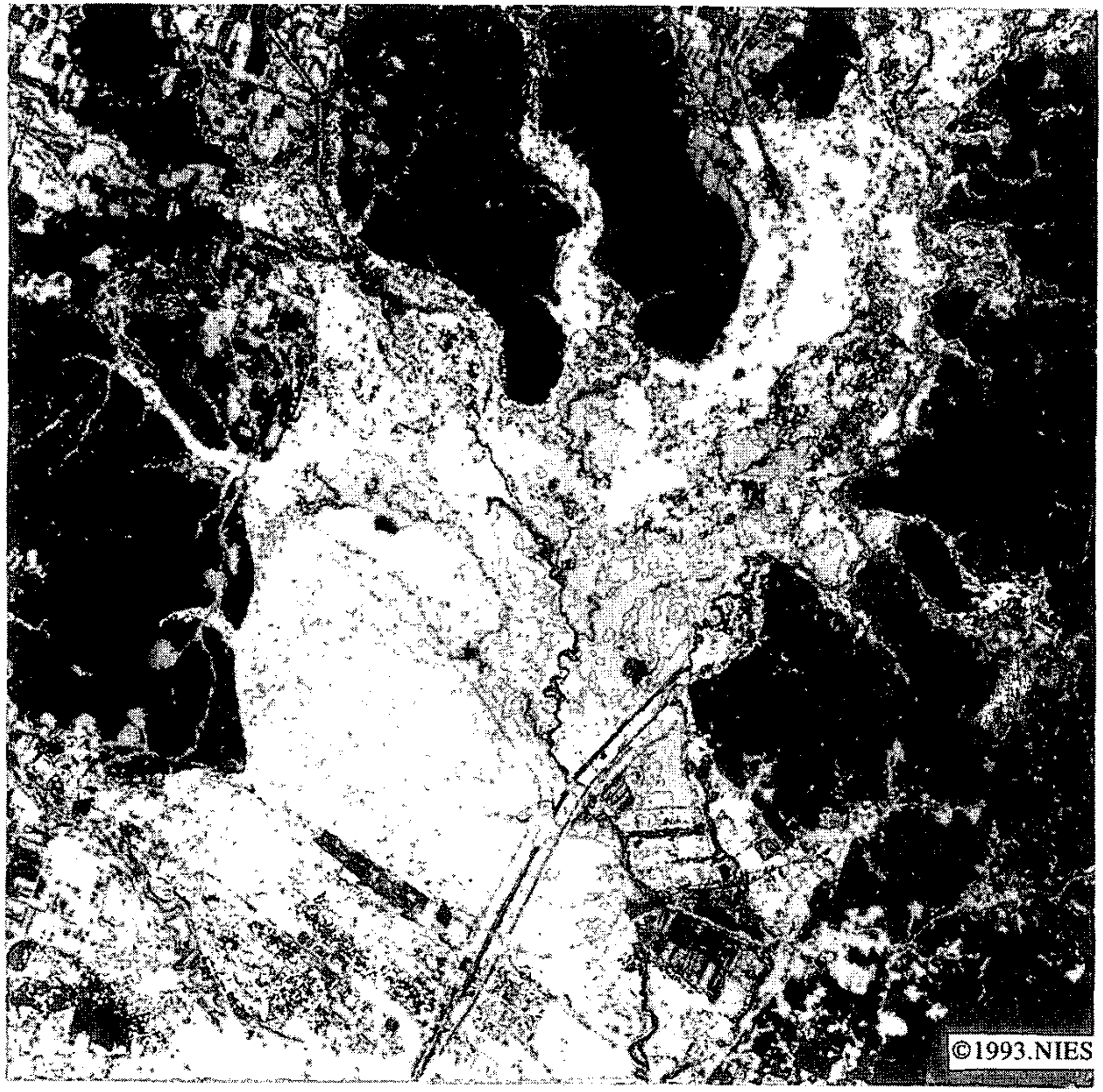


Fig. 2
**ランドサットTM画像による
釧路湿原植生分類図**

Vegetation Classification
Map of the Kushiro Mire
Using LANDSAT TM Image

ミズゴケ (Sphagnum)
スゲ (Sedge)
ヨシ (Reed)
ハンノキ (Alder)
水域 (Water)
森林 (Forest)
その他 (Others)

国立環境研究所 (NIES)
宇宙開発事業団 (NASDA)