CHINESE GEOGRAPHICAL SCIENCE
Volume 9, Number 4, pp. 330- 334, 1999
Science Press, Beijing, China

RESEARCH ACTIVITIES ON LAND-USE/COVER CHANGE IN THE PAST TEN YEARS IN CHINA USING SPACE TECHNOLOGY①

Zhuang Dafang(庄大方) Liu Jiyuan(刘纪远) Liu Mingliang(刘明亮)
Institute of Remote Sensing Applications, the Chinese Academy of Sciences, Beijing 100101, *P. R. China*
(Received 21 July 1999)

ABSTRACT: Land-use/cover change, which in China is characterized by urbanization resulting in a decrease in arable land in the east along with a large area of grassland being cultivated in the west, has been accelerated by rapid economic development in the last years. All of the above changes will affect sustainable development in the next century. The Chinese Academy of Sciences is conducting a study of land-use/cover change over the last ten years based on the integration of remote sensing and GIS technology to establish a multitemporal database covering all of China. Fundamental data for land-use/cover for the year 1996 has already been developed by the Chinese Academy of Sciences. In order to reconstruct fundamental land-use/cover data for the year 1986, a central data processing and analyzing system and a regional data acquisition, processing and analyzing system have been established and are joined together as a network. After the 1986 database is established, the comparative research on the reduction in arable land, urbanization, desertification, changes in forest and grassland, and lake and wetland land-use/cover change will be carried out. In addition, a transect for a key regional comparative study was selected along the Changjiang (Yangtze) River. The driving forces of these changes also will be extracted. The result of this study will be not only make a contribution to global land-use/cover change research, but will also support decision making for sustainable national development.

KEY WORDS: land use and land cover change, reconstruction, space technology

1 INTRODUCTION

The recent and future development of space-based remote sensing technology has brought a reformation to research work as well as formulating suitable policy for population, resources, environment and development. Through real-time and periodic observations of a large area of the earth's environment and natural resources, the spatial information technology plays an indispensable role in surveying resources, monitoring environment, and estimating crop production areas. Especially with the need for national and even global-level sustainable development, the sustainable management of land resources has been highlighted. Land-use intensity, land-use diversity and land cover are land quality indicators for sustainable land management. To be able to assess the indicators and then to judge the implementation of sustainable strategies, we need to depend on the spatial technology that has special characteristics to meet those need. Nowadays spatial technology is an integrated methodology and technology, incorporating satellite technology, remote sensing technology, and temporal-spatial GIS technology for retrieving and representing data sets. Studies of the physical characteristics of earth's surface and ongoing processes of change have entered a quantification stage, with the whole data acquisition accomplished with spatial

① The key project of the Chinese Academy of Sciences for Knowledge Innovation(KZCX1- Y- 02)

technology. Historical observation data and survey data can be transformed into spatial systems under the support of spatial simulation models. Then a spatial information system integrated by social, economic, environmental and land-use/cover change data can be built up to reconstruct the contemporary processes since the historical data were produced, and to support the further quantified research work on the interaction process between nature and human beings.

It is now universally recognized that indisputably huge economic, social and cultural development has occurred in the past few years in China. All Chinese people hope that the process will be a continuous one, or in scientific terms, a sustainable development. But in fact, in the past ten years due to the single-minded enthusiasm for economic development on the part of some regional authorities, many environmental problems have occurred, which could disrupt the sustainable developmental foundation. land use and land cover change(LUCC) can indicate land quality and environmental change and provide information about the result of the interaction between human and natural driving forces. LUCC also can cause regional and even global climate change through changing the energy exchange substance cycle within terrestrial ecosystems. In addition, because the Chinese government is making great efforts to manage its land resources in a sustainable way, LUCC data for the recent years and the regional driving forces should be applied by the government through the use of spatial technology. Under the above circumstances, the Chinese Academy of Sciences(CAS) is carrying out a study of the land-use/land change over the past ten years based on the integration of remote sensing and Geographic Information System technology to establish a multitemporal database covering all of China. A brief description of the project will be presented in this paper, including what the objectives are and how the objectives and purposes can be reached.

2 OBJECTIVES

(1) With the anxious need by the Chinese government for a variety of data sets covering the whole country, a fundamental land-use/cover digital temporal-spatial database, which can reconstruct the history of land-use/cover change during the past decade in China, should be built through integrated application of spatial information technology.

(2) LUCC mechanisms should be studied under the impact of environmental dynamics and human activity. Research should be done on the interactions between land-use and terrestrial biophysical processes and to further identify current LUCC trends so that future land-use/cover changes can be foreseen and rigorous decision support can be provided for sustainable land use management.

(3) Keeping pace with significant international research projects on global environmental changes, the LUCC research project in China should focus on some key research subjects with high compatibility with the International Geosphere-Biosphere Programme(IGBP) and the International Human Dimension Program (IHDP) on Global Environmental Change.

3 RESEARCH FOCI

3.1 Constructing a TM Image Database and Land-Use Maps in Mid 1990s

(1) The CAS has completed the construction of a TM image database covering the whole country with images dating from 1995 to 1996. The images have been rectified and registered to a consistent projection system with the same parameters, which will also be used to construct the image database from the TM images dating from the mid-1980s.

(2) Also the CAS has made a digital land-use map at the scale of 1∶100 000, including an ecology/environmental background spatial database (Liu, 1996). These databases will provide fundamental data for reconstructing the historical situation.

3.2 Reconstructing the Land-Use Distribution in the Mid 1980s

3.2.1 Constructing the image database covering the whole country in the mid 1980s

The success of trial applications of remote sensing in China in 1979 has lead to the development of widespread aspects of the implementation of remote sensing. Ground stations in China were built in the mid 1980s, and they have received and distributed a large amount of multi-temporal and multi-sensor remote sensing image data. At the same time, with help from some other related research projects, many other types of multi-temporal remotely sensed image data covering various regions have been collected, which reinforce the data sourced from the satellite ground stations.

Mining and managing the various existing aerial and satellite remotely sensed data obtained since the 1980s has an indispensable role in understanding the national land resources and environmental situations of the mid 1980s. On the basis of the image databases for the mid 1990s, the national database for the mid 1980s will also be created to meet the project needs and to further provide the data foundation for an even longer temporal series of land-use/cover change research.

3.2.2 Representing the national land-use spatial distribution in the mid 1980s

The research project plans to reconstruct the historical land-use/cover and environmental situations as of the mid 1980s with the application of remotely sensed images and spatial technology.

Since the 1980s, the continuous economic development in China has had more and more impact on the land resources and environment both in quantity and in extent. The usage style of land resources and resource structure has been changed very seriously. As a result, resource shortages and eco-environmental crises have received broad attention from all of the world, and these situations can hinder China's sustainable development strategies. Understanding the changing conditions of national land resources in recent years, we can create the data foundation to preserve and explore the land resources effectively in a sustainable way and put forward decision support for preserving and reforming the environmental conditions to realize regional sustainable development in the future.

Remote sensing technology is an important pathway to acquire spatial and temporal series of data. The land-use situation, with spatial and temporal characteristics, is a direct indicator of human activity on the land conjoined with the natural impact on it. The remotely sensed data that were received by the ground stations in China since their construction became a most important information source for reconstructing the history of the land-use/cover situation.

Depending on the abundance of remotely sensed data and the integrated technology of remote sensing and Geographic Information System, the project will reconstruct the land-use history in the mid 1980s with man-machine interactional interpretation within an overall digital working environment. Comparing the land-use situation in the mid 1980s with that of the mid 1990s, the modern change process and the change trends on land resources and ecological environment can be derived in order to provide useful information on forecasts and decision advice.

3.3 Research on Regional Characteristic of Land-Use Dynamics in the Past Ten Years

As a large country, China exhibits great differences in natural resources and social economic development. Obvious regional characteristics also exist in land-use patterns, land-use structure and land-use intensity. The purpose of spatial comparison and analysis in land-use and land-use change in different areas is to get a full understanding about spatial land-use information and the spatial characteristics of land-use change, and thus to assure the validity and effectiveness of making decisions. It will also be helpful for the sustainable development of natural resources and environment, which can be used as a way to achieve the sustainability of regional economic development and ultimately to realize the concordant and further development of the national economy.

The establishment of "National Environment and Resource Database and Information System" provides not only the data resource for comparison and analysis of the spatial characteristics of land-use, but also the technique and methodology are needed in such kinds of studies. In addition, it is the premise for improving quality analysis. On the basis of the comprehensive and systematic study of time-serial data covering the mainland of China, this project will explore the temporal-spatial dynamics of national resources and environment as well as their characteristics in different regions. Examples are: (a) The regularity and regional characteristics of land-use. (b) Spatial land-use structure and its regional differences. (c) Land-use intensity properties and their regional differences. (d) Quantitative descriptions of the characteristics of land-use change processes in the past ten years by use of the new concept of "land-use change degree" and forecasting the change tendencies in land-use patterns, land-use structure and land-use intensity.

The research emphasizes the following aspects: (a) Changes in urbanization and basic farmland resource dynamics. (b) Forest resource dynamics. (c) Lake dynamics. (d) Desertification dynamics in semi-arid and arid areas.

The analysis and tendency forecasts in land-use change characteristics will be performed in six zones: Northeast China, North China, Northwest China, Southwest China, Central China, and East China.

3.4 LUCC Contemporary Processes and the Driving Forces in Typical Research Zones

In the past ten years, while the economic zone along the Changjiang (Yangtze) River has achieved great progress in economic development, but environment problems have occurred. The project selected this zone as a case study area because of its unique characteristics with multiple land-use categories, different economic development levels, and different landscapes. Through the case study, we can get the premier data material to construct and rebuild the mutual effect between the LUCC and the driving forces from nature and from human beings. According to the landscape of the Changjiang River, four research districts are distinguished. They are: Changjiang River delta, Middle Changjiang River plain, Three Gorges Reservoir, and Changjiang River upper reaches area.

4 METHODOLOGY

Historical remotely sensed data is an important information source to reconstruct the history of land-use/cover. Since the 1970s, large amounts of these valuable data have been received from the satellites and those data have been preserved as digital image data or photos. Relying on the historical remotely sensed data and some other point data sources and survey data sets, the land-use/cover situation and other relevant terrestrial environmental conditions of the time can be reconstructed through interpretation. Through comparing the historical condition with the recent one, the environmental change characteristics during this period can be revealed. Assisted by spatially disaggregated socio-economic data, the environmental and human driving forces, and the interacting process between them, also can be identified. According to the above idea, the experts group of the LUCC research project puts forward a methodology to study the land-use/cover change in the past ten years (1985–1995) almost covering the whole country. The methodology is as follows:

(1) Interpreting the historical remotely sensed data sets of the year 1985 and the newly developed data sets of the year 1995 through overall man-machine interaction before the land-use/cover change detecting operation.

There are two main ways to detect the LUCC using remotely sensed data imaged at different dates from the remote sensing platforms. One is to compare the two images directly using digital change-detection techniques. The other way is to interpret the images and change detection. Advantages and disadvantages both exist in the two methods.

With regard to the first method, although it

needs less labor and has higher processing speed in detecting changes, it also has rigorous demands for image quality and consistency in sensor type, imaging dates and overall image characteristics, and so data pre-processing requirements are critical. The historical remotely sensed data for the middle of the 1980s for China have just been acquired from different remote sensing platforms and from different sensors. In other words, it is impossible to make the data sets of the two dates compatible thoroughly over the large area of China. In addition, the change detection results obtained in this way contain much false information, in that the detected changes are probably not true land use/cover changes but are only due to different imaging dates.

By comparison, the post-classification change detection process by overall man-machine interaction interpretation does not have the critical requirement for image quality and precise comparability. Further, this interpretation method has very high accuracy due to the experts' integrated geo-scientific knowledge involved in the classification process. Generally, a classification criterion should be pre-constructed before interpreting the images, so that consistency between the land-use/cover maps can be ensured. As an input to this project, the land-use maps at scale 1∶100 000 for the year 1995 have been completed after about two years of work, and the interpreting process on the image data for the middle of the 1980s is now getting underway. The personnel in charge of this interpreting work are almost the same as for the mid 1990s data. Therefore, the comparability between the two dates of land use maps will be very high.

(2) Constructing data criterion and operationalizing standardization in the temporal-spatial dynamic database.

In order to manage the multi-temporal series of data efficiently and ensure the consistency between the series of land-use maps of multiple dates, data criterion, data operating standardization, and a tempo-spatial database including data management and data maintenance, should be established.

(3) Developing land-use/cover temporal-spatial database system and metadata database.

Relaying on the two date series of national agricultural land resources databases at the scale of 1∶100 000, and with the consistent data and metadata criterion support, the project will build up both an integrated temporal-spatial database and its metadata database.

(4) Generating the land-use temporal-spatial thematic data sets.

A dynamic database at the scale of 1∶1000 000 with different thematic subjects including farmland, urban area, forest and lakes for all of the country as well as desertification dynamics in semi-arid and arid region will be developed by overlaying the land-use data of two different periods (mid 1980s and mid 1990s). The contemporary land-use/cover change processes from the end of the 1950s along the Changjiang River will be derived using spatial analysis tools and the LUCC process database of different case study areas will be derived by employing the land use data of the two periods and other relevant data.

5 DISCUSSION

This LUCC research project is supported by the Chinese government, so it will serve the government at the national level directly. The implementation plan was brought into practice two years ago. During the former process, we confronted many new matters that had not appeared before. However, by trial and error, we tackled these problems through developing expertise, and as a result plenty of experiments have been obtained. With the support from these two periods of databases and these valuable experiments, we can research more time-slices of land-use and cover history, reconstructing the historical conditions and change processes, and understand the role of change in the terrestrial biosphere under the interactivities between humans and nature.

REFERENCE

Liu Jiyuan, 1996, *Macro-scale Survey and Dynamic Study of Natural Resources and Environment of China by Remote Sensing*. Beijing: Chinese Sciences & Technology Publishing House. (in Chinese)