Mapping on Land Use and Land Cover Change in China Based on Remote Sensing and GIS Technology

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ABSTRACT

The land use and land cover change is an important study field of the international global environment change research programs. The core technology of the study is how to implement the change monitoring in large scale effectively. With the supports of the key science and technology programs of The Chinese Academy of Sciences and The Ministry of Science and Technology of China, the scientists working in the field of remote sensing and GIS have carried out and are carrying on a series of projects on dynamic monitoring in national land use and land cover change.

The key technical problems for the study include: the combination classification system of national land use and its environmental background based integrated of remote sensing and GIS technology; the interpretation and techniques that classified and digitized of land use/land cover and environmental background information from Landsat TM images and other data sources using integrated RS and GIS system; the designing and establishing of background database which is important foundation for dynamic monitoring of land use/cover change; the regionalization for Chinese farmland and urban land dynamic sampling; the dynamic index model of land-use and spatial statistical model for sampling study; etc.

Based on the achievements of technology study, the Chinese Academy of Sciences established an operational land use/cover change monitoring system and spatial-temporal database on land/cover, completed land use/cover mapping of series scales, and developed several spatial data analysis models to support the environment study. The results of land use and land cover change study by remote sensing will not only be able to support the decision-making of national sustainable development, but also will make contribution to the study of global environment change.

1. INTRODUCTION

The coming and recent development of the space technology has bring a reformation to the research work and making suitable policy on population, resources, environment and development. Through the real-time and periodic observing on the large area of earth environment and natural resources, the spatial technology has played indispensable role in resources surveying, environmental monitoring and crop production estimating area. Especially with the need for the national and even global level of sustainable development, the land resources sustainable management has been brought out. 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 strategy, we should depend on the spatial technology that

just has the special characters to meet the needs. Nowadays spatial technology is an integrated methodology and technology, such as satellite technology, sensor technology and tempo-spatial data sets representing and retrieving technology. Study on the physical characteristic of earth's surface and modern process has entered the quantification stage with the whole data acquirement by the spatial technology. Historiacal point data and survey data can be transformed into spatial systems under the support of spatial simulation model. Then a spatial information system integrated by societal, economic, environmental and land-use/land-cover change data can be built up to reconstruct the modern process since the historiacal data was produced and to support the further quantificational research work on the interaction process between nature and human being. At recent years, study on global LUCC has become the core research project in IGBP, HDP and WCRP. The purpose of the project is to carry out global LUCC research all over the world to establish quantificational model of LUCC depending on the terrestrial surface tempo-spatial series of data, and to identify the biophysical and social driving force on the LUCC. Further, using dynamic theory, a predictive model on LUCC should be built in order to provide advises to the governmental authorities in charge of land use management.

Resent years, the economic development and the growth of population in China have put double pressure on the land use and land cover, which has brought out more influences on them than any time before. Land use/cover condition has important environmental meaning. The land use/cover change (LUCC) can degrade or improve the capability of continuous land using and the original cover's resuming. Sustainable development stratify require the government to make suitable decision on the sustainable land use management at macro-scale efficiently. Such as to guide and give administrative order to exploit the natural resources in right way not destroying the ecological environment. For this objective, the information on the farmland change, urbanization, deforestation and reforestation, desertification, water body dynamic and land degradation etc., should be acquired accurately in time to the government authorities. The information-obtaining problem has become the central attention of national decision making authorities and the scientist at home and abroad. Therefore, it is very valuable to use the remote sensing technique as main data source to provide the urgent needed information on land use/cover change to national decision making authorities to make scientific decision on land use management at multilevel, such as national integrated, regional and thematic areas.

Through 20 years research work, remote sensing and GIS technology have been used in widespread area of our nation. A group of scientific stuffs were brought up and a systematic theory and methodology are built in this technology area. At the middle of 1990s, we had completed a large project successfully, which titled " Remote Sensing Investigation and Dynamic Study on Resources and Environment in China ", making use of the macro-scale, quickness and high accuracy virtues of remote sensing. It proves that we have the capability and foundations to establish our national "operational land use/cover dynamic monitoring system" based on remote sensing and GIS technology.

Land use/cover and the environment are always in dynamic process. After surveying on land use/cover all over the country at the first time, providing the dynamic information in certain period and renew the data in time is meaningful to the government. The operational system would meet the continuous information needs for making macro-scale decision support on sustainable land use management at state level.

Almost all the people in the world have realized the indisputable economic, social and cultural huge development in the past few years in China. All Chinese people hope that the process will be a continuous one, in scientific terms, a sustainable development. But in fact, in the

past ten years, due to the sole economic development enthusiasm in some regional authorities, many environmental problems occurred which could disrupt the sustainable developmental foundation. LUCC can indicate the land qualitative and environmental change and contains the information about the result of interaction between human and natural driving forces. LUCC also can cause the regional and even global climate change through changing the energy exchange substance cycle among the terrestrial ecosystems. In addition, because Chinese government is making its great efforts to manage the land resources in a sustainable way, the LUCC data in the past times and the regional driving forces should be applied to the government through the spatial technology. Under the above circumstances, the Chinese Academy of Sciences is carrying on the study of the land use/cover change in the past ten years based on the integrated of remote sensing and Geographic Information System technology to establish the multi-temporal database cover China.

2. THE OPERATIONAL STATE LAND USE/COVER MONITORING SYSTEM IN CHINA BASE ON REMOTE SENSING AND GIS TECHNOLOGY

2.1 BACKGROUND FOR ESTABLISHING THE OPERATIONAL SYSTEM

2.1.1 THE EXISTED FOUNDATION AND THE CAPABILITY TO ESTABLISH THE STATE OPERATIONAL LAND USE/COVER DYNAMIC MONITORING INFORMATION SYSTEM IN CHINA

Since 1970s, Chinese government and Chinese Academy of Sciences have organized many surveys on land use, soil general survey and other special topics all over the country and carried out series of research work on regional environment at national scale. As a result, many land use/cover and environment background data sets had been accumulated. However, because of the problems on the different task and the scattered devises, the primitive communicative way and the inconsistency of data standard, the data sets are difficult to be systemized and so they cannot bring into play its valuation thoroughly. Facing to the problems mentioned above, we need to preprocess the data sets and integrate them into the national information system with modern management. Then the organized data can provide efficient service for making strategic decision and project on our national and regional exploitation and developing with the land use/cover dynamic information obtained from remote sensing and GIS technology.

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2.1.2 THE OBJECTIVES OF THE STATE OPERATIONAL SYSTEM

The project focuses on establishing the state operational land use/cover dynamic monitoring information system so that it can improve the establishment and development of national integrated serving system basing on remote sensing. Through monitoring the change on land use/cover and environment over the whole country every five years and over typical area every year, the operational system should achieve the following objectives:

— To obtain and provide the dynamic information on main land use types such as farmland and urban land every year of the country as a whole.

— To obtain and provide the information on national fundamental resources and environment of which the agricultural resources as the main part, every five years.

— To obtain and provide the land use/cover and environment dynamic information of some key area with significant meanings to the whole country every year.

— To investigate the interrelationship between the land use and land cover and the driving force from human activity to LUCC, and assess the process of LUCC impacting on potential agricultural environment, further, forecast the change trends in the future.

— To establish state assistant decision support system on sustainable land use management, environment protection and agriculture sustainable development.

— To establish stable and integrated state operational land use/cover dynamic information serving system.

— To provide the Internet service for national high-level decision making authorities and other involved informative department in certain term and in emergency.

2.2 PRINCIPAL TECHNIQUE AND METHODOLOGY

2.2.1 COMBINING CLASSIFICATION SYSTEM ON LAND USE/COVER AND ENVIRONMENT

According to the following considerations: (1) the work should be compatible with the international global change research projects, and (2) the thematic information needs for large area of land use/cover monitoring, and (3) accessibility from remote sensing data sets, the project chose land use/cover as main investigation and monitor object. At the same time, with the assistant from geomorphology map and climate data, the satellite image have be interpreted into primary geographic environment units at the same scale as the land use/cover map. Under the GIS working environment, these two types of classification system can be integrated to produce the land use/cover-environment combined classification system through overlapping the land use/cover data on the primary geographic environment unit. The realization of classification under GIS technology support can produce any kinds of combining maps and data on land use/cover and environment which clients need. Also, the clients can retrieve any kinds of environmental background on any kinds of land use/cover types. As a result, the operational system can meet multiple sides of needs from the different clients on the resources and environment dynamic information.

Land use/cover classification system

Dynamics on land resource, including land use and land cover change, is the most direct imprints of human’s activity on the nature. It is also the research area that can mostly represent the high priority of macro-scale and quickness character of spatial remote sensing technology. To counter the demands of macro-scale investigation for results data and remote sensing characteristics, land use and land cover types were classified two levels including 6 first level

class types and 24 second level types. The first level types include farmland, forest, grassland, water body, resident and industrial site land, and others. The first level types are divided into 26 second level types based on the land cover character and the land use pattern of human beings. For example, the forest type is divided into forest coverage land, shrub land and others types; grassland is divided into high coverage grassland, middle coverage grassland and the low coverage grassland. This classification has great meaning to support further research work on plant cover change, land degradation and desertification.

Basic geographical environment classification system

In order to create environment classification system and further understand the relationship between land use/cover change and geographical environment background, the boundary of primary geographical units are drawn while remote sensing images are interpreted for land use/cover. Multi-attribute judgments of one unit are realized through matching remote sensing data with non-remote sensing data. The classification system is consisted 43 types and two levels.

a. Temperature: 9 classes are divided according to accumulated temperature index (>0℃);

b. Moisture Coefficient: 6 classes based on aridity;

c. Geomorphologic features: 4 types and 12 grades are divided by geomorphologic forms:

1.Mountainous land: 4 sub-types are divided according to relative elevation differences

2.Hill land: 4 sub-types according to elevation

3.Plat form: 4 sub-type according to plat form altitude

4.Plain: 7 sub-types according to slope altitude and aspect

d. Soil texture: sandy, loam, and fine soil types are divided.

2.2.2 OVERALL DIGITAL WORKING ENVIRONMENT TO BUILD THE BASIC DATABASE USING INTEGRATED TECHNIQUE OF REMOTE SENSING AND GIS

Under the overall digital techniques support, we have finished building the Landsat TM images database with imaging date at mid-1990s and land use/cover map at scale of 1:100,000 coving all though the country. During the image interpreting work, we thoroughly utilized the man-machine interactive priority to increase the classification accuracy through enhancing the image at the real time. Putting the image on the screen as back layer, the interpreters draw the object boundaries on the screen directly which were saved as vector format of data. Comparing with the traditional work style, at which the boundaries were draw on the photos and then digitized into computers, the overall digital working style can decrease the accumulated errors and labors. After the establishment of basic database by the experienced researcher, some interpreting standards and interpreting sighs with regional characters have been built. Depending on these experiments, we have built up the information extraction and applying model on selected GIS software platform. It is designed with so flexible interface that it can realize the synchronous management on the image data and the vector coverage and can be easily used by the operators after their short time's studying. This technique system can realize the information extraction and database renew at real time and increase interpreting accuracy on remote sensing image, which all would be the key technology bases on establishing the operating information system.

2.2.3 DYNAMIC INDEX ON LAND USE/COVER CHANGE

Dynamic index system should be designed to describe the dynamic degree on LUCC in quantity. As to the farmland and urban land dynamics, an index named "farmland-urban dynamic degree" is made as following expression:

$$I_d = 100\% (|A_{fh} - A_{fn}|) / A_{fh} + 100\% (|A_{ch} - A_{cn}|) / A_{ch}$$

Here, A_{fh} is the farmland area at former period; A_{fn} is the farmland area at current period; A_{ch} is the urban, resident and industrial site land area at former period. A_{ch} is the urban, resident and industrial site land area at current period.

As to the forest and grassland dynamics, we emphasized not only to monitor the change in quantity, but also to the change on quality. Relaying on the environmental background data and DEM data which contains geographic form elevation and slope information, the project take the weight mean of the forest and grassland area change under different ecological environment background as environmental dynamic index on these types of LUCC.

2.2.4 DESIGNATION FOR DYNAMIC MONITOR SAMPLING SCHEME ON FARMLAND AND URBAN LAND CHANGE

As the largest developing country with huge territory, China has amounts of land use/cover types and complex regional environment background. During the increasing development in industry, the high dynamics on farmland and urban land have been introduced. In order to meet the demands for continuous national economy development, the dynamic condition should be monitored. The traditional investigate way cost amounts of money and labors, the most important limitation is that it cannot satisfy the accuracy needs and the time limit needs. Although the investigation based on remote sensing covering on the whole nation can satisfy the above needs, the image data are so expansive that we can not provide them all at every year. In addition, it is unnecessary for macro-scale investigation. So it is necessary to design an efficient spatial sampling scheme to deduce the general change condition accurately when investigating the sample sites. The traditional statistical sampling methods has some shortages in survey the spatial object, such as the large amounts of samples, the low accuracy etc., also the estimating process is not consider the spatial distribution character.

The operational project have designed a sampling scheme which consider the spatial remote sensing surveying character and the special land use/cover change condition in history periods to realize the monitoring work on farmland and urban land dynamic during the natural cycle.

The sampling scheme utilized the spatial statistics theory on the sample estimation, best samples chose, and the sampling accuracy pretest. The main part of the scheme include: zoning on land use/cover dynamics based on the farmland and urban land change condition; distributing the sampling sites relaying on the multi-layers dynamic spatial sampling scheme according to the division of basic sampling unit on farmland dynamic degree in the former period.

— To overlay the land use structure donation on the county level administrative zonation to produce the primary sampling units layer.

— To produce the dynamic zonation units according to the farmland and urban land dynamic degree during the beginning of 1990s to the mid-1990s.

— To simulate to chose samples in each zone with stratified random sampling and to estimate the change degree in order to obtain the errors distributions when using different number and different sites of samples. According to the pre-requirement for estimation accuracy, we make decision on the sampling frequency.

— To investigate the sample units every year by interpreting the Landsat TM image covering the area. The dynamic degree map on the samples units during this period would be produced by comparing the land use/cove map at this period with the former one.

— To estimate and summarize farmland and urban land dynamic degree and their area in each report unit applying the traditional stratified random sampling ratio estimation, in further,

estimate the errors possible distribution range.

— To apply the spatial statistical interpolation method to estimate the dynamic degree in non-sampling units. Through this process, the farmland and urban land dynamic conditions could be estimated in each basic sampling unit.

2.2.5 KEY MONITORING AND INVESTIGATING AREA

As to the significant land use/cover and environment change phenomenon that would produce intensive impact on our nation's sustainable development, the operating system would pay more attention. The interactive processing mechanism between land use/cover change and the environment change, especially the human activity's driving process on LUCC should be investigated in further.

According to the regional differential distribution characters on land use/cover and environment, the project performs different emphasis in monitoring and analyzing in six zones of China:

(1) Northeast of China: forest cover, farmland and the wetlands dynamics;

(2) North China: It is the most farmland centralized and the most significant of its change zone in China in resent years. The farmland and urban land dynamic in this zone and the grassland dynamic in inner Mongolia would be the monitoring emphases;

(3) Northwest China: desertification dynamic, soil elusion and land degradation;

(4) Southwest China: the farmland dynamic on high slope of mountain area;

(5) Central China: water body, farmland and forest dynamics; seek the suitable way to protect the environment for preventing the flood hazard in middle reaches of Yangtze river at land use/cover aspect;

(6) East China: urban and transportation land expansion dynamics; the exploitation on beach; reclamation situation on hillock and hill area;

(7) South China: farmland and urban land dynamic, especially the reclamation on hill area.

2.2.6 THE STRUCTURE AND OUTPUT OF THE OPERATIONAL SYSTEM

The being established state operational land use/cover dynamic monitoring information system contains the following sub-systems: remote sensing image data processing and analyzing system; main operating system and departmental and regional information systems.

Sustainable land use management has three levels. They are household, regional and national levels. The main data source in this monitoring system is Landsat TM image that has 30 meters of ground resolution, which had determined that they would be served for regional and national level of land, use management. It just meets the objective of the project. Multi-level outputs can be produced in this system, including primary, basic and high-level outputs from statistic survey data to data analyzing report and decision-making support advises. The primary output contains the new TM image data and the land use/cover change maps in sample units. Basic output includes the change area in each region with different land use/cover types under different environment background. Also, the possible influence on environment and economic development by the LUCC should be assessed in quantity or in semi-quantity. High-level information output is produced to serve for national decision-making authorities. In these type of output, the macro-scale LUCC information on the whole country and the advises reports on state level land use management according to the benefit principle for the nation as a whole would be offered in time relaying on the decision support system. All the outputs can offer as report papers, figures or as files transmitted through the Internet. Besides the operational system offers the

dynamic information at certain intervals, some information requirements in emergency can also be provided in 24 hours from image processing to finishing the analyzing process and the final result.

3. RESEARCH ON LAND USE AND LAND COVER CHANGE IN THE PAST TEN YEARS USING SPACE TECHNOLOGY

3.1 OBJECTIVE OF THE PROJECT

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

(2) Study the LUCC mechanism under the impact of environmental dynamics and human being's activity; study the interactions between land use and terrestrial biophysical process, and further identify current LUCC trends so that foresee future land-use/cover so that rigorous decision support for sustainable land use management and supervision on the implementation could be provided;

(3) Keeping pace with international significant research projects on the global environmental changes, the LUCC research project in China should focus on some key research subject with high comparability with International Geosphere-Biosphere Programme and the International Human Dimension Program on Global Environmental Change. Such as, the modern process in global environmental changes, it's formation mechanism, the driving forces on LUCC, and the tempo-spatial imitation/forecast model should be emphasized in the project.

3.2 METHODOLOGY

Historiacal remotely sensed data is an important information source to reconstruct the history of land-use/land-cover. Since 70's, vast of these valuable data have been received from the satellites and those data have been preserved as digital image data or photos. Relaying on the history remotely sensed data and some other point data sources and survey data sets, the land-use/cover situation and other relevant terrestrial environmental condition of the time can be reconstructed through interpreting. Through comparing the history condition with the recent one, the environmental change characteristic during this period can be obtained. Assisted by the spatially disaggregated socio-economic the environmental and human driving forces and the interacting process between then also can be identified. According to the above idea, the experts group of the LUCC researching project brings forward a methodology to study the land-use/cover change in the past ten years (1985 ~ 1995) almost covered the whole country. The methodology includes:

Interpreting the history remotely sensed data sets of the year 1985 and the newly received data sets of the year 1995 through overall man-machine conversation 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 many digital change-detection techniques, such as image overly, image differencing, principal component analysis and CVA (Change Vector Analyses) methods. The principle of this way is that the changes in radiance of the same pixel indicate that land use/cover type has been

changed during the period. The other way is to interpret the images and then to produce the land use/cover maps of the two dates separately before operating the change detection. Advantages and disadvantages all exist in the two ways. The first one although needs less labor and has higher processing speed in detecting the change, it has rigorous demands for the image quality and consistency in sensor type, imaging date and overall image characteristic, and so data pre-processing requirements are critical. The historiacal remotely sensed data in the medium of 80's of China just were 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. In addition, the change detection result in this way contains many false information that the detected changes are probably not the true land use/cover changes but only due to the different imaging date. By comparison, the post-classification change detection process by overall man-machine conversational interpretation has not critical requirement for the image quality. Further, this interpretation method has very high accuracy due to the expert's integrated geo-scientific knowledge involved in the classification process. Generally, a classification criterion should be pre-constructed before interpreting the images, so that the consistency between the land-use/cover maps can be ensured. As to this project, the land-use maps at scale 1:100,000 of the year 1995 have been completed after about two years of work, the interpreting process on the image data in the medium of 80's is kicking off now. The personnel in charge of the interpreting work are almost the same as the first one. Therefor, the comparability between the two dates of land use maps will be very high.

Constructing data criterion and operating standardization at the tempo-spatial dynamic database

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

Developing land-use/cover tempo-spatial database system and metadata database

Relaying on the two dates series of produced national agricultural land resources database at scale 1:100,000, and with the consistent data and metadata criterion support, built up both integrated tempo-spatial database and its metadata database.

Generating the land use temporal- spatial thematic data sets

Generate dynamic database at scale of 1: 100,000 with different thematic subject including farmland, urban area, forest and lake all over the country as well as desertification dynamics in semi-arid and arid region by overlaying the land use data of two different periods (mid-80's and mid-90's). Derive the land use/cover change modern process from end of 50's along the Yangtze River using spatial analysis tools. Derive process database of different case study areas by employing the land use data of two periods and other relevant data.

3.3 THE RESEARCH FOCUS

3.3.1 CONSTRUCTING TM IMAGE DATABASE AND LAND USE MAPS IN MID-90'S

The Chinese Academy of Sciences (CAS) has completed the construction of TM images database covered all the country with imaging date at the year 1995 to 1996. The images have been rectified and registered to a consistent projection system with the same parameters, which is

very useful to construct the image database for the TM images with imaging date at mid-80's.

Also, CAS has made the land-use map at scale of 100,000 and the ecology environmental background spatial database. These databases would provide fundamental data for reconstructing the historiacal situation.

3.3.2 RECONSTRUCTING THE LAND USE DISTRIBUTION IN THE MID-80'S

Construct the image database covered all over the country in mid-80's

Since the development of remote sensing technique from 1960's, especially with the launch of Landsat series satellite by USA in 1972 and with its widespread use, the application of remote sensing had been proved that it is very successful in the development of national economic. With the success of trial application of remote sensing in China in 1979, it has lead to the development of application of remote sensing in all-around aspects. The ground stations in China have been built in the middle of 1980's, which have received and distributed amount of multi-temporal and multi-sensors remote sensing image data. At the same time, with the help from some other relational research project, lots of other types of multi-temporal remotely-sensed image data covered various regions have been collected which reinforce the data source from the satellite station.

Mining and managing the existed various of aerial photographs and remotely-sensed data from satellite since 1980's has an indispensable role for understanding the national land resources and environmental situations at mid-80's. On the basis of the image database at mid-90s, the national database at mid-80's would be created also to meet the project needs and further provide data foundation for even longer temporal series of land-use/cover change research.

Represent the national land-use spatial distribution in the mid-80's

The research project plans to reconstruct the historiacal land-use/cover and environmental situations at mid-80's with application for remotely sensed images and spatial technology.

Since 1980's, the continuous economic development in China has more and more impact on the land resources and environment in quantity and in extension. The usage style of land resources and resource structure has been change very seriously. As a result, the resources shortage and ecological environmental crisis has introduced broad attention from all around the world, and these situations can hinder the sustainable development strategy. Understanding the national land resources changing condition in recent years, we can make up 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 environment condition to realize regional sustainable development in the future.

Remote sensing technology is an important pathway to acquire spatial and temporal series of data. Land-use situation, with spatial and temporal characteristics, is a directly indicator of human being's 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 it constructed have became a most important information source for reconstructing the history land-use/cover situation.

Depending on the plenty of remotely-sensed data and the integrated technology of remote sensing and Geographic Information Systems, the project would reconstruct the land use history in mid-80's with man-machine conversational interpretation under overall digital working environment. Comparing the land use situation in mid-80's with that in mid-90's, the modern change process and the change trends on land resources and ecological environment can be derived and so that it can provide useful information on forecast and decision advises.

3.3.3 RESEARCH ON REGIONAL CHARACTERISTIC ON LAND USE DYNAMIC IN THE PAST TEN YEARS

As a large country, China exhibits great difference in natural resource and social-economic development. Obvious regional characteristics also exist in land use pattern, land use structure and land use intensity. The purpose of spatial comparison and analysis in land use and land use change in different area is to get full understand about land use spatial 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 resource and environment, which can be used as a way to achieve the sustainability of regional economic development and ultimately to realize the concordant and highly development of national economy.

The establishment of "national environment and resource database and information system" provides not only the data resource for comparison and analysis spatial characteristic on land use, but also the technique and methodology is needed in such kind of studies. In addition, it is the premise for improving quality analysis. This project is going to, on the basis of comprehensive and systematic study on time-serial data covering the mainland of China, explore the temporal-spatial dynamics of national resource and environment as well as its characteristic in different region. Such as,

(a) The regularity and regional characteristic of land use

(b) Land use spatial structure and its regional difference

(c) Land use intensity property and its regional difference

(d) Quantitatively describing the characteristic of land use change process in recent ten years by use of the new concept "land use change degree" and forecasting the change tendency in land use pattern, land use structure and land use intensity.

Research emphasizes on the following aspects:

(a). Changes in urbanization and basic farmland resource dynamic

(b). Forest resource dynamic

(c). Lake dynamic

(d). Desertification dynamics in semi-arid and arid area.

3.3.4 LUCC MODERN PROCESS AND THE DRIVING FORCES IN TYPICAL RESEARCH ZONE

In the past ten years, while the economic zone along Yangtze River has obtained big progress in economic development, while the environment problems come along. The project selects this zone as case study area, because of its unique characteristic with multiple land use categories, different economic development levels, and different landscapes. Though the case study, we can get the premier data material to construct and rebuild the mutual effect between the LUCC and the driving force from nature and from human being. According to the landscape of Yangtze River, four researching districts are divided. They are:

(a) Yangtze River delta;

(b) Medium of Yangtze River plateau;

(c) Sanxia Reservoir;

(d) Yangzi upper reach area;

4. CONCLUSIONS AND DISCUSSIONS

As state level land-use and land-cover change research projects, they must meet the needs

from the related national communities. In other words, the research work should provide valuable and real time advises on making sustainable development strategies and protecting our national natural environment through multiple ways. According to the requirement from practical social and economical developments on national land resources and environment, the LUCC research projects in China have carried out the systematic research scheme and methodology, and future they will be perfected more and more in the future. We will overview the general experience in LUCC research in China as following aspects.

(1) Temporal continuity

LUCC research not only need reconstruct and search historical environmental status to identify the change intensity and extensity, but also need monitor the change at real time, which the operational systems should be built for this purpose. In addition, the research cannot realize their valuations until they have the forecasting capability. The land use/cover change trends in the future should be put foreword by establishing the dynamics model of the LUCC. The driving force mechanism and the interrelationship between land use and land cover change should be studied in detail to establish the process/causality model.

(2) Spatial seamless

Spatial scale is an important consideration to start the LUCC research project. As the state level projects for academic research and establishing operational information system, we should try our best to make our products from the projects meets different level needs, e.g., from local level to national level, regional level is included. In order to realize the plan, we should construct a systematic working scheme at different spatial scales and design practical scale-up and scale-down method to produce different level products. They must consistent on each other and contains various characteristics and emphases.

(3) Multiple data sources fusion

In order to satisfy the demands for land use/cover change mentioned above, multiple sources of data should be used to collect enough information. In the data fusion process, multiple spatial and temporal resolution data and multiple spectral band data from different sensor and different platforms would be used together. In addition, historical literature data, surveying data at ground, social-economical survey data statistical data should also be used to get suitable results.

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