

Review of Land Use and Land Cover Change research progress

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Abstract. Land Use and Land Cover Change (LUCC) can reflect the pattern of human land use in a region, and plays an important role in space soil and water conservation. The study on the change of land use patterns in the world is of great significance to cope with global climate change and sustainable development. This paper reviews the main research progress of LUCC at home and abroad, and suggests that land use change has been shifted from land use planning and management to land use change impact and driving factors. The development of remote sensing technology provides the basis and data for LUCC with dynamic monitoring and quantitative analysis. However, there is no uniform standard for land use classification at present, which brings a lot of inconvenience to the collection and analysis of land cover data. Globeland30 is an important milestone contribution to the study of international LUCC system. More attention should be paid to the accuracy and results contrasting test of land use classification obtained by remote sensing technology.

1. Introduction

Land Use and Land Cover Change (LUCC) is the leading edge and hot topics of global change research. The mutual influence between LUCC and human society acts on the human survival environment and food safety. In the global scope, LUCC plays an important role in the hydrothermal cycle in globe land water cycle [1]. Some research shows [2,3], in the past more than 100 years, CO₂ emission to the atmosphere under the influence of LUCC is equivalent to the industrial era fossil fuel emissions to the atmosphere, which accounts for 35% of the total CO₂ emission from human activities into the atmosphere, so this change has a direct impact on the global water-land-carbon cycle and balance of energy and a number of regional ecological balance. In addition, it also has the extremely important influence to maintain the sustainable development of modern society.

Surface coverage determines the earth surface's radiation balance, water flow, material handling, surface water permeability and so on, then its spatial distribution and change are important basic data and key parameters of global change research, earth system model research, geographic situation detection and sustainable development planning etc..[4,5] Therefore, the research of LUCC has become the focus of research in the field of environmental today [6]. In the past few decades, researchers have done a lot of research on LUCC about the causes, the results, the dominant factors, and the land use optimization by policy makers. At the end of twentieth Century, LUCC research is proposed by International Geosphere-Biosphere program (IGBP) and International Human Dimensions Programme on Global Environmental Change (IHDP), and a deeper study on the linkages between human activities and LUCC are analysed [7]. Through the research on the feedback mechanism of LUCC under the influence of human activities acting on the globe ecological changes and then on the environment,



ecological assessment influenced by human activities has been done in space and time, and appropriate intervention, so as to achieve the sustainable development of human and ecological environment.

2. Research status at home and abroad

2.1. Research status at abroad

Since industrialization era, the globe environmental problems have become increasingly prominent. With the deep study on the environmental change, researchers recognize that the land cover change affected by human activities is an important factor leading to the globe environmental change [8]. Because human activities are based on natural environment, such as soil, water resources, climate and vegetation, which are affected by LUCC. LUCC is the product of interaction between human social economic activities and natural environment. This is the core of sustainable development in ecological environment. Therefore, the LUCC research is the focused of IGBP and IHDP [8].

In 1930s, the research of LUCC began to rise. In North America, some scholars had analyzed the land use types in the America plains. In South America and Africa, some scholars believed that LUCC caused by human social activities was one of the factors that affect global climate change [9]. At the same time, some scholars also used the Markov stochastic process analysis method to analyze land change and trend. The study of LUCC in this period mainly focused on the planning and management of land use. Since the 1990s, with the beginning of interdisciplinary research, land use change has attracted much attention, especially the research of LUCC driving mechanism [10,11]. Considering that LUCC research was one of the main support for the study of global environmental change, IGBP and IHDP began work on this field in 1990. Since then, they had reviewed and prepared a scientific research plan on LUCC, mainly put forward 2 emphases: (a) study on LUCC mechanism; (b) regional and global change model research [12, 13].

As a result of the implementation of the plan, many countries' research organizations had joined the study and accumulated many experiences and achievements in the LUCC research. Since then, many research projects had commenced, The International Institute for Applied Systems Analysis initiated the research project of LUCC change model in Eurasia. The United Nations Environment programme launched land cover assessment and planning project in 1996 [14, 15]. The United States Global Change Research Council linked LUCC research with climate change and ozone layer depletion. It was cited as a priority in the area of global change research.

2.2. Research status at home

Since the 1950s, China started the large-scale land resources survey. From 1958 to 1962, the first national land and soil resources were carried out. In 1979, China's Agricultural Zoning Committee presided over the second national land census. Due to the limitation of technology, the results couldn't satisfy the needs of governments at all levels for our own economic development. The survey results provides the basic data for our country land use change survey in the future [16]. In 1990s, China carried out a survey of resources and environment, then remote sensing technology has been widely used in the investigation. At the same time, in the global LUCC research program, China also conducted research on the mechanism of land use change and its driving factors. LUCC is a comprehensive result involving complex interdisciplinary studies. So far, although Chinese scientists have done a lot of research, many aspects of the LUCC's theory and research methods need to be discussed and improved deeply [17, 18].

In recent years, the industrialization has created an opportunity for China's social development and economic growth. It has also brought many problems to people's living environment, such as water quality deterioration, soil erosion, air pollution and the extinction of species. Therefore, the study of LUCC has become the key point of sustainable development of China's society and economy [19]. Due to the great difference in natural and social economy in different regions of China, the sources of LUCC-related factors differ greatly. Therefore, the research on regional LUCC is paid more attention by researchers in China. At present, the domestic LUCC research focuses on two aspects: on the one hand,

"developed areas", that is the region where human social activities are very active. Researchers tend to choose the area of highly complex social and humanistic factors. For example, Shi Peijun analyzed the dynamic trend of land use in Shenzhen city [11]. Peng Buzhuo conducted a study on the driving force of land use change and the change of cultivated land amount in the Yangtze River Delta region in the past 50 years [20]. On the other hand, "ecological fragile area", that is the region where environmental degradation occurs due to the imbalances between population expansion and the consumption of environmental resources with the development of social economy. Research on this type of area can help to understand the vulnerability of the ecological environment and reveal its evolution mechanism. Many researchers in China chose the latter for their research. For example, Zhang Ming has done a lot of work on the statistical analysis of the land use structure and its driving forces in the Loess Plateau [21].

The analysis of the factors and mechanisms of LUCC is the focus of the study. The researchers applied statistical analysis methods to study the driving force of LUCC. For example, Shi Peijun obtained the role of human factor in land use change through the analysis of socioeconomic factors and natural environment factors in Shenzhen City [11]. Bai Wanqi put the main driving factors into the system, then analyse the dynamic trend of land use, finally obtain the weight of the contribution value from the primary and secondary factors. Researchers should conduct research in selected representative areas, integrate with international LUCC research programs and accumulate experience and data in order to facilitate the establishment of LUCC models and the improvement of simulation results.

3. Application of remote sensing in LUCC

With the development of science and technology, research methods and ideas of the early qualitative has been unable to meet the research needs. From 1970s, satellite remote sensing image data provides the basis and data for the dynamic monitoring and quantitative analysis of LUCC. For the study of LUCC, this is undoubtedly a pioneering undertaking in the field of global environmental change [22]. With the rapid development of computer software technology and geo-software GIS, the remote sensing image information can be analyzed comprehensively with the original land survey and basic data. This can not only reflect the true features of land elements, but also can better study the dynamic change of land use [23]. In 1970s, the United States Geological Survey established a land use classification system to adapt the needs of artificial and computer interpretation in modern remote sensing to facilitate the use of remote sensing for land use mapping.

Remote sensing images contain rich spectral information, which has always been an important data in the field of LUCC research. The color gray value of remote sensing images will appear on the remote sensing images when the ground objects are in different reflection spectrum characteristics. Due to the obvious difference of spectral types, different types of bands can significantly improve the discrimination degree of the ground features. Therefore, in multispectral data, the most appropriate bands and color combinations are selected to facilitate the information extraction in the interpretation process. The establishment of a classification system suitable for the study area is the basis of remote sensing classification, and also a necessary condition for automatic recognition of fast computers. Due to the limitations of satellite, local geographical features and resolution, there is no standardized remote sensing classification system. To ensure the reliability of the classification results, the classification images need to be compared with the actual data (land use status map or ground survey data). In practical work, sampling is usually used for precision analysis [24]. Currently the Kappa coefficient of Confusion Matrix proposed by Cohen (1960) is widely used to evaluate the classification accuracy of images. This method has been developed as the main method to evaluate the accuracy of remote sensing information extraction. Confusion matrix is composed of $n \times n$ matrix, which can represent the accuracy of classification results. The accuracy of land use evaluation classification mainly includes user precision, producer precision and Kappa coefficient. The advantage of Kappa coefficient is that it considers not only the number of pixels to be correctly classified, but also the number of pixels that are not correctly classified. Therefore, it can better reflect the accuracy of remote sensing image information classification.

GlobeLand30 is the world's first two (2000-2010) 30m resolution global land cover data product developed by China under the support of 863 project (www.globeland30.com). It contains ten land cover type: cultivated land, forest, grassland, shrub-land, wetland, water bodies, tundra, artificial surfaces, bare land and permanent snow and ice (see Figure 1)[4]. The overall accuracy of the third party institutions evaluation was 83.5%. It's the China's major contribution to the study of LUCC and globe environment change. GlobeLand30 has also significantly promoted the data sharing of earth observation and geo-information in the world.

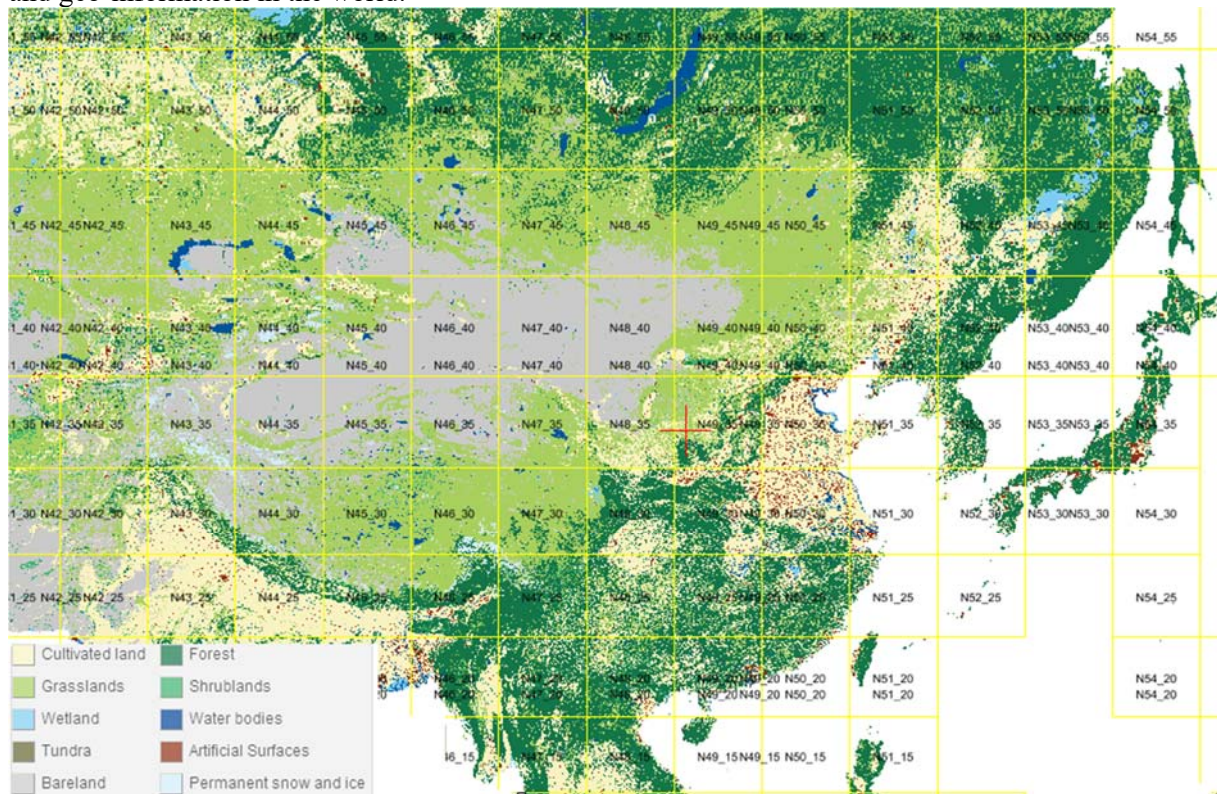


Figure 1. The GlobeLand30 data of 2010 in China and around areas

4. Conclusion and prospect

Modern remote sensing technology has been widely used, and researchers have established a database of LUCC changes at different scales to meet the needs of environmental change research. At present, there are some problems in land use / land cover change research, mainly summarized in several aspects: (a) Not enough attention to the data except remote sensing data, the research on land use influenced by weather, drawing technician's skill, equipment precision and other factors, so it may not be able to fully display LUCC. It should be combined with the field survey data and the correlation of the terrain data for analysis when performing the accuracy verification. (b) Most of the LUCC models are greatly affected by the regional environmental factors, and due to the limitation of data quality, the function of the established model is not representative. (c) There is no unified theoretical system for reference, so the methods and models used by researchers have obvious regional limitations. They can't be extended in large areas. (d) The GlobeLand30 has only two base-line years (2000 and 2010), it can't meet researchers' strong demand for up-to-date and timeliness of the global land cover data.

With the further study of LUCC, the future research should pay more attention to the LUCC driving factors and the exploration of the environmental change effect caused by LUCC. A unified theory system of LUCC should be established. In order to solve the multi-scale problems in LUCC research, the development of LUCC research model should have the following trends: (a) LUCC model should be able to simulate and combine the two driving forces of social economy and the natural environment. (b)

Resolution should be increased to get the long-term (50-100a) easily. (c) The impacts of other factors on LUCC, such as population growth, economic development and technological progress should be fully considered.

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