Discussion on the Technology Route for Land Degradation Monitoring and Assessment based on 3S Technique

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Abstract: This paper analyzes three theories for land degradation assessment and international/domestic methods for land degradation monitoring and assessment. Under the guidance of absolute degradation thought, this paper proposes the technological framework for monitoring and appraising cultivated land degradation based on the 3S technique. We can apply 3S technique and analyze the nature, the environmental, the social, and the economic elements which influence the land utilization and degradation synthetically, to set up the indicator system of the cultivated land degradation monitoring and assessment based on 3S technique; to propose the degradation information extraction methods based on 3S technique; to create the quantitative assessment model and method for land degradation; to analyze the ecological environment response of land use and degradation quantitatively; and to propose the measure, policy and suggestion for solving the land degradation problem from the point of view of land utilization.

Key word: land degradation, cultivated land degradation, monitoring and assessment

1. Proposition of the question

Since reform and opening to the outside world, the industrialization and urbanization of China have accelerated. The modernized construction achievement is remarkable. But at the same time, the motivation of market economy interests' mechanism has brought marked change to the type and structure of land-use. As a result, such rapid changes have caused the land to degrade, because of the intensification of contradictions between mankind and land. Consequently, the resulting environmental and resource problem seriously affects sustainable development with regards to socio-economy and regional environment. Land degeneration is an important reflection of land quality condition, and an important indicator to monitor sustainable use of land resources. Food security is the primary concern at present to ensure national security of China. The security of land is the foundation of food security. Therefore the reduction of the quantity of cultivated land and the degradation of quality threaten China's food security, and are the utmost important factor that influences regional sustainable utilization of land and land security. Because of the restriction of techniques and means in the past, China now lacks accurate information of land degeneration, thus affecting the ability to make decisions based on scientific data. The scientific decision is dependent on reliable information; reliable information acquisition must be

sustained by modern information technology (IT). Monitoring land degradation using Remote Sensing is not only low cost but also macroscopic and prompt, and therefore have wide application prospect. The progress of information acquisition technique will further the study in the impact of land use on the ecological environment. The study in monitoring and assessing cultivated land degradation will contribute to making and perfecting the ecological environmental protection plans, offer scientific guide and basis for confirming feasible countermeasure and measure, and have certain scientific meanings for promoting the coordinated development of regional population, resource, environment, and socio-economy.

2. Domestic and international method progress in land degradation monitoring and assessment

Developed countries have a long-standing history of monitoring land degradation. Professor Stamp, a British economist, led the first land use investigation and mapping of Britain in 1931. In 1952, Japan formally implemented land use investigation, which described the land use condition and ecological environment in different areas. The Japanese land investigation issued a land use map that revealed the condition of the land at the scale of 1:25000. Furthermore, it described the relationship between land use and the surrounding environment.

At present, the international Land Quality Indicator System (LQIS) study has already been confirmed as the research project by several international organizations (FAO, UNDP and World Bank). These international organizations are the most active in the land science research field. Its key question concerns land use pressure and land degradation. To a great extent, they probe into the correlation between land use and the ecological environment.

Land Use/Cover Change (LUCC) is one of the main reasons causing land degradation, such as soil erosion, salinization and basification, acidification, and desertification (Buol, 1990). Special attention is paid to human-induced land degradation monitoring, assessment and its process mechanism and control research in world scope. A lot of projects launch around this theme or regard it as the main research subject. For instance, the United Nations Environment Programme (UNEP) started the worldwide human-induced soil degradation condition assessment project in 1990 (Oldeman, 1990). This project has established a human-induced soil degradation type classification (contain reasons) framework which was used to evaluate the worldwide soil degradation condition. Food and Agriculture Organization of the United Nations (FAO) has developed the land degradation assessment method and land desertification mapping study.

In the 1990s, UNEP launched the project "Global Assessment of Human Induced Soil Degradation (GLASOD)". It classified land degradation into four types: water erosion, wind erosion, chemical deterioration (such as pollution, acidification, salinisation, loss of

nutrients or organic matter) and physical deterioration (such as soil compaction, sealing and crusting, water-logging, and subsidence of organic soils). The GLASOD assessment was mainly reflected in the World Atlas of Desertification UNEP published in 1997 and land degradation assessment of other regions (Nicholas,1997 and Nicholas, 1992). Though the United Nations made the assessment regulations of danger degree with detailed quantitive indicators in 1984, the practical implementation has a certain degree of difficulty. The theory of assessment includes the degree of degradation, the overall state of degradation and degree of threat as well as related indicator system. The core of the theory is assessing the state and degree of degradation (Sun Wu, 2000). There is certain progress on the theory and method of land degradation assessment and monitoring all over the world. At present, there are three kinds of assessment theories: Global Assessment of Human Induced Soil Degradation (GLASOD) (global and absolute degradation assessment), Status of Human-induced Soil Degradation in South and Southeast Asia (ASSOD) (regional and relative degradation assessment) and the method put forward by Russia academy of sciences (RUSSIA) (synthetic assessment). Along with the application of sophisticated technique, Argentinean desertification state assessment was completely based on remote sensing and image processing system. It has represented the present new tendency of method on this field (Valle, 1998). Tripathy utilized MultiSpectral Scanner (MSS) and India Remote Sensing Satellite(IRS) data, merged the soil information of the ground through GIS in the research of monitoring of desertification in Karnataka state of India to finish the monitoring of land degradation (Tripathy, 1996). Hill explored the use of linear spectral mixture model to carry out image split, land degradation, soil erosion and desertification monitoring in the Mediterranean ecosystems (Hill, 1995).

China realizes the importance of land degradation monitoring and assessment while carrying on the scientific management of land. Using remote sensing technique to carry on degradation monitoring and assessment has become one of the main research tools nowadays and in the future. For instance, the National Forestry Bureau launched a pilot project in Ningxia in the 1990s. This project used remote sensing to carry out large-scale desertification monitoring of China. Gao (1998) and Zhu (1998) utilized TM data to set up an indicator system for the sandy desertification monitoring and assessment. Ma (2000) studied the sandy desertification and soil erosion caused by wind and water erosion of western Hainan based on RS and GIS technique. Liu adopted the method that combined remote sensing with GIS technique. He worked out the Normalized Difference Vegetation Index (NDVI) using NOAA/AVHRR data, and carried on a large amount of research in the synthetic vegetation classification and the ecological environmental quality relation on the basis of combination with geographic digital information (Liu,

1996). Based on "the national resource environmental remote sensing macroscopic investigation and dynamic analysis", Fu (1997) and Li (1996) probed into land use and land cover mechanisms and the impact on the ecological environment through their study on land quality.

Now correlative research is improving, but some problems still exit. Such as (1) the limitation of remote sensing data as well as the lack for its research development; domestic and international researches still have not come up with a set of land degradation monitoring and assessment indicator system which is especially suitable for remote sensing application and macroscopic monitoring. (2) Though synthetic utilization of 3S technique could improve the precision, efficiency and depth of land degradation monitoring and assessment, research in carrying out land degradation monitoring and assessment using 3S technique efficiently is still in the initial stages.

In addition, with the high spectral resolution of imaging spectrometer, utilization of hyperspectral remote sensing technique to carry out resources and ecological environmental monitoring will become the development trend for the future. The evolution of hyperspectral remote sensing technique makes precise spectrum feature analysis and quantitative spectral reflectance retrieval of surface features parameter possible. This makes imaging spectra technique significant in many fields of research such as geological surveying, mineral exploration, soil surveying, land degradation (such as desertification and salinization) monitoring, mine environment monitoring, pollution surveying and monitoring of land and water bodies (Gong, 1999).

Goetz (1990) and Miller (1990) have studied the retrieval of vegetation biochemical information. In China, we effectively applied this technique in geological lithological identification, mineral mapping, urban land use surveying, forest investigation surveying, and precise estimation of crop yield (Wang, 1996; Zhang, 1997). Zhang studied the nonlinear spectra mixing model of soil and canopy (Zhang, 1997). But the study on utilizing the hyperspectral data to carry on the organic matter level, cultivated land pollution and sandy desertification monitoring has not yet been launched.

3. Study of technology route for degradation monitoring and assessment of cultivated land based on 3S technique

This research mainly utilize hyperspectral RS data, acquires the ground coordinate data with the aid of GPS, and combines with ground surveying data to retrieve cultivated land information of degradation. It makes use of GIS as the means for data storage and analysis. This research explores the application of 3S methods into degradation monitoring and assessment of cultivated land. Moreover, it sets up a method system for the research of land use change and cultivated land degradation environment response, and improves the precision and depth of the research.

The basic train of thought for this research is to adopt 3S technique synthetically to analyze the natural, environmental and socioeconomic essential factors which influence land use and degradation., 3S technique is used to construct the monitoring and assessment indicator system of cultivated land by selecting different degradation indicators with diagnostic spectral feature. It represents a form of information retrieval method of land degradation. Establishing a quantitative assessment model and method of degradation based on 3S, it allows further investigation on the origin, type and degree of cultivated land degradation by the scientific means. Further, it allows analysis of the ecological environment response of land use and land loss to obtain comprehensive information about land use and degradation. For example, the interactional mechanism among different factors, the domino effect of structure, and the influence of the driving force of land degradation. With these data available, putting forward regulation and control measures, policy and suggestions to solve land degradation from the angle of the land use may be achieved. (Figure 1)

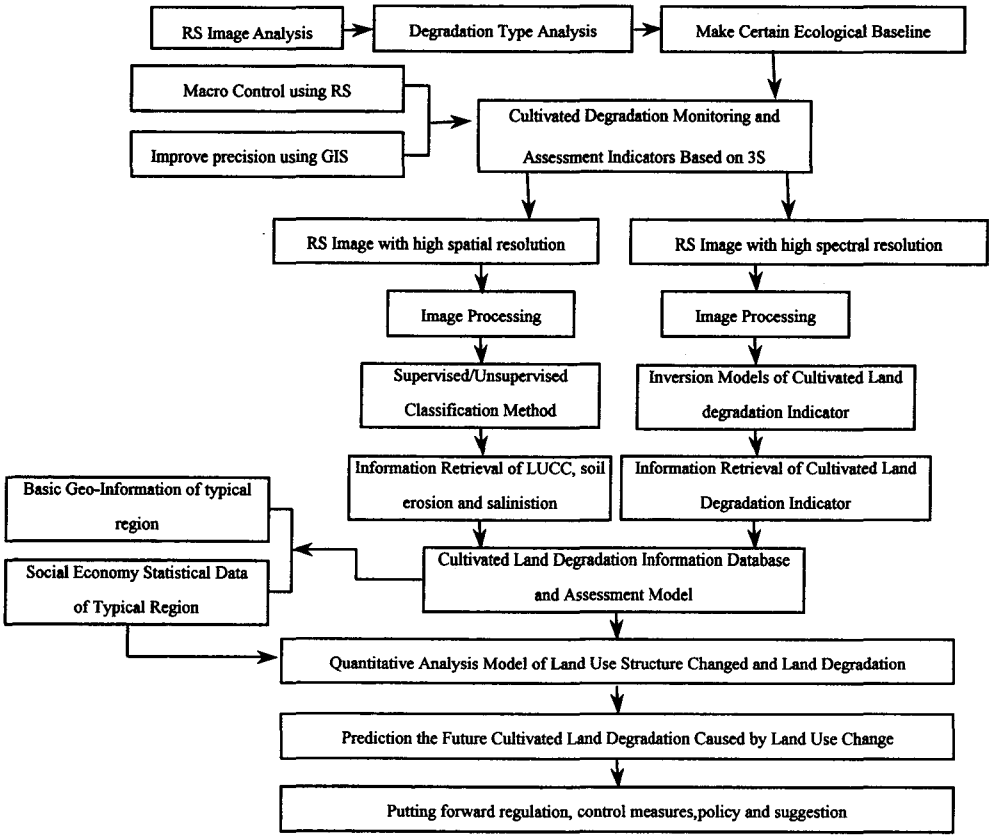

Fig.1 Technology flow chart for the cultivated land degradation monitoring and assessment

4. The route research of 3S-based degraded farmland monitoring and evaluation technology

(1). to set up degradation monitoring and assessment indicator system of cultivated land based on 3S technique

To analyzed various environmental, social and

geographical factors in China. (The factors included ecological environment in different areas and characteristics and differences of economic conditions); to study cultivated land degradation types in different regions; to analyze various RS data with different space-time resolution and hyperspectral RS data; to examine the typical spectral feature change reflected by various degradation type; to set up degradation monitoring and assessment indicator system of cultivated land based on 3S technique.

(2). to assure the space-time scale of relative benchmark of farmland degradation in the research sites.

Farmland degradation is the changing of relative benchmark. The verification of benchmark is the foundation of objective degradation assessment. The benchmarks include the primary and final benchmark of degradation. Commonly, a farmland quality from a certain time represents the elementary status. The benchmark for the theories of degradation and recovery is difficult to be directly confirmed. Due to the accumulation of information and human-affected time cycle, we chose late 70s as the benchmark time period for farmland degradation to get the elementary information of farmland quality.

(3). to obtain farmland degradation information by using RS and GIS technique in research site

a) To conduct research on soil erosion and salinisation information extraction method from high spatial resolution RS data

Based on different sources of RS data, we select late 70s as benchmark period for ecological environment and choose four different temporal data between 1980 and 2000. We could synthetically analyze the existed technique and technology of degradation information acquisition by using of RS image processing and GIS software to integrate RS data and field investigation information on the basis of the founded indicator system. We could also study how different sources of data reflect soil erosion status and salinisation level under different timings. We could acquire the changing and degradation state information via Supervised and Unsupervised Classification.

b) To conduct research on information extraction method of farmland desertification, fertility declination and pollution based on hyperspectral RS data.

We used high spectrum remote sensing data in our research. According to the soil maps, we located the central position with GPS. We examined the parameters (soil organic matters, heavy metal or organic pollutants and soil granule) that are reflected from the spectrum property of soil. We built a farmland degradation model by applying multiple statistics analysis technology, optical model and the technique of analyzing variable spectrum positions, as well as the examination of field data. We gathered the data of earth matter's spectra reflectance and farmland degradation index to test our model's parameters and to correct any mistake. We could

compare the model's parameters and different types of parameters spatiality distributing map with the state of farmland degradation in the research sites and to make a quick and ration monitoring for farmland degradation.

(4). Set up a 3S-based farmland degradation information bank

The information bank includes the data that was collected with using the above techniques and RS-based image processor, and GIS-based statistical information for topography, biology, physics and social economy. We built a 3S-based technical farmland degradation information bank in support of professional knowledge system.

(5).Originated a quick and ration technique to assess farmland degradation

A) Researched a 3S-based farmland degradation evaluating model

Gathered and analyzed the data of farmland degradation in typical areas. With the aids of field works, farmland degradation monitoring and evaluation index system, and usage of regression analysis, mistiness judgment, professional knowledge and model, we could set the index into different rational grades. After we assure the index and its weight, we built a model of farmland degradation rational evaluation.

B) Researched on the technique of evaluating farmland degradation ration.

We could carry on a farmland degradation evaluation on the information, which is spatially continuously distributing, by using the evaluating model of farmland degradation, the evaluating methods of the integrated analysis of integrated index, gray evaluating technique, never cell evaluating method and the information bank of farmland degradation. By combining the information from ground investigation and comparing the farmland degradation in various timings, we are able to get the information of the tendency of farmlands that are spatially continuously distributing in research areas.

(6) The effect of quantitative analysis of land use in farmland degradation

We combined the qualitative and quantitative analysis and used the changing, nature, society and economy information from the farmland degradation bank to analyze how different combinations and varieties of natural characteristics affect farmland degradation.

5. Conclusion and suggestion

(1) There is a great prospect in applying 3S technology to inspect farmland degradation. The application of new technology in land is going to deeply influence the ecological environment. The new technology also has certain scientific importance in promoting coordinated development of regional population, resource and environment with social economic.

(2) We still need to conduct further research on integrated usage of 3S technology in farmland degradation.

Moreover, we need an appropriate application of remote sensing and suitable index system of inspecting farmland degradation and evaluation. It is also necessary to improve the precision, speed and deepness in the research on monitoring of farmland degradation and evaluation. The future tendency is to synthetically apply 3S technology in researches on farmland degradation, rational monitoring and evaluation.

(3) This research points out the paths of 3S-based technology in the monitoring of farmland degradation and evaluation, as well as some need-to-be solved theories and techniques. Our research talks about the monitoring of different degradation types and evaluation methods that composite farmland degradation theory, integrated usage of 3S technology, running out of water and soil in farmland, desertification, salinaization and fertility declination.

(4) Based on 3S technology in monitoring farmland degradation and evaluation, integrated analysis can affect land use, and the natural, environmental and social economic factors of farmland degradation. We chose various types of farmland degradation index that has typical spectrum property to set up a 3s-based index system for farmland degradation monitoring and evaluation. We stated the 3s-based techniques of obtaining farmland degradation information to create a 3s-based farmland degradation model and an evaluation method. Through scientific pathways, we can gather the mechanism of different essentials in farmland degradation and land use by further investigating the origin, category and level of farmland degradation, ration analysis of land use and ecological effect of farmland degradation. Policy, suggestion and controlling arrangement can be established after understanding all the information of the mechanism, and structure and effect of its driving force.

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