

RESEARCH ON ASSESSING THE PROGRESS TOWARDS SUSTAINABLE DEVELOPMENT SUPPORTED BY THE GEO-SPATIAL INFORMATION TECHNOLOGY

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ABSTRACT:

In China, sustainable development (SD) has been confirmed as one of the two basic strategies (the other is “developing through science & education”) for national development. How to translate it into several concrete, executable and assessable standards is an essential question for SD to be effectively implemented. In this study, a concept framework and an index system for regional sustainable development evaluation supported by geo-spatial information technologies, were built based on some essential achievements attained domestically and abroad such as Human Development Index (HDI) and ecological footprint. Then, an Evaluation Information System for Regional Sustainable Development (EIS/ RSD) was produced based on this concept model, the index system and their algorithms. With the help of Geo-spatial information technologies and the EIS/RSD, dynamic analysis and assessment of progresses toward SD in 32 provinces, seven main districts and three main zones of China are attained, using time serial statistic data, vector data and remotely sensed images. The concept framework of regional sustainable development assessment, its index system and the development and applications of EIS/RSD are discussed in this paper.

1. INTRODUCTION

In the last three decades, sustainable development (SD) has been proposed and promoted as a new development model. In China, SD has been confirmed as one of the two basic strategies (the other is “developing through science & education”) for national development. Regional sustainable development can be interpreted as the consumptions of resources which are within a region’s ecological carrying capacity., the assessment of the current situation is a prerequisite to achieve regional sustainable development. Until now, studies on SD have been mainly focused on two domains, one is the concept and theory of SD and the other is the effectively realizing processes of SD, while few studies were carried out on evaluation methods of SD.

Recently several investigations have been devoted to the evaluation methods of SD. Several studies are presented as the following: Yewenhu et al. assessment and a set of evaluation indexes of SD (1996), Wackernagle et al. Analysis National Capital Accounting with the Ecological Footprint Concept (1996), Niuwenyuan et al. Sustainable Development Stratagem Report in China (2000), Zhangzhiqiang et al. the footprints of 12 provinces in the western China (2001). In those studies, some index systems and expressing methods were applied to carry out quantitative researches of SD.

Recently the application of Geo-spatial information technology in SD assessment, has gained great attention, mainly because the conventional statistic methods cannot satisfy the requirements of SD assessments. On one hand, remote sensing technology plays an essential role in data collecting. The evaluating object of SD is the human-resource-environment-economy system, which has regional and dynamic features and complicated data structure and functions. Remote sensing

technology, is an important data resource of SD assessment, it can provide spatial information and basic parameters integrally, continuously and quickly. Therefore, the introduction of the remote sensing technology could change the current investigation methods of natural resources, which mainly depended on regular statistics and thus has a long data updating cycle. On the other hand, the Geographic information system (GIS) is an effective tool for spatial data managing and analysis. It can provide SD assessment with several functions such as data fusion from multiple sources and in multiple formats, information management, comprehensive analysis and visualized expression.

A concept framework and an index system for region sustainable development evaluation supported by geo-spatial information technologies, such as remote sensing, geographic information system, were built, and an Evaluation Information System for Regional Sustainable Development (EIS/ RSD) was produced based on the investigations of the theories, index system and evaluation methods of SD. With the help of Geo-spatial information technologies and the EIS/RSD, dynamic analysis and assessment of progresses toward SD in 32 provinces, seven main districts and three main zones of China are attained, using time serial statistic data, vector data and remotely sensed images. In the following sections, the concept framework, the index system, the EIS/RSD and the main productions obtained by the evaluation system will be discussed respectively.

2. CONCEPT MODEL

In order to dynamically assess the progresses towards sustainable development of different regions in China, a

concept model of regional SD assessment, using high space-time resolution remote sensing satellites as important data sources, was built based on some essential achievements attained domestically and abroad such as Human Development Index (HDI) and ecological footprint. The concept model was shown in Figure1. In the concept model development and sustainability were used as two primary criteria to evaluate the regional SD situation. Human Development Index, which including health and life span, education and living conditions., was used to evaluate development. Ecological remainder, which measures ecological carrying capacity, was used to assess sustainability. Human Development Index and ecological remainder were calculated by using the regional time serial statistic data of society and economy and thematic information

of remote sensing satellites. The progress towards sustainable development of different regions could be evaluated and classified into different types according to the indexes and their variations. As a result, the decision-makers could adjust their courses, policies, relative plans and measurements to guarantee the ruled regions' sustainable developments. The concept model exhibited the main processes of regional sustainable development evaluation, the types of data and some essential concepts used in the processes. From the concept model, people can learn an outline of the SD evaluation. The technology steps/courses are shown in Figure 2, which are applied to realize the concept model into the evaluation system. Figure 2 demonstrates concretely how the evaluation was carried out step-by-step.

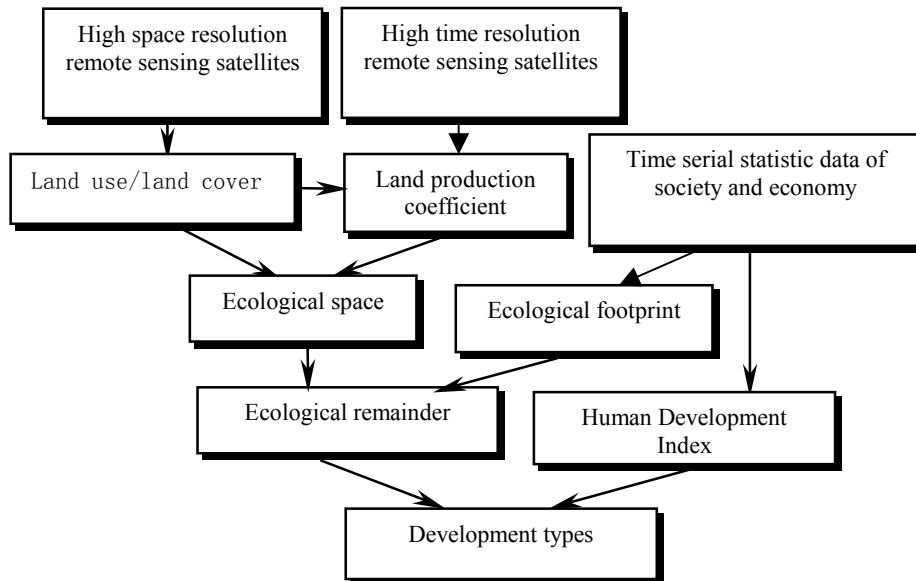


Figure 1. concept model of regional sustainable development evaluation

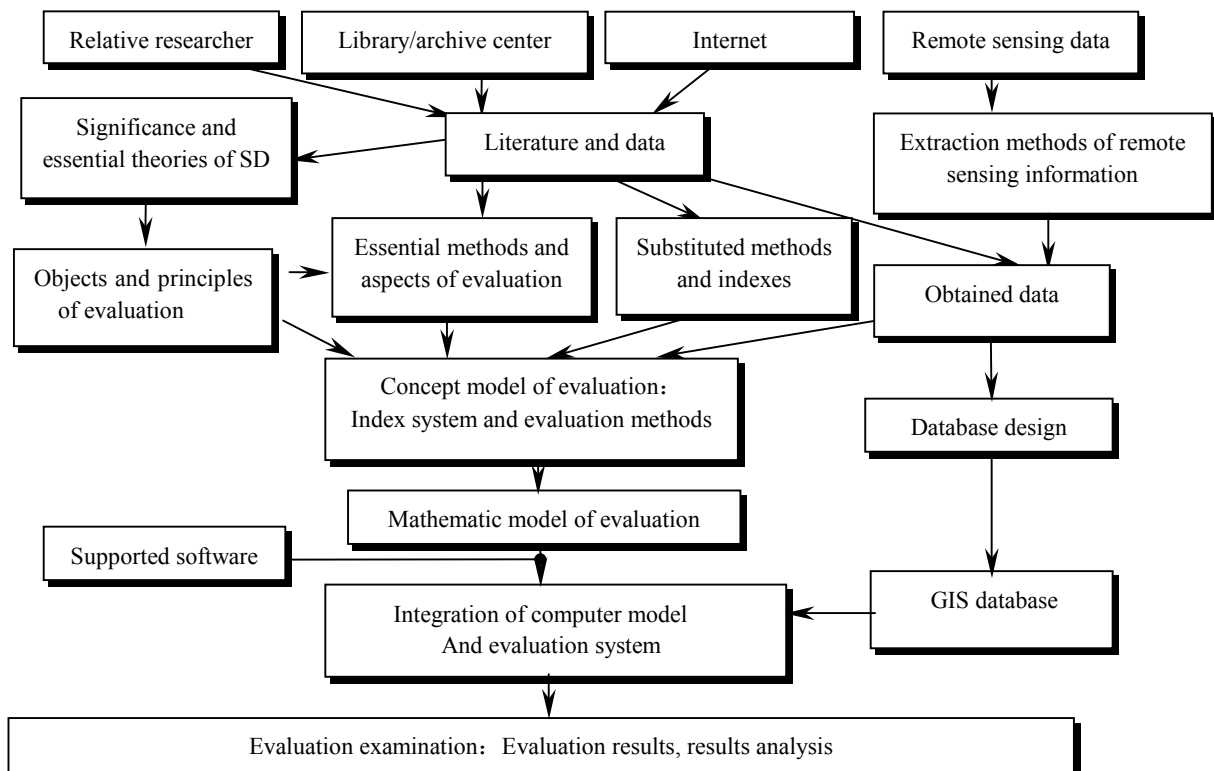


Figure 2. The technologies courses of regional sustainable development evaluation

3. INDEX SYSTEM

An index system with a pyramid shape was built from top to bottom, based on the analysis and comparisons of several kinds of index systems and assessing indexes of sustainable development evaluations. Compared with the currently prevalent matrix index systems, the index system used in this study is cascading and relatively simple and the relations among its indexes are more explicit. The basic principles used to build this evaluation index system are: 1) using as less assessing indexes as possible, and 2) improving the indexes' handle abilities. According to the principles, an index system was built and shown in Figure 3, in which Human Development Index and ecological remainder, which reflected the difference between ecological space and ecological footprint were used as the two top indexes. Human Development Index consisted of 3 indexes: life span expectancy, education and living conditions. It evaluated development from social and economic factors, and reported results more comprehensively and objectively than GDP, which conventionally used to assess economic growth. Corresponding data could be obtained from various national

statistic annals. Ecological remainder, which measured ecological carrying capacity, was used to assess sustainability. The mechanism of its calculation was to compare available ecological areas with carrying ecological areas, which was converted from the pressure for China achieving SD, such as population expansion, resources exhaustion, and environment pollution. The difference between the resources background in a region and natural resources human used to maintain their lives in the region reflected the relation of how much resources human exhausted and how much they owned. The calculation of ecological remainder was based on two factors: ecological space and ecological footprint. (Ecological Remainder=Ecological Space - Ecological Footprint) Ecological space measured the resources background in a region. Ecological footprint measured how much natural resources human used to maintain their lives. It was hard to obtain ecological space by conventional investigation. Fortunately, it can be obtained from the images taken by high space-time resolution remote sensing satellites. There were some great achievements in calculating ecological footprint. Therefore, it could be attained in mature methods.

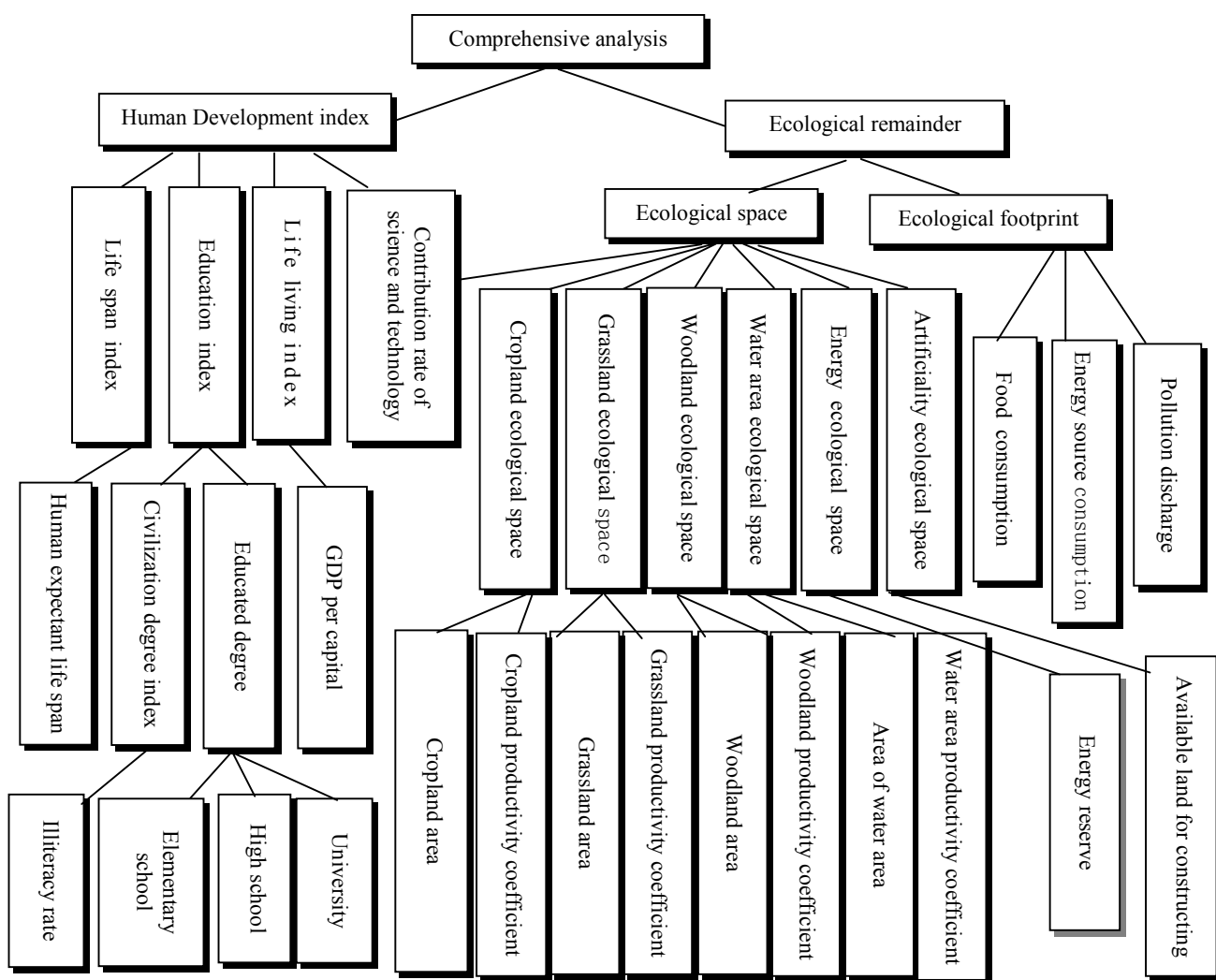


Figure 3. Index system of regional sustainable development assessment

4. EIS/RSD

Evaluation Information System for Regional Sustainable Development (EIS/RSD) was developed based on this concept model, the index system and their algorithms. The functions of EIS/RSD were shown in Figure 4. The EIS/RSD consisted of 7 modules: data management module, region culling module, basic indexes calculation module, HDI calculation module, ecological deficit calculation module, comprehensive analysis module and results output module. These 7 modules provided a serial of functions respectively: data updating, region culling, indexes calculating (including HDI calculating and ecological remainder calculating etc.), comprehensive analysis, thematic mapping, etc. The sequence from the left to the right in Figure 4 reflects the process of the sustainable development evaluation. That is, when regional sustainable development is evaluated, an object is firstly selected from China, the 32 provinces /or cities, three zones or 7 economical areas. Then, relevant data such as its basic indexes, HDI and ecological remainder can be calculated. Based on the calculations, comprehensive analysis of sustainable development situation in each evaluated unit is carried out, in which the most important step is mapping the HDI-ecological remainder processing curve of each evaluated unit and analyzing its type, feature and developing trends. Therefore, the sustainable development situation can be evaluated on the basis of the characteristics of each evaluated unit, which aids the adjusting and controlling measurements by providing scientific evidences. Concrete explanations of the 7 modules are presented below.

1. Region culling module was used to select evaluated regions. In this study, China was measured as three zones, 7 economical areas and 32 provinces/cities by different units according to administrative functions and subordinate relations. Corresponding administrative bound maps were stored in the EIS/RSD system in vector data format.

2. Basic indexes calculation module was one of the two main modules of the system (another was comprehensive analysis assessment module). In this module, life span expectancy index, education index, living conditions index, contribution rate of technologies, yield adjustment factor, ecological footprint and ecological space were calculated.

3. Human Development Index calculation module was used to calculate Human Development Index, which reflected sanitation and health situation, education degree, economic development and living conditions in a region.

4. Ecological remainder calculation module was mainly used to calculate the total ecological footprint, total ecological space and total ecological remainder. The total ecological footprint was calculated mainly by using time serial statistic data, and the total ecological space could be obtained from the

images taken by high space-time resolution remote sensing satellites. Ecological remainder, which measured ecological carrying capacity, was used to assess sustainability. It reflected the pressure that human being faced and its tolerance.

5. Comprehensive analysis and assessment module was the hard core of the EIS/RSD. It provided 9 models for multi-indexes analysis: static classifying, dynamic classifying, comprehensive assessment, regions ordering, regional stabilization analysis, regional development trend analysis, regional development conditions analysis, developing trace, and statistic analysis. At the same time, dynamic parameters, such as regional

development speed, development conditions, stabilizations, development trend, etc. were introduced into this module. Two analysis methods were used: one was static data analysis, which can provide analytical results instantly, the other is dynamic data analysis, which can provide analytical results based on processes.

6. Files management module and results output module were used to call both vector/raster data and statistic data separately or together, and to open, store, print and close files. Visual expressions such as thematic maps and report forms were applied in results output.

5. APPLICATIONS AND DISCUSSIONS

Supported by the EIS/RSD, a serial of basic assessing results such as life expectancy index, education index, living standard index, HDI, ecological space and ecological remainder of each province in China from 1986 to 1998 were obtained. Using the HDI as the X-axis and the sustainability index as the Y-axis, a coordinate system of SD assessment was built and the current situations of SD could be classified into 8 types. The results showed the basic situation of SD in China. Further analysis revealed a few important phenomena and rules.

First, the HDI of China increased dramatically from 1986 to 1996, however, notable differences among regions and obvious space diversity phenomenon in geographic distribution still existed. Average increase in HDI was 0.1232 in ten years, from 0.5494 (1986) to 0.6726 (1996) with a relatively increasing rate of 22.42%. With such a rate, the average HDI value will reach 0.8 in the following 10 years, which is beyond the high developing index line that was prescribed by UNDP. The increase in HDI descended from southeast coast to northwest inland, the seven provinces/cities with the biggest increases in HDI were all located in coastal areas except Liaoning province and Guangxi province, whereas the 10 provinces with the least increases in HDI were all located in northwest, southwest and Huabei regions.

Second, although the value of HDI in China increased from 0.5494(1986) to 0.6726(1996), the ecological remainder decreased from 0.0209 hectares per capita to -0.0027 hectares per capita. It indicated that the pressure from human being was beyond the ecological capacity and the ecological foundation was weakened with the development of society and economy. The provinces with low ecological remainder were concentrated in a triangle region whose three vertexes were Liaoning, Guangdong and Qinghai province, including the regions with low ecological space mainly in the Yellow river drainage areas and the regions with high ecological footprint mainly in the Yangtse River drainage areas and southeast coast. However, Jiangxi province is an exception, whose ecological remainders were both relatively high in 1986(0.1492) and 1996(0.1063). In this triangle region, besides Jiangxi province, there were only three provinces, Guangxi, Zhejiang and Shandong, whose ecological remainders were positive, but the values of the ecological remainders were very low. The ecological remainders of the provinces outside this triangle region were all positive.

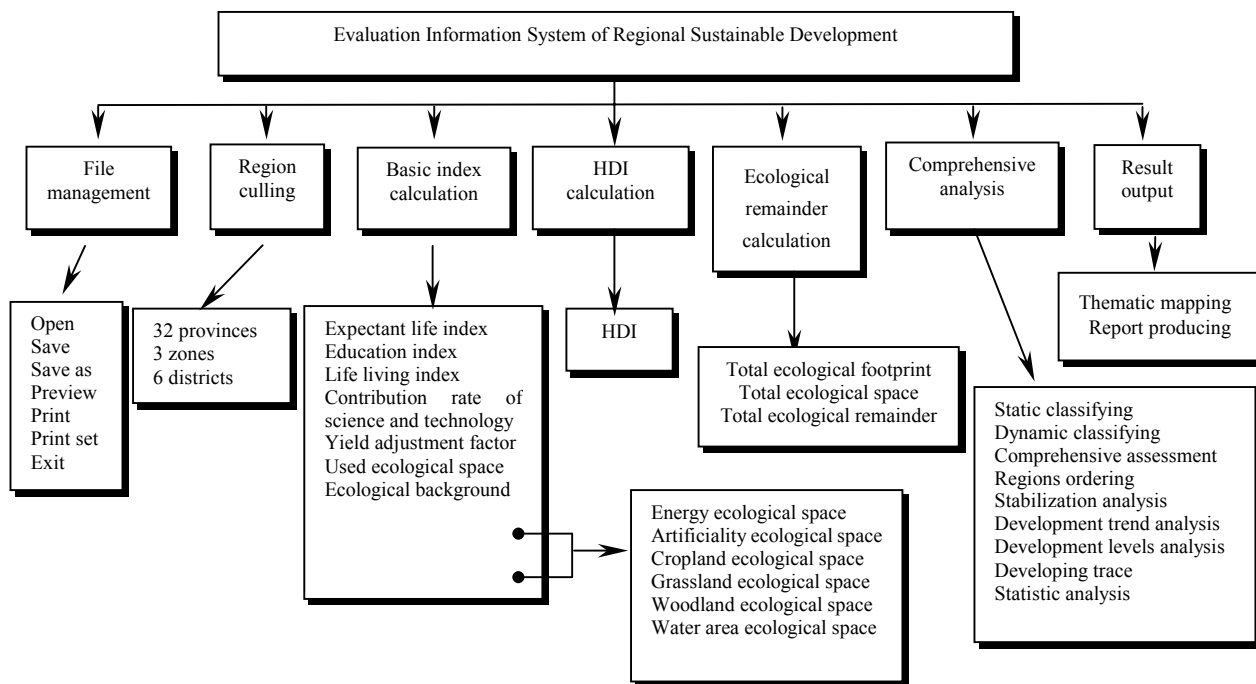


Figure 4. System Function of EIS/RSD

Third, Figure 5 shows obvious space diversity phenomenon in geographic distribution in the regional sustainable development comprehensive assessment of China in 1998, which was carried out by using the AHP method to calculate the weights of different indexes that indicated the priority of the development. The spatial distribution of sustainable development conditions was similar to the pattern of the distribution of the three zones of China and the values of progress towards sustainable development descended from east to west in a stripe shape. The main reason may be related to the high levels of technology and education in the developed coastal regions and the northwest regions, which expanded the scope of natural resources' utilizations and improved the efficiency.

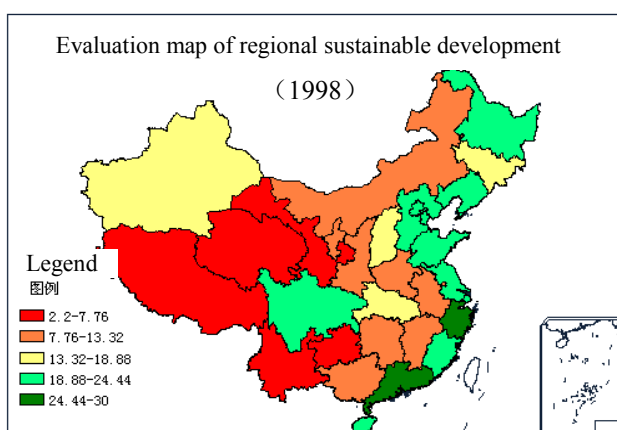


Figure 5. Assessment of Regional Sustainable Development in China

Last, the increase of HDI and the ecological remainder in each province were not statistically correlated, which indicated that there was no necessary relation between the pace of economic

development and sustainability, and what really affected sustainability was the mode of development and consumption.

With the support of Geo-spatial information technology, we developed EIS/RSD to a dynamic, quantitative, and continuous system. EIS/RSD has made the SD assessment in 32 provinces, seven districts and three natural zones of China one step further. However, the establishment of its measurement standards and the processes of regional SD assessment are quite complicated. The present system should be improved in various ways, such as: i) combining administration divisions with nature divisions and establishing different assessment index systems for different regions, because of the great differences among regions in China and the different factors that restrict the social and economic development; ii) reinforcing the study on the relationships between society, economic and ecologic carrying capacity, and research of remote sensing data-mining by using space information analysis technology, and extending the scope of remote sensing used in the study of regional SD; iii) improving the assessment system, forming a flow-driven assessment platform, enhancing real-world interpreting capability of computer system, building a spatial decision support system of regional SD.

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