

Editorial

Towards Sustainable Land Use in China: A Collection of Empirical Studies

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Abstract: Achieving sustainable land use is one of the most important ways to achieve regional socio-economic sustainable development. We have collected 12 papers in this special issue “Sustainable Land Use in China” to show the varied application of sustainable land use studies and to provide meaningful decision-making information and policy implications for land use planners. We summarize the contributions to this special issue on sustainable land use and place them in perspective. Several studies focus on sustainable urban land use, some focus on sustainable rural land use, and others on environmental issues on land use. These studies have analyzed a broad array of topics related to land use, including the dynamic changes and driving forces of land use spatial patterns, sustainable land use, land use policy and optimization, and the environmental problems related to certain types of land use.

Keywords: sustainable land use; land use policy; ecological sustainability; economic sustainability; social sustainability

1. Introduction

Land use is widely understood as a manmade adjustment of the land surface and has a crucial role in shaping ecosystem functions [1]. With the advent of rapid urbanization, rural transformation, and the development of modern agriculture, a number of issues (e.g., cultivated land degradation, unsuccessful transfer of cultivated land, low efficiency utilization of urban construction land, and soil degradation and contamination) arising from rapid economic development and urbanization in China have generated wide international attention [2,3].

Currently, the concept of sustainable development has been widely accepted around the world; this concept emphasizes efficient use of resource. Regarding land resource in China, the astonishing waste of land and environmental pollution incidents with respect to land use have threatened to increase land use efficiency [3,4]. Therefore, effectively solving the problems in the process of allocating land uses and achieving sustainable land use is vital to realizing sustainable development in China where conflicts between people and land are serious. The concept of sustainable land use derives from the concept of sustainable development, which was proposed in the early 1990s and emphasizes the requirements of meeting the development needs of both contemporary people and future generations [5]. Similarly, we should protect the terrestrial ecosystem to meet the needs of future generations while making the best use of land resources to produce as much economic output as possible. Therefore, we should adopt reasonable land use methods, such as optimizing land resource allocation, fallowing some cultivated land to maintain high agricultural production capacity, protecting the terrestrial ecosystem, and alleviating land pollution, etc. However, there are various conflicts of interests among related stakeholders (e.g., government, enterprises, and farmers) that have hindered

the implementation of policies related to land protection. In addition, the existing land use problems vary greatly in different regions due to differences in their society, economy, land policy, etc. Therefore, an important pre-condition of achieving sustainable land use is to have an overall understanding of the main problems related to land use, the regional differences regarding land use and the driving forces of dynamic change of land use patterns [6].

This special issue has collected 12 papers concentrating on issues of “sustainable land use” in order to illustrate the main problems in the land use management process and analyze the dynamic change of land use and its driving force with the goals of finally raising land use efficiency, saving precious land resources, improving land environmental quality and accelerating the achievement of sustainable land use. The remainder of this paper is organized as follows: Sections 2–4 review the contribution and conclusions of the articles in this issue from the perspectives of sustainable use of urban land, sustainable use of rural land and main environmental issues in land use, respectively; Section 5 summarizes the relative advanced methodologies for analyzing land use issues; and Section 6 concludes with some suggestions for future studies.

2. Sustainable Use of Urban Land

Analyzing the dynamic changes of land use spatial patterns and their driving forces is an important prerequisite for sustainable land use. Li and Liu [7] suggest that in order to achieve the sustainable development, it is necessary to analyze the spatial and temporal characteristics of regional land use and explore its driving factors, especially for developing countries. They find that dramatic land use conversions have taken place in Tianjin City in China. In the four years 2000, 2005, 2010, and 2015, built-up areas of the city have been increasing, and the cultivated land has been shrinking, which means the continuous loss of fertile land. In addition, the landscape pattern also changed significantly in this city, the landscape fragmentation of cultivated land is becoming more and more serious, making it harder to make large-scale use of cultivated land. Additionally, the use of urban built-up area has faced the similar problem, which results in an incredible waste of valuable land resources. This is mainly due to irrational urban development planning. More importantly, the land policies of the local government have exerted very important impacts on land use change in this city. Therefore, the local governments must formulate reasonable and targeted land use policies, effectively protect arable land resources, and improve the efficiency of cultivated land use. At the same time, local governments should limit the frequent conversion of cultivated land for non-agricultural production activities to avoid the potential dangers of a food crisis.

Additionally, Hasan et al. [8] argue that, in many countries and regions, the land resource is scarce and tend to be in short supply; it is difficult to meet the needs of urban expansion and further development. In some extreme cases, the problem of land misallocation has threatened sustainable development. Therefore, it is necessary to analyze the dynamic and spatial pattern of land use and land cover change. In order to provide scientific policy advice to the land management department, they have established a comprehensive method of forecasting land use patterns. In the empirical analysis, they used the dynamics of land systems (DLS) model to predict the land use and land cover changes in Bangladesh from 2010 to 2030. The results show that the urban land expansion in Bangladesh and the decrease of cultivated land resources are very common. However, under different assumptions, the variation of land area varies greatly. They argue that the land administrative departments need to carefully design reasonable land use plans, and make timely adjustment of land use in order to protect the precious land resources and ecological environment and achieve the sustainable development of the country.

Regarding the driving forces of the spatial pattern change of urban land use, Zhao et al. [9] have analyzed the effect of urbanization and farmland transfer on the spatial patterns of non-grain farmland (NGF) in China. They found there are significant regional differences in the NGF region due to unbalanced urbanization. In 2000, the urbanization rate has caused a significant impact on the NGF area, but in 2014, this effect is not significant. In addition, the proportion of the secondary industry in

the region's overall GDP and the proportion of the tertiary industry in the region's overall GDP also have exerted significant impacts on the NGF area, and this impact in 2014 is the largest during the study period. Similar to the urbanization rate, the per capita income of rural households has caused a significant impact on the NGF area in 2000, but this effect is not significant in 2014. In addition, the number of agricultural employees and the total power consumption of agricultural machinery also have significant impacts on the NGF region.

Additionally, many factors, such as social (e.g., income gap), economic (e.g., gross domestic product and per capita GDP), demographic (e.g., population growth and population migration), and governmental urban development policies (e.g., land use policy) will have significant impacts on the spatial pattern of urban land use [7]. Based on the empirical analysis in several regions of China, Li and Liu argue that the driving factors leading to the change of land area and land area of urban construction have obvious differences in different periods and regions. They further divided the study period (2000–2015) into three stages, with the first stage from 2000 to 2005, the second stage from 2005 to 2010, and the third stage from 2010 to 2015. Specifically, in the first stage, among the influencing factors, the fixed asset investment has caused the greatest impact on the change of urban construction land area. Urban population and gross national product have exerted the greatest impact on the change of urban construction land area in the second and third stages, respectively. At the same time, the factors affecting the change of cultivated land area the most are the permanent population and gross national product of the city. Therefore, it is necessary to consider the difference between time and region when analyzing the driving factors of the dynamic change of land use pattern.

A comprehensive evaluation of sustainable urban land use is an important work that adds to a more complete understanding of regional land use and provides useful information for land use planners. Wong et al. [10] argue that assessing sustainable urban land use is a meaningful work, especially in areas where land is extremely scarce. They use Hong Kong as an example and conduct an empirical analysis to assess the sustainability of the dynamic changes of impervious surface in 1995 and 2015 based on analyzing satellite images and the linear spectral mixture (LSM) model. The results prove that the land use policies of local government are effective to maintain sustainable land use in Hong Kong. The authors suggest that increasing land supply by reasonable conservation of the country's parks, mountains, and coastal protection areas is a very important and urgent work, which can effectively solve the problem of the shortage of land that is brought by rapid population growth. One of the specific strategies is building more pencil-thin buildings with extremely high density, which can effectively save space. Another important strategy is reclamation, which can effectively increase land area. These two strategies are proved to be very effective in the short term, though targeted improvements are needed in the long run. Therefore, land use policies need to make dynamic changes according to the actual situation. In addition, the land from reclamation requires a relatively long time of period for consolidation to improve its availability and stability.

As Xie et al. [1] suggested, making reasonable land use policies and implementing them are the most important guarantees of the realization of sustainable land use. Regarding the issue of urban land use policy and optimization, Yan et al. [11] argue that, in many regions across China, the local governments does not implement efficient utilization of land, which has caused a serious waste of land resources. Therefore, how to improve the urban land use policy to optimize the land use efficiency is an important issue. They suggest that the land management department should design reasonable plans to optimize land allocation and improve land use efficiency according to the different functions of land use and the actual demand of urban development. They take the Haidian District in Beijing as a case study to develop a comprehensive framework to assess the overall demarcation of functional units for land consolidation and conduct an empirical analysis to demonstrate this framework. They suggest that the proposed model enables local governments to achieve sustainable utilization of land resources as much as possible. The comprehensive index system has incorporated many indicators from perspectives of production, human lives, and ecological properties of the land parcels.

More importantly, ensuring the full implementation of land use policy is the main guarantee of the realization of sustainable land use. Based on an empirical analysis, Wu et al. [12] have found that large-scale expansion of cities is now a very common phenomenon, which leads to many urban development problems, especially the problem of the shortage of land resources. This issue also hinders increasing land use intensity and realizing the sustainable utilization of land. They analyze the spatial and temporal changes of typical characteristic factors in the process of urban development in the past 50 years since 1964, taking Hangzhou City of China as a case. They find that land use policies on urban planning have failed to perform effectively in Hangzhou and, thus, the policies have caused inefficient land use. Thus, to achieve sustainable land use, we not only need to develop reasonable land use policies, but we also need to ensure the full implementation of these policies in practice. In addition, setting the ecological red line is necessary and urgent, which follows the technical guide initiated by the Ministry of Environmental Protection of China in 2015. The ecological red line is the bottom line of ecological security, and its purpose is to establish a strict ecological protection system and put forward high regulatory requirements on the ecological function protection, environmental quality and safety and the use of natural resources, so as to promote the protection of ecological environment while promoting social and economic development.

Regarding the popular issue of “Land fragmentation”, which has been present in China for thousands of years, Liu et al. [13] argue that the fragmentation of land resources in most Chinese cities is due to the scarcity of land resources and the long period of irrational urban development. In fact, in most of China’s cities, the phenomenon of fragmentation of urban construction land is widespread, and the fragmentation of residential land is the most serious, which has seriously hindered urban sustainable development and brought a lot of difficulties to the planners of urban development. Based on empirical analysis, the authors argue that, there are many factors contributing to the serious fragmentation of urban residential land. Among them, the rapid development of urban tertiary industry and the irrationality and variability of urban development policies have exerted greater impacts. Therefore, in the future urban development, planners of urban development must make rational urban development planning to effectively alleviate the problem of land fragmentation. The authors further propose that the land fragmentation should be incorporated into the evaluation system of quality of the urban development, because the “compact city” will be the mainstream of China’s future urban development pattern. Therefore, local governments can effectively improve urban development. The local government must make timely adjustments according to the actual situation, so as to effectively alleviate the problem of land fragmentation and improve urban land use efficiency.

3. Sustainable Use of Rural Land

Regarding specific ways to improve the efficiency of rural land use, proper conversion of land use is a good approach. However, conflicts of interest between stakeholders may hinder this work. Xie et al. [14] argue that it is necessary for local government officials to make some economic compensation to farmers when they want to promote farmers to give up the arable land that should be fallowed. However, it is important to determine a proper compensation standard, since a relatively high compensation would bring a large fiscal burden for local governments, and a relatively low compensation would discourage farmers from fallowing arable land. Based on the field investigation of Hengshui County of Hebei Province in China, the authors put forward a reasonable compensation standard using a famous Cobb-Douglas production function model. The empirical results show that the reasonable compensation standard is 0.00095 \$/hm² that can make most of the surveyed farmers accept a winter-wheat-fallow policy.

Xie et al. [14] also stress the importance of improving the efficiency of cultivated land use and increasing grain production because China has the largest population in the world and it is necessary to ensure the food supply. Zou and Wu [15] have analyzed cultivated land use and food security issues, and they state that obtaining the spatial information of grain production in the face of China’s food security problems is one of the important ways to achieve the sustainable utilization of cultivated land

resources. They find that, at the county level, plains counties have much greater grain output than hill counties and mountain counties. The reason is very simple, plain counties enjoy more arable land area, and the quality of farmland and irrigation facilities are much better than those in hill counties and mountain counties.

Ren et al. [16] further discuss the issue of land property rights in China. They argue that poor land transfer is an important reason for inefficient land use, especially for the cultivated land in rural areas. They argue that in order to achieve successful land transfer, the local government should effectively improve the land tenure reform, especially in rural areas of China. More importantly, the main reason for unsuccessful land transfer is that participants (e.g., local governments, farmers, and land developers) tend to be unwilling to cooperate with the implementation of the policies due to their conflict of interests. Therefore, how to properly coordinate the conflict of interests among the participants and achieve the equilibrium is the most important problem. Local governments should first respect the wishes of farmers, then design reasonable land transfer norms, and promote the establishment of the land circulation market as soon as possible.

4. Environmental Issues in Land Use

In recent years, environmental pollution incidents have frequently occurred in the process of land use, and this has mainly been because people only focus on short-term economic interests [2]. Yang et al. [17] argue that environmental problems caused by chemical fertilizer abuse in land use might be an important problem that is easy to ignore. They assessed the negative impact of the misuse of fertilizer on the ecological environment and people's health. In the empirical analysis of China from 1990 to 2012, the empirical results show that the excessive use of chemical fertilizer has caused a great negative impact on people's health. Specifically, during the study period, the health costs caused by the misuse of fertilizers have increased by more than ten times, and the negative impact has obvious regional differences, the coastal provinces suffer a greater impact than western provinces. In addition, per capita GDP and arable land area are two main factors of the negative impacts.

Yan et al. [18] have conducted a thorough analysis of environmental problems during land use in a mining area. They argue that it is very important to evaluate the ecological environment quality of coal mine. In general, coal mining can cause great negative impact on the surrounding ecological environment. However, solving the problem of environmental pollution can bring a great deal of costs to producers and they have no incentive to take the initiative to protect the environment. Therefore, it is necessary for the local government to master the dynamic change of ecological environment quality and its driving factors. They construct a comprehensive evaluation index system based on the Pigouvian tax theory, the empirical results show that the coal surrounding ecological environment quality improvement is very slow and one of the main reasons is too little investment on ecological environment protection. Therefore, the local governments need to actively invest in environmental protection while they can expand investment through the establishment of cooperative projects and effectively improve the quality of ecological environment around coal mines in the short term.

5. Methodologies for Analyzing Land Use Issues

The field of sustainable land use includes many hot topics (e.g., the dynamic changes and the driving forces of land use spatial patterns, the evaluation of sustainable land use, land use policy and optimization, improving the efficiency of land use and alleviating environmental pollution in the land use process) [19]. Therefore, improving research methods are essential to effectively analyzing the issues and providing policy implications. The studies in this special issue have proposed diverse methodological approaches to analyzing land use issues. Below are some meaningful and innovative research methods.

Simulating the dynamics of the land system is essential work for developing an intuitive understanding of land use change [20]. Zhao et al. [9] have developed a dynamics of land systems model (DLS) and a number of factors from many related models are included. The DLS model is a

widely used simulation model of the land system. The DLS model has two important features: First, at the regional level, this model can be used to analyze at pixel level and the important issue of land use and land supply. More importantly, this model also can undertake many scenario analysis, simulation of a variety of different results. Second, the model also takes into account the spatial relationships of different factors. In the empirical analysis, the authors take Bangladesh as the research case and predict the future land use situation in three different situations. In particular, they also predicted the dynamic change of land use under the premise of protecting the ecological environment, thus this is conducive to the sustainable use of land resources in Bangladesh.

Regarding obtaining the data used in the empirical analysis, it is much more difficult to get data from field survey work than from public sources, such as statistical yearbooks or online communiqués. Ren et al. [16] have proposed a more effective method to obtain the data they need while carrying out studies in the wild. It is important for them to prepare a reasonable questionnaire beforehand. Then one can organize interviewees to ask specific questions. After obtaining the data, one should further analyze the effectiveness of the questionnaires and eliminate the invalid questionnaires, and then the data can be classified, which will facilitate the empirical analysis of the next step.

To conduct spatial analyses and statistical analyses of the dynamic change in land use patterns it is necessary to adopt and improve upon research methods in the field of spatial geography [21]. Li and Liu use several effective software packages to carry out spatial analysis, including ArcGIS 10.3 and ENVI 5.3 [7].

The change of land use pattern is difficult to analyze and predict because of the influence of many external factors, and multi-scenario simulation analysis offers a distinct picture of land use and land cover changes. Hasan et al. [8] state that in the analysis of land use and land cover change, we must perform multiple scenarios under different assumptions and analysis, so as not to make empirical analysis and reality deviate too far, and we can obtain reasonable land use policy suggestions. Specifically, in their case studies in Bangladesh, they propose three hypotheses, namely, the hypothesis of baseline scenarios, the hypothesis of an ecological conservation scenario priority and the hypothesis of the economic growth priority.

In order to better analyze the spatial change of land use, it is necessary to improve the visualization of empirical results, so that readers can easily understand the spatial change of land use. Liu et al. [13] have proposed a relatively better approach to calculate the change of the land type distribution based on ArcGIS 10.0 and FRAGSTAT 4.2. In the empirical analysis, they further analyze the dynamic change law of residential land on the temporal and spatial level, and the empirical results are helpful to analyze the influencing factors of residential land fragmentation, therefore, the land management departments can effectively improve the efficiency of residential land use.

In the process of allowing cultivated land to lie fallow, it is vital to mobilize the enthusiasm of the peasants so that they can cooperate with the government. From an economic point of view, Xie et al. [14] proposed an opportunity cost method based on the Cobb-Douglas production function model to estimate the appropriate standard of compensation price.

Regarding the evaluation of the effectiveness of land use policy, Wu et al. [12] have established a comprehensive index system that can analyze land use planning results from many aspects such as scale, structure, and pattern. Thus, we can carry out dynamic analysis on the actual effect of land use policy, and land use policy can not only find the gap with the actual demand, but also make the targeted improvement and improve the efficiency of land use. Similarly, Yan et al. [18] argue that it is very important to design a comprehensive index system to evaluate the dynamic changes of land ecological environment status. Therefore, we can observe the dynamic change of land use efficiency and find countermeasures to protect the land resources and its surrounding ecological environment to improve the land use efficiency. They suggest that the comprehensive index system should contain at least indicators from four perspectives, i.e., the status of land use, the status of water use, the status of waste emissions and the status of air quality. Therefore, we can make a dynamic evaluation of land use efficiency, so that the land management department can fully grasp the land use situation [18].

To assess impervious surface changes in sustainable coastal land use, Wong et al. [10] have applied an LSM (linear spectral mixture) model, which can describe the mixed compositions of pure endmembers. Specifically, the LSM model is used to calculate each fraction pixel. Using Hong Kong as a case study, this paper further uses an accuracy assessment model to quantify the evaluation results of sustainable land use, making the empirical results more credible and reliable. Additionally, the empirical results with quantitative conclusions can provide guidance to make improvements in land use policy and make those improvements operational. Therefore, empirical results based on the data obtained in this study are more credible than those based on statistical data, and these empirical results will be more instructive for the land management departments to improve the efficiency of land use.

6. Conclusions

The sustainable land use connotes the maximization of economic benefits and the maintenance and improvement of the surrounding ecology and environment in land use, which enables future generations to possess the same, or even better, land resource conditions as the current generation. The above connotations include the following three meanings: first, human beings possess only one common Earth, from a spatial perspective, and should adhere to the principle of mutual complementary and beneficial use in interregional land use. We should pursue the comprehensive benefits of land use rather than benefiting oneself at others' expense. Second, in the time dimension, considering future generations' land use efficiency, we should pursue land use efficiency rationally rather than "over drafting" land resources. Third, to ensure human survival and the sustainable land use, in addition to economic benefits, ecological and social benefits should be taken into full consideration during the process of land use, which means that the connotation of sustainable land use generally includes three aspects: ecological sustainability of land use, economic sustainability of land use and social sustainability of land use.

A core issue of the ecological sustainability of land use is the influence of modern land use on the potential productivity of land resources. Contemporary agricultural land uses are characterized by intensive cultivation, intensive planting, high input of chemical agents and frequent use of agricultural machinery, which result in problems, such as soil erosion, loss of nutrients, soil hardening, soil pollution, and damage to the productivity of land resources.

The economic sustainability of land use mainly focuses on the long-term interests of land users. One of the main issues is the sustainability of production. Land degradation and other environmental problems will change the bio-natural conditions of crop production and, thus, affect production. It is clear that the economic and ecological concerns of sustainability are interrelated, but we focus on future productivity and output rather than the natural resource, itself, here. Another important aspect of economic sustainability is the economic performance and profitability of land use.

Social sustainability of land use emphasizes meeting basic human needs (food, clothing, housing, etc.) and higher-level social needs, such as cultural requirements (security, equality, freedom, education, employment, entertainment, etc.). One of the major objectives of sustainable land use is providing adequate and reliable agricultural products (especially food) and other land products to meet social needs. In developing countries, providing adequate food and clothing and avoiding famine are usually the urgent requirements, which are the so-called issues of food security and population carrying capacity of land. In developed countries, meeting demands usually means providing adequate and various products that meet consumers' demands and preferences as well as providing a secure and reliable supply of those products. The concept of social sustainability generally contains a sense of equality, including equality among generations and equality within a generation. Equality among generations refers to reserving essential resources for future generations and protecting their rights and opportunities for gaining benefits from resource utilization. Equality within a generation refers to the equitable distribution of resource utilization and the benefits from production activities between countries, regions, and social groups. Land use leading to environmental degradation, which increases

the cost of production and environmental restoration, as well as the damage to other countries, regions, and social groups is considered to be unsustainable.

Land use patterns and land use changes are considered critical for sustainable development in developing countries. With the advent of rapid urbanization, rural transformation and the development of modern agriculture, China currently faces a number of land use challenges including, conversion of productive farmland to real estate development, excessive intensification of agricultural land, land degradation, farmland abandonment, emerging “hollow villages” and land fragmentation [19,20]. These competing interests have produced fierce land use conflicts and negative environmental impacts and threaten sustainable land development. As the largest developing country in the world, the key difficulty facing China is how to manage and balance the use of land from the perspectives of socio-economic development, food security and natural conservation. The eighteenth central committee of the Communist Party of China has recommended important strategies “to optimize the spatial pattern of land development, to build scientific and reasonable urbanization, agricultural development and ecological security patterns, as well as to delineate control boundaries for production, living and ecological space utilization”. To establish sustainable land use in China, it is essential to identify the major changes that are occurring in the use of land and their underlying motivators, control of the extensive expansion of developed land, protection of farmland and conservation land, regulation of unsustainable land use patterns and land use changes, improvement of land use efficiency and mitigation of negative environmental impacts. Despite the attention on sustainable land use in China, the extent of sustainable land use remains unclear. Its evaluation—the major obstacles to sustainable land use, and the tools that are available (e.g. market instruments, institutional innovation and policy reform) to establish sustainable land use in China—is equally unclear.

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