Toward a Sustainable Utilization of Land Resources in China: Problems, Policies, and Practices

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Abstract China's economy is growing explosively with double-digit rates of growth. However, behind the scenes of this economic miracle, a dark underbelly exists. The potential impact of the unsustainable use of land resources is increasing. Each parcel of land has a stationary geographic location, while its utilization is optional. The readjustment and optimization of land use patterns ought to be encouraged. Spatial reconstruction refers to the combination of various land elements, which can promote the rational and efficient allocation of land resources through a four-layer action framework: the development of unused land, urban renewal, ecological reconstruction, and spatial displacement. The feasibility and validity of these methods are illustrated by practical cases in different provinces in China. We thus propose that pursuing sustainable development and building an ecological civilization will be necessary for China in future decades.

Keywords Sustainable land use · Spatial reconstruction · Urban–rural development · Land use policy · China

INTRODUCTION

Sustainability has become the theme of our time (Wu 2010). In essence, sustainability refers to meeting the needs of the present generation without compromising the ability of future generations to meet their own needs (Brundtland 1987). The view of “human predicaments” proposed by the Club of Rome deeply shook the world and gradually prompted people to consider sustainable development. Extending sustainable development theory to the domain of land management, a new relationship between people and land—sustainable land use—has been conceptualized. In 1990, the Indian Agricultural Research Institute, United

States Department of Agriculture (USDA), and the United States Rodale Institute put forth the concept of sustainable land utilization for the first time at the land use symposium held in New Delhi. The concept was composed of two parts: the human–land relationship and human–human relationship generated by land. A widely accepted definition of sustainable land management was proposed by the United Nations Food and Agriculture Organization (FAO) in 1993. It involves the simultaneous achievement of the five objectives of productivity, security, protection, viability, and acceptability combined technologies, policies, and activities aiming at integrating socio-economic principles with environmental concerns (Smyth and Dumanski 1995). In that way, sustainable land utilization can be manifested as how the optimal solution for the triangle model is sought based on the unification of social economy and environmental effects (Yang et al. 2009).

Land is an essential resource for humans and our means of production for existence and development. The efficient use of the Earth's finite land is becoming a matter of life or death for humankind. Since the 1990s, the sustainable utilization of land resources and research on this topic have been addressed continuously in most countries, particularly developing ones (Zinck and Farshad 1995; de la Rosa et al. 2009). For example, the International Symposium on Sustainable Land Utilization Evaluation in Developing Countries was held in Chiang Mai, Thailand, and the 21st-Century International Symposium on Sustainable Land Use Management was held in Lethbridge, Canada. Bonn, Germany and Beijing, China launched relevant international conferences. These seminars have pushed sustainable land utilization to the peak of global strategic research (Dai et al. 2002). The World Bank also regarded sustainable land management as an important investment target. Currently, sustainable land utilization has attracted broad,

Fig. 1 Comparison of total cultivated area and cultivated land per capita in China from 1998 to 2011

intense interest all over the world (Krajnc and Glavič 2005; Luo et al. 2010). Developed countries paid more attention to the improvement of life quality and emphasized environmental benefits, while developing countries focused on the ecological balance on the premise of economic interest (Schoot Uiterkamp et al. 2011).

SUSTAINABLE LAND UTILIZATION ISSUES IN CHINA

China now is the world's second largest economy, and its GDP per capita is approaching the world average. As a result, China is beginning to encounter certain inevitable problems. From a macro point of view, there are conflicts among land demands for food security, urbanization, and ecological protection, which have threatened the use of land resources for future generations.

Farmland Protection in China Is Facing Difficult Challenges

The “red-line” limit of cultivated land is often breached, and farmland protection entails security risks (in China, the red line refers to the lowest allowable area of regular farming land, while the green line refers to a sufficient area of reserve cultivated land resources, where some could be converted to cultivated land under certain conditions). The competition between using land for economic development and using land for grain production—a game in which one side wins and one side loses—is fierce. First, it is difficult

to adhere to the red line of 121.2 million ha of cultivated land (Gong et al. 2007). From 1998 to 2010, the cultivated land per capita decreased from 0.26 to 0.22 acre, and there has been a net decline of approximately 8.01 million ha of cultivated land (Fig. 1). The cultivated land per capita in China was equivalent to only 1/34 of Australia's, 1/20 of Canada's, and 1/8 of America's in 2010. Second, the green line of reserve cultivated land resources continues to shrink. The high intensity of land development in recent years has led to the continuous use of farmland. As a result, grasslands, forests, ponds, and ditches have been converted to farmland to maintain the grain yield. In 2012, the concentrated reserve cultivated land resource was only 7.34 million ha in China, and it was unevenly distributed, being mainly concentrated in the dry areas of the North and West.

Idle Land Is a Bottleneck

The tension regarding land resources and the low ratio of land utility are bound to hamper sustainable development. The predominant land use type has not fundamentally changed, especially in the southeastern urbanized areas. In response to the economic crisis of 2008, China launched a massive economic stimulus plan. Tens of thousands of new projects were put into practice, producing a large amount of abandoned lands and seriously damaging the ecological environment. According to incomplete statistics, the total area of idle and damaged land created by construction activities or natural disasters reached 8.67 million ha in 2010. In addition, although the land reclamation rate in

China has risen from 1 % before 1989 to the current 25 %, this value is still much smaller than those of developed countries (70–80 %).

It Is a Clash Between the Blind Expansion of Cities and Scientific Development

Most of the urban spatial extension has occurred via the “spreading pie” pattern, manifesting as an outward expansion without inner function enhancement. As shown in Fig. 2, the built-up area of 20 major cities in 2010 was more than twice as much as that in 1990 (the expansion rate was calculated by the area ratio of 2010 and 1990). The built-up area of Chongqing in particular increased more than tenfold. Studies have found that more than 80 % of new construction land in China directly occupied cultivated land around the city, and 60 % of the cultivated land was fertile and rich (Chen and Huang 2001; Zhang and Liu 2013). Furthermore, urban land expansion was faster than the population increase during urbanization. The population was growing faster than household registration as well (Siciliano 2012). This abnormal phenomenon has remained unchanged for a long time. From 2004 to 2011, the total urban built-up area expanded by 43 % in China, but the urban population increased by only 27 %, and the household registration population increased by 20 %. The situation was no better in rural areas. From 1997 to 2007, China’s rural population decreased by 13 %, but the rural residential area increased by approximately 4 %, manifesting the opposite trend to that in which the population was increasing while the land was decreasing.

POLICIES OF SPATIAL RECONSTRUCTION

Land use is a complex process with a time orientation and spatial characteristics. Land use problems are identified in both spatial and time dimensions as some land conversions are found to occur at the “wrong” time and locations (Yeh and Li 1998). People can consciously interfere and guide the evolution of the spatial structure of land use to comply with the requirements of social and economic development. The concept of spatial reconstruction is derived from the field of urban planning and is characterized by a homogeneous urban space transforming into a heterogeneous multiple-use urban space (Feng and Liu 2007; Chai et al. 2011). The mixed strategy of land use, proposed internationally, is typically embodied as the flexibility to control urban land and allowing its conversion within the same land use categories, thus attaining highly efficient land use (Borrego et al. 2006; Kangalawe 2010). Likewise, the reallocation or redistribution of land resources and the optimization of the spatial distribution is called the spatial reconstruction of land use. Beyond simply adjusting the types of land use, spatial reconstruction readjusts the land use status and spatial form to achieve the optimal efficiency and sustainable utilization of land (Chen et al. 2004; Yu et al. 2009).

Based on this concept, structure adjustment and layout optimization of land use is the basic form of the spatial reconstruction in China. Some specific modes have emerged for practical applications, and these modes can be divided into four levels based on principles (Fig. 3). The first level is the development of unused land, wherein the

Fig. 2 Comparison of built-up-area expansion of major cities in China from 1990 to 2010

Fig. 3 The four levels of spatial reconstruction

land use structures are directly adjusted. Reclamation is the main principle of the mode, which involves the transformation of land that is unsuitable for farming or building into land that could be used. It is generally considered to be a valid way of increasing the cultivated land quantity and raising land productivity, such as the development of land among mountainous and hilly areas. Urban renewal is the second level. In contrast to level 1, wherein land is reclaimed for use for the first time, level 2 is more likely to involve the redevelopment of land resources (reuse principle). Urban renewal allows an area that was in functional decline to experience redevelopment and prosperity (Hin and Xin 2011). In this mode, urban areas in decline are subjected to relocation, investment, and reconstruction, and the material spaces that cannot adapt to modern urbanization are replaced, such as “San-jiu” reconstruction (“San-jiu” refers to the old towns, factories, and villages in a city). Ecological reconstruction is the third level, and its principle is recycling. Ecological reconstruction could both improve land production capacity by pollution control and rebuild ecological balance by recovering or rehabilitating the area subjected to man-made destruction into a balanced ecosystem (Liu and Hu 2005). It is a land issue as well as an environmental problem (Hu et al. 2004). The damaged ecological structure and function are reconstructed through land rehabilitation, such as abandoned field rehabilitation. Finally, spatial displacement is the fourth level and is crucial for balancing urban and rural development. This

mode involves the functional replacement of land resources, which provides solutions for solving the contradictions between the shortage of land for urban construction and the unused rural construction sites, ultimately achieving their optimal allocation in terms of land use patterns (Long et al. 2012). Based on the principle of reconfiguration, this mode improves efficiency by addressing the imbalance between urban and rural built-up land and calls for greater liberalization of production factor movements. For example, the urban–rural development and population mobility are interrelated due to the link between population and land policy.

The goal of sustainable land use is to keep land available and retain its ecosystem stability in the long term. Compared with traditional land use patterns, sustainable land use emphasizes the coordination of land use (ecological sustainability), the profitability of land use (economic sustainability), and the fairness of land use (social sustainability) (Pauline and Andreas 2009). As shown in Fig. 4, the spatial reconstruction of land use is a framework for action to realize the sustainable utilization of land resources. The four levels mentioned above could help achieve layout optimization through the adjustment of land use structure and ultimately maximize the overall benefits of the land use system. Conversely, sustainable land use provides guidance for spatial reconstruction. Spatial reconstruction must follow the theory of sustainable development: the material existing in the earth’s surface

Fig. 4 Interaction mechanism between spatial reconstruction and sustainable land utilization

ought not to accumulate within the ecosystem; social production ought not to accumulate in nature; and the material basis for productivity and diversity of nature ought not to worsen.

SPATIAL RECONSTRUCTION PRACTICES

The coordinated development of population and land is the major avenue to the realization of sustainable development in China's modernization. In recent years, China has applied the concepts and principles of spatial reconstruction to the planning of sustainable land development, which has led to many new ideas and methods in land management. These innovative practices, with local characteristics, are the premise and foundation of the social economy's sustainable development.

Development of Unused Land: Mild-Slope Hilly Land Exploitation in Yunnan Province

Yunnan Province is faced with the problem of rationally utilizing a limited amount of land for regional sustainable development. Indeed, 94 % of Yunnan Province is mountainous. The 6 % of the province that is flat is both the main cultivated land and the main land for urban construction. The shortage of land for construction has restricted economic development in Yunnan Province, leading the government to encourage the construction of towns on the hill and industrial projects on the slope (Fig. 5a). Owing to its scarcity and non-regenerate characteristics, land resources on the low hills and gentle slopes could provide numerous benefits when exploited.

The most straightforward significance of this policy is to protect cultivated land. At present, a total of 30 % of high-

quality cultivated land in Yunnan Province has been used for construction. At this rate, the high-quality cultivated land will completely disappear within 10 years. To address this issue, Yiliang County, for example, built an industrial park on the barren hills, allowing nearly 4680 ha of basic farmland to be preserved on its original location for future crop farming.

In 2010, the urbanization rate of Yunnan Province was only 35 %. The province was facing the arduous task of urbanization and improving its residents' livelihood, which needs to provide substantial land resources for urban development. It is estimated that low hills and gentle slopes with a gradient of 8°–25° account for 61.9 % of the total area of the province. If all of this land is exploited by the improvements in land leveling engineering, the supply of construction land would increase greatly, alleviating the disparities between economic development and the scarcity of construction land in mountainous areas. It should be noted that such a project should choose an exploitation model that is conducive to protecting the ecologic environment and reducing the exploitation cost (Zhou 2011).

Urban Renewal: “San-Jiu” Reconstruction in Guangdong Province

Guangdong Province is located in the Chu Chiang Delta, which is widely known as the most economically dynamic region of Mainland China. Its economy has been top in the country for the past 20 years, and manufacturing and

tertiary industry are its leading industries. However, rapid economic growth inevitably comes at the expense of a large consumption of land resources. Construction area accounts for more than 30 % of the total land area of this province; specifically, this figure was 47 % in Shenzhen, 41 % in Dongguan, and 33 % in Foshan in 2010. Globally, the land development intensity is generally between 20 and 30 %.

The rapid land urbanization certainly leads to a series of urban problems, such as inefficient urban land use and irrational land structure of inner cities (Zhou and Fu 2011). At the same time, construction land overtakes agricultural land and aggravates the burden of the urban land system. “San-jiu” reconstruction refers to the reconstruction of old towns, factories, and villages when the urban area develops to a certain stage. It aims to revitalize the stock of land, tap into the potential of existing construction land, and promote the efficient and intensive use of land. Old towns, factories, and villages, which are considered to be a burden of urban development, become a positive factor for economic and social development (Fig. 5b, c).

The “San-jiu” reconstruction policy is an effective means to promote the sustainable use of urban and rural land. The main stakeholders in “San-jiu” reconstruction include the local government, developers, and villagers or the village collective. The reconstruction plans must be acceptable to all of the tripartite interests (Wang et al. 2012). Certainly, when the government, developers, and individuals divide the land value-added benefits of policies,

Fig. 5 Living examples of sustainable land use based on spatial reconstruction in China. **a** Land leveling in Chuxiong City, Yunnan; **b, c** before and after the chemical plant energy renovation in Guangzhou City, Guangdong; **d, e** before and after the open-pit mine rehabilitation in Jilong Hillside, Jiangsu

negotiating ability will play a decisive role. To a large extent, this negotiating ability implies a synthesis of social status, economic level, and traditional culture. Therefore, the Guangdong government clearly stipulated that more than 90 % of the village collective members must agree with the reconstruction plan. Furthermore, 60 % of the revenue of the land should be returned to the landowners. Respecting the wishes of the villagers is a necessary prerequisite for the policy implementation.

Ecological Reconstruction: Abandoned Field Rehabilitation in Jiangsu Province

Located in the lower reaches of the Yangtze River, Jiangsu Province is the most concentrated district of cities and towns in China, and is a member of the Yangtze River Delta economic area. As of 2012, the comprehensive economic power of Jiangsu has always been among the best in the country, and its GDP is the second highest in Mainland China. Its GDP per capita exceeds \$10 000 and is the highest among all provinces. Due to the full-scale implementation of industrialization, urbanization, and agricultural modernization, the rigid demand for land resources is increasingly high. With the promotion of industry and the elimination of production surplus, there are an increasing number of abandoned mining areas. These mine tailings could easily become ecologically fragile regions and induce environmental problems because the core of the land is damaged, posing a significant threat to humans as well as the sustainable development of the social economy (Li et al. 2012).

Ecosystem restoration efforts have become a booming business in China (Guan et al. 2011). The ecological restoration of damaged land, such as depleted mines, is currently attracting a large amount of attention. In addition to land leveling, parcel division and transformation from slope into terraces, the relevant ecology rehabilitation engineering also involves infrastructures (irrigation equipment, farmland path, production path, etc.) as well as ecological projects, including afforestation and the management of the geological environment (Fig. 5d, e). The reclamation of each ha may cost more than \$100 000. For this reason, a long-term investment and financing system for the rehabilitation of mine tailings should be created, through which government investment, refunds from the sales of new constructional land and social capital can establish a multiple-subject mechanism of investment and financing.

Brownfield redevelopment relieves environmental pressure and resolves the glaring contradiction between idle urban land and urban sprawl (Cao and Guan 2007). Recovering this abandoned field into arable land is a priority, but its quality level must remain. The reclaimed arable land outside cities can be equally qualified as the constructional occupation of arable land, namely, newly

built. Only when the abandoned fields are reclaimed in the first place, can the incremental construction land quotas be approved for use. This model of rehabilitation substantially boosts land value but is also considered to be plundering agricultural land, with negative effects on rural areas. In response to critics, the State Department has clearly put forward that “it should take the priority to protect peasants’ legal rights,” ensuring the public’s rights to obtain information and participate.

Spatial Displacement: Link Between People and Land in Henan Province

Henan is the largest agricultural province, with a large population and good economic development. Its GDP was the fifth highest in the nation in 2012, and it is the most highly populated province in the nation. It is also the main body of the Central Plains Economic Zone, the fourth largest economic zone in China. During recent years, the conflict between humans and the land has been gradually increasing. Industrialization and urbanization have led to a decrease in cultivated land, which directly threatens the safety of food production. In 2008, the strategy of linking population with land was considered in the Major Function Oriented Zone Planning and then implemented in Henan Province in September 2011.

The link between people and land can be expressed simply as “land moves along with population migration.” This policy enforced agricultural land rehabilitation in rural areas and exchanged it with an equal area of urban construction land (namely, the newly built index) after rural migration to the cities. Suppose that a farmer arrives in a city to find a job and then settles down. The homestead he owned in the countryside would be recultivated to increase the arable area, which would ensure that the total cultivated land did not decrease (a certain amount of cultivated land would be occupied by newly increased construction land). At the same time, the city he moved to is eligible to obtain a qualification for new construction land index. In this case, both urban and rural areas can benefit from the flow of population and land (Fig. 6).

At present, the operating model of the link between people and land in Henan Province is in an exploratory phase. The general approach is comprised of the following steps: measuring the amount of urban resident growth according to the future urbanization rate in overall land use planning, calculating the special construction land index in accordance with construction land per capita control standards, and issuing the same amount of urban construction land scale and rural residential areas tasks. Scientific assignment of construction and rehabilitation land is necessary in all stages of policy implementation (Wang et al. 2012).

The essence of the link between population and land is that it rectifies the mode of “land urbanization without

Fig. 6 Schematic map of the link between humans and land in Henan, China

population urbanization” from an institutional aspect (Wang 2012). This policy encourages a synergy between land and population urbanization by linking an increase in urban population and construction land with a decrease in rural construction land. It then boosts the population agglomeration in the process of urbanization and realizes optimized disposition to the resources in higher levels and broader spheres, such as land, labor, or capital. As such, Henan Province can serve as an exploratory case study in the attempt to change traditional ideas to accelerate urban and rural development.

DISCUSSION

The limited supply of land resources struggles to meet the ever-growing demand for land, which is considered to be

the root cause of land issues in China. By 2020, the Chinese urbanization rate will reach 60 %, and the industrialization rate will rise to 70 %, requiring an increase in construction land of nearly 10 million ha. However, under the premise of sticking to the red line of cultivated land, the amount of newly available land that could be used for construction is less than 2 million ha in real terms over the next 7 years. China has proposed an innovative land management system, including the approaches described above, and all of these components have different implications and are important.

From 2009 to 2012, the area of cultivated land remained above the red line, and a balance between cultivated land occupation and compensation was gradually reached. The Chinese government speeds up the reclamation of land discarded by factories and mines to extend cultivated land, while it adopts measures to protect the existing cultivated

land. In case 1, the exploitation of low hills and gentle slopes converts the unused land into cultivated land, which could enlarge plots and increase the social gross supply. In case 3, Jiangsu Province will gain 12 000 ha of arable land as a result of the rehabilitation of mine tailings from 2012 to 2014.

The effort to address idle land will be intensified to bring it back into active use, which would be helpful for the promotion of economical and intensive land use. Several observations from case 2 and case 3 provide evidence of this effect. In Guangzhou City, Guangdong Province, 49 410 ha of urban development land was subjected to “San-jiu” reconstruction from 2010 to 2012 (including 5596 ha of old towns, 17 166 ha of old factories, and 26 648 ha of old village areas); thus, the revitalized land could meet the future demand for quite a long time. In Changzhou City, Jiangsu Province, 3989 ha of abandoned industrial and mining land is to be reclaimed from 2012 to 2014, with the land reclamation ratio reaching 43 %. All of these changes indicate that the old perception of vacant and abandoned land has indeed been revitalized.

The State is increasingly occupied with the problems of rapid urbanization, especially the handling of the stock land in cities and promoting integrated urban–rural development in practice. In case 2, urban renewal is the secondary development of the urban stock land and a new reform of the existing pattern of rural land for construction purposes in Guangdong Province (including the patterns of land use and the revenue generation system). Additionally, in case 4, linking the change in the population with a change in construction land area helps to realize and balance the flow of population and land elements between rural and urban areas. Also, the differential earnings from land are invested in new rural construction to form a virtuous circle of urban and rural development in Henan Province.

As observed, only by the combined utilization of these approaches can we solve the land issues to the greatest extent. However, there are many differences among the cases in their application conditions, objects, and effectiveness, which require diversified policies in accordance with the local conditions. For example, in case 1, the exploitation of mild-slope hilly land was motivated by the highly mountainous geography of Yunnan Province. In contrast, case 3 is more suitable for rapid urbanization developed areas, and a large amount of idle land and strong demand for construction land are the necessary conditions. In terms of goals, the implementation targets of case 3 and case 4 are both construction land, but the former is targeted at abandoned fields (especially construction land located in the periphery of urban built-up areas), whereas the goal of the latter is to organize idle rural settlements.

The “increasing vs. decreasing balance” land use policy has distinctive Chinese characteristics among all of the practices of spatial reconstruction. Its key objective is to

achieve equilibrium in the supply of land in China by connecting an increase in urban construction with a decrease in rural residential land. This policy has been adopted in case 3 and case 4. Specifically, the cultivated land was effectively increased by the reclamation of abandoned industrial and mining land and idle rural settlements. The cities could increase construction land by using the same area of construction land reduced, alleviating the current contradiction between the supply and demand of land in Jiangsu and Henan Provinces. The results can provide guidance for the improvement of the intensive level and healthy development of land use for other countries. It might be equally applicable to other rapidly growing economies, such as that of India.

However, one further observation is worth making. Strategies for rural development encountered resistance and have the potential to incite conflict and protests anywhere in the world (Woods 2003). China is not an exception. The “increasing vs. decreasing balance” land use policy shares features with rural restructuring in Europe and North America, but it is in essence a top-down reform based on state intervention. The traditional elements of rural lifestyle and culture would be more at risk in China. Violent protests against the demolition of housing are a typical example. Rural development in Europe is a synthesis of top-down and bottom-up approaches, as a bottom-up emphasis based on local empowerment is likely to lead to more diverse and embedded activities, while a top-down approach is one in which regional and national authorities set the objectives at a central level (Bristow 2000). Lessons might be learned from Europe and other countries by incorporating elements of “bottom-up” planning into the process to safeguard farmers’ rights and mitigate rural protests (Long et al. 2012).

In general, sustainable development is a theme that attracts the attention of contemporary people, and it affects the long-term and basic interests of humans. The achievement of the core values and principles of sustainable development on the ground remains a challenge (Guerin 2001). The conversion of land (including cultivated land) to non-agricultural use is bound to continue in the coming decades in China (Ho and Lin 2004). Spatial reconstruction will continue to stimulate the double optimization of structure and allocation of urban–rural land use. We have a long way to go toward the sustainable utilization of land resources. In 2012, the new Chinese leadership advocated eco-civilization, emphasized sustainable development and added conservation culture to the framework of economy, politics, and culture. Awareness of conservation culture will be firmly established in the whole society, which could benefit the populace by providing a stable and orderly evolution process that is more energy- and resource-saving and more eco-friendly.

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