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Cultivated land quantity niche regulation and its environmental effect

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Abstract: The change in the quantity of cultivated land influences the structure, function and evolvement of ecosystem. The rational change in the quantity of cultivated land will be propitious to ecological security and sustainable development, and irrational change will deteriorate ecological environment. The concept of cultivated land quantity niche regulation was firstly put forward based on niche theory and the action-feedback mechanism between cultivated land quantity niche and cultivated land benefit niche. Then, the regulation measures of cultivated land quantity niche were brought forward in rural−urban area, agro−forest area and consolidation-reclamation-exploitation area. Finally, the ecological environmental effect after regulation was analyzed. The results show that different measures should be taken to regulate cultivated land quantity niche in different areas. The economic and social benefit niche of cultivated land should be promoted to regulate cultivated land quantity niche in rural−urban area and consolidation−reclamation−exploitation area. The social benefit niche of cultivated land should be reduced in agro−forest area. The regulation goal of cultivated land quantity niche will be attained by different measures.

Key words: niche theory; cultivated land quantity niche regulation; land reclamation; environmental effect

1 Introduction

Cultivated land is a natural−economic−social multiple ecosystem. It shows dynamic complexity and variable characteristics. Traditional methods cannot solve the complex problems effectively. Some ecology theories and methods such as niche theory are proper means for cultivated land researches. Niche theory is an important theory of ecology, which can measure the frames of continuous change process in cultivated land ecological relations. It can clearly reflect the succession and development of cultivated land ecosystem [1−2]. So, the niche theory has an important theoretical and practical value.

The concept and content of niche have gone through a long term development process. Among them, spatial niche or habitat niche, nutrition niche or functional niche, and super-size niche which were put forward by GRINNEL, ELTON and HUTCHINSON, are the most famous theories of niche theory [3−5]. Then, some ecologists make further researches in niche theory [6−8]. In addition, LIU [9] proposed the concept of eco-unit, which is an ecological function unit of material transformation, energy conversion and information processing in natural−economic−social multiple ecosystem. It can be every biological tissue level (such as genes, cells, organs, landscape, ecosystem, biosphere, earth , etc), also can be a number of other function units (such as business, farmers, industry, farming systems, planting patterns, economic entities, etc). Based on these, the concept of eco-unit niche was put forward by LIU, which offered a theoretical foundation of niche theory using in resources utilization, assessment and ecological protection [9].

Cultivated land ecosystem is a special ecological form, and it is between natural ecosystems (such as grassland and forest ecosystems) and artificial ecosystems (such as urban ecosystem). In essence, the regional land ecosystem is a natural−economic−social multiple ecosystem. It is a kind of function unit of ecological processes in material and energy conversion and information processing, which has general characteristics of the eco-unit. Therefore, the cultivated land ecosystem is a special kind of eco-unit, named cultivated land eco-unit. NIU [10] proposed the concepts of cultivated land niche, and expounded its object, essence, types, characteristic and development law based

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on niche theory. The cultivated land niche mathematical models including cultivated land niche, expansion−reduction degree, niche quotient and quantity niche barycenter were constructed, which can provide new theory and ways for the study on the change in the quantity and quality of cultivated land [11−12]. Then, NIU and ZHANG [13] put forward the comprehensive benefit niche driving forces system and mathematical models according to the coupling relationship between quantity niche and benefit niche of cultivated land, and the mechanism and function course of benefit niche driving forces system in rural−urban area, agro−forest area and consolidation−reclamation−exploitation area were analyzed.

This work puts forward the regulation measures of cultivated land quantity niche and analyzes ecological environmental effect based on the function-feedback mechanism between the change of cultivated land quantity and benefit niche driving forces, niche-fitness theory and niche competition theory.

2 Concept and theory of cultivated land quantity niche regulation

Quantity niche regulation of cultivated land is that a series of ecological, policy, engineering and planning measures are taken to promote regional economic and social sustainable development, ecological environment quality improvement. It is based on supporting and suitability of eco-unit affected by natural, economic and social factors in a specific space, and feedback mechanism between driving forces as well as quantity changing of regional cultivated land. Theoretical basis of quantity niche regulation for cultivated land is mainly reflected on niche fitness, niche competition theory and the benefit-driving theory [14]. Niche fitness is similarity of eco-unit between its actual and optimal resources/conditions. It reflects fitness of eco-unit and its resource variations in the habitat, i.e., resource satisfaction of the habitat on its development.

In a specific space, realistic conditions, such as natural, economic and social conditions, are given. When they can satisfy the existence and development of cultivated eco-unit, the space can be used as cultivated land pattern. The more the fitness of niche in cultivated land eco-unit, the more suitable the eco-unit to the environmental variations. The niche is hardly occupied by other land use patterns. Whereas, if the actual environment can not satisfy the existence and development of cultivated land eco-unit, the space will not be suitable for cultivated land. Measures, such as ecological restoration, policy, engineering and planning, i.e. quantity niche regulation, should be taken before being used in cultivated land. This niche is easy to be occupied by other land use patterns. Niche competition refers to expansion or compression phenomenon of niche in competing space and environment resources between two eco-units with similar requirement of eco-environment. When competition between cultivated land eco-unit and other land use patterns exists, eco-environmental conditions, policies and resources suitability regulation, should be changed to ensure reasonable expansion or compression of the quantity cultivated land niche. From driving-force mechanism of cultivated land changes and niche benefit, cultivated land changes in Jiaozuo are determined by unbalancedness of integrated benefit on eco-unit between cultivated land and others, i.e., direct driving force of cultivated land quantity change is formed by integrating benefit difference of niche in different eco-units, which cause spatial variations of cultivated land quantity.

Therefore, measures, such as economic, ecological and policy, should be taken to regulate niche benefit between cultivated land and other patterns, based on driving-force and feedback mechanism of cultivated land quantity and niche benefit. The niche of cultivated land needs stable, or reasonable expansion (development and reclamation of arable land) and compression (eco-restoration).

In brief, three theories, including the theory of niche fitness, niche competition and benefit niche driving forces theory, are jointly integrated as system together. In a certain space, the greater the fitness of cultivated land niche and actual eco-environment, the higher the integrated niche benefit for cultivated land. It can maintain its stability or reasonable expansion in competition with eco-units of other land use patterns.

In Jiaozuo city, because of variation in natural, economic and social conditions, driving force of benefit niche shows obvious difference. Cultivated land niche regulation in rural−urban region, agro−forest region and consolidation−reclamation−exploitation region, should be adapted to local conditions, for the realization of integrated regulation on cultivated land niche in the region.

3 Study area

Jiaozuo city is located in the northwest of Henan Province, China. It is situated between 112°43'31" and 113°38'35" E longitude and between 34°41'03" and 35°29'45" N latitude. The distance from east to west is approximately 102.05 km, and the distance from north to south is 75.43 km. Its total area is 4 000.89 km^2. Jiaozuo city is in the connection region of Mount Taihang and Yubei Plain. The total topography is high in north and west, low in south and east. The cultivated moisture soil and brown soil are the primary soils in Jiaozuo, which

are accompanied with stony soil, thick bone soil, salt soil, paddy soil, etc together. Jiaozuo city includes four counties, two cities, five urban zones (urban district), which respectively are Qinyang, Mengzhou, Wenxian, Xiuwu, Wuzhi and Boai, Jiefang, Shanyang, Zhongzhan, Macun and Gaoxin zone.

Based on studies of the nature, economy, society and ecology factors distribution in the region, the influences of ecology factors on cultivated land resources development, utilization and quantity, unifying research goal and the land utilization cover type, Jiaozuo city can be divided into four utilization ecology areas, namely mountain and hill region, town and industry region, agricultural region and agriculture and forestry exploitation region (Fig. 1).

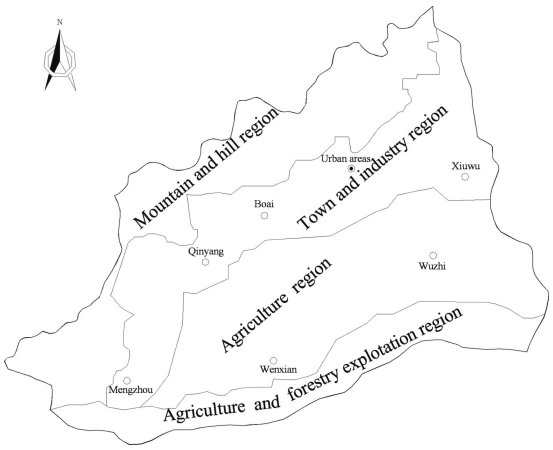

Fig. 1 Sketch map of land use ecological region

4 Cultivated land quantity niche regulation in Jiaozuo city

4.1 Cultivated land quantity niche regulation in rural−urban area

On the analysis of the niche-benefit driving force of rural−urban area in Jiaozuo, leading benefit (economic benefit) of niche between the cultivated land and construction land is enlarged quickly. The direct driving force of niche compression in the cultivated land is the integrated benefit imbalance of cultivated and construction land niche, causing social benefits declining in cultivated land niche [15].

Two plans, including overall planning and urban planning of Jiaozuo city, for the implementation of urbanization, speed up the process of urbanization. The construction of the whole urban system should be in accordance with the overall strategy of integration of central China city group development, i.e., to accelerate development of large cities (central urban) and actively develop small cities, small towns as well, to form a reasonable layout of urbanization system.

It can be expected in the next period that the niche difference of leading benefit between cultivated land and construction land will continue to exist and enlarge. Main driving-force of cultivated land shifting to construction land will still exist and reinforce. So, some measures, economy, planning and policy, should be adopted to regulate cultivated land quantity niche to make sure construction land comply with city plans, and preventing cultivated land being occupied blindly.

4.1.1 Improve economic benefit niche of cultivated land

In rural−urban area, the main reason of niche compression in cultivated land quantity, is the existence and continued expansion of leading benefit (economic benefit) gaps of niche between the cultivated land and construction land. Therefore, enhancement of benefit on cultivated land leading niche is very important for narrowing niche compression of cultivated land quantity. Specific measures should be taken as follows:

1) Adjust crop cultivation structure and enhance direct output benefits of cultivated land. The adjustment of crop cultivation structure is on the precondition of keeping the current land use patterns, to expand the planting areas of famous, unique and excellent agricultural products, for improving the output efficiency of cultivated land and achieving optimal allocation of regional resources. Jiaozuo city is the major commodity crop base in Henan Province, China. The main crops are wheat, corn, rice, cotton, oil plant and other cash crops. Wheat is known for its stable and high yield, and its four Huaiqing Chinese medicines, Huaiqing yam, chrysanthemum, rehmannia and achyranthis bidentatae. Therefore, the main strategy of improving economic benefit of cultivated land niche is to enhance cultivated area of these cash crops, especially for four Huaiqing Chinese medicines and vegetable cultivation in suburbs, on the basis of breeding varieties and wheat commodity crop base.

2) Implementation of agricultural tax cuts and crops subsidy policy, and to enhance the output benefit of cultivated land, indirectly. Further reduce the burden of peasants, encourage the enthusiasm for crops cultivated and ensure food security, which also indirectly enhance the output efficiency of cultivated land as well. Therefore, it is very important to adhere to rules of “more giving, less taking and be flexibility” for implementation of related agricultural subsidy policy. To some extent, improve the economic benefit of cultivated land niche, and restrain cultivated land abandon for other uses.

4.1.2 Improve social benefit niche of cultivated land

The internal driving force of urban development and related policies of urbanization acceleration will reduce urban−rural land protection efforts. Therefore, reducing social benefit of cultivated land niche in urban−rural area is another main reason for the niche compression. When land protection policies are rigidly implemented, the

social benefit of cultivated land niche will be improved, which can balance the imbalance of integrated benefit of niche causing the gap enlargement of economic benefit in the niche, effectively. The cultivated land is protected. However, if land protection policies are ignored, the social benefit of cultivated land niche will decline, and cultivated land niche will be compressed because of further aggravating imbalance of integrated benefit of niche.

The price rising, tax cuts and subsidies of agriculture have a positive effect on economic benefit improvement of cultivated land niche. However, they can not change the large gaps of leading benefit in niche between cultivated land and construction land. Driving force on niche quantity of construction land expansion and cultivated land compression still exists [10]. Therefore, reducing the gaps of niche by enhancing economic benefits of cultivated land niche shows great challenges. So the realization of integrated benefit balance between cultivated and construction land should focus on implementation of cultivated land protection policy and social benefits improvement of cultivated land niche. Specific cultivated land protection policies should focus on strict implementation of urban planning, land use overall planning, censorship and approval of cultivated land occupied, etc. In addition, the development of city should depend on the existing urban construction land and cultivated land in surrounding villages to form a radial network of cities. So, the symbiotic of urban and natural, city and agriculture, and urban and cultivated land ecology, should be given full attention. Meanwhile, symbiotic of urban and agriculture realization is also the important social benefit performance of cultivated land niche.

4.2 Cultivated land quantity niche regulation in Jiaozuo agro−forest area

The main reason of the compression of the cultivated land quantity niche in agro−forest area is the dominant driving force formed by the drop of the cultivated land social benefit niche, which highlight the leading benefit niche gaps between the sloping cultivated land and forest. Ecological restoration is the key measure in reducing soil erosion, wind erosion and desertification, improving the regional ecological environment and land yields and protecting the basic farmland. So the regulation of the cultivated land quantity niche in Jiaozuo agro−forest area mainly refers to taking effective measures in plan and step by step on turning the steep and serious soil erosion of cropland to be forest. The essence is to promote the implementation of ecological restoration by reducing the social benefit niche of slope farmland and highlighting the driving force that formed by leading benefit niche gaps of slope farmland and forest.

Based on the above analysis, in the future period, the north of the Mount Taihang and the southwest of Loessial Gully Hill area in Jiaozuo city should be inputted more efforts to achieve the ecological reconstruction in the hilly area. In order to achieve the sustained reductions of the social benefit niche of cultivated land, we should adhere to the preferential policies of "Grain for Green Ordinance" and the state has adopted the "three grants and a waiver" (food subsidies, seed and planting subsidies, and living allowances, reduction of agricultural taxes) to implement ecological restoration and remove the non-performing land eco-elements.

4.3 Cultivated land quantity niche regulation in Jiaozuo consolidation−reclamation−exploitation area

The cultivated land quantity niche in the consolidation−reclamation−exploitation area is in the expansion state. The reason is that under the investment of consolidation−reclamation−exploitation special funds and policy support, the dominant driving force is formed by the gaps between comprehensive benefit niche of the cultivated land and the land to be consolidation−reclamation−exploitation. So the regulation of the cultivated land quantity niche in consolidation−reclamation−exploitation area mainly refers to taking ecological, engineering, economic and political measures to develop the potential niche of the cultivated land quantity, that is, achieving some of the measures will enable the original part which can not be adapted, used or occupied by the cultivated land eco-elements into niche.

4.3.1 Analysis of potential cultivated land quantity niche

Potential cultivated land quantity niche is a series of ecological, engineering, economics and policy measures, which is used as a specific space for land use patterns. According to the difference of the measures types and natural−economic−social conditions of the specific space, they are divided into potential consolidation quantity niche, potential reclamation quantity niche and potential exploitation quantity niche.

Meanwhile, potential consolidation quantity niche can be classified into two types. The first type is potential cultivated land consolidation quantity niche, which refers to farm land with large number of partitions without systematic planning of the ridge, road and trench. Among them, the basic farmland facilities are not perfect, and they spread across the land which is pocketed with unused land and abandoned land, so they cause the phenomenon of extensive utilization. By means of reasonable planning, field patch arranging, open drains and road regulating, merging land patches and

eliminating sporadic unused land and abandoned land, the land quantity could be improved. The second type is potential village land quantity niche. To scatter layout, loose internal parts and the diffused layout, the internal parts are loosen, and the facilities of road and water supply are lack of unified plan. By the way of hollow village planning and rebuilding, combination of bulk villages, adjustment of the building house, and arrangement of village site, the cultivated land will be improved.

Potential reclamation quantity niche refers to occupation area and wastelands of industrial mines (contain waste lands of brick kiln) for mining subsidence, digging gangue and fly ash, and we can take ecological and engineering measures to repair and increase the cultivated land quantity. Also, potential exploitation quantity niche refers to the unused land, including beaches, unbounded grassland, bare land and so on. The cultivated land quantity could be increased by ways of taking ecological and engineering measures.

In Jiaozuo city, through the investigation, statistics, feasibility analysis and evaluation, potential cultivated land absolute quantity niche is 29 734.47 hectares. It shows that the potential cultivated land quantity has some expansion spaces. By ways of taking measures of ecology, engineering, technology and economy, the cultivated land quantity niche can be expanded in a specific area.

4.3.2 Zoning development of potential cultivated land quantity niche

Based on the investigation, analysis and evaluation of potential cultivated land quantity niche, the development should be divided into several areas depending on different conditions to suit the overall arrangement.

1) Key areas of land consolidation in plain.

The total topography is as flat as a pancake, and the morphological types are piedmont alluvial and piedmont transition depression. Huangqin River of alluvial plain is owing to hillock of the floods. The cultivated soil is well with the soil type of drab soil and damp soil. Therefore, we should take the major measures to increase arable land area as follows: combining with the infrastructure of irrigation and water conservancy, making an effective plan to change medium and low-yield land, building high-standard farmland and increasing the effective farmland areas.

2) Reclamation area of mining subsidence under the Mount Taihang.

The region areas consist of Wangfeng Town, Zhucun Town of Zhongzhan District, Shangbaizuo Town of Jiefang District, Baijianfang Town of Shanyang District, Anyang Town and Jiulishan Town of Macun District, which are mainly abandoned mine and reclamation of mining subsidence. Most of cultivated lands which are damaged by coal mining activity, mainly select reclamation as the cultivation operation. Therefore, land reclamation is the main direction for the area. We should take the major measures as follows: combining with the recovery and treatment of ecological environment, taking measures of engineering, biology and so on to reclaim the land of mining subsidence and digging gangue and fly ash, so as to increase farmland areas and improve the ecological environment.

3) Comprehensive development area of Yellow River sand.

Yellow River flows through Wuzhi, Wenxian and Mengzhou, which lasts 100 km. As the reserve land resource of Jiaozuo city, this large area is suitable for large-scale development. However, the farmland of Yellow River Wetland reserves to the south of Xinmang River, especially the core wetland reserves to the south of Yellow River dam should be returned to wetland. The major measures for development are as follows: focusing on the soil and water conservation and small watershed management, combining the construction of the Yellow River wetland and ecological shelterbelt to exploit agriculture and forestry comprehensively in order to increase arable land area. Meanwhile, we should take administrative and economic measures to reduce the social cultivated land benefit niche in Yellow River Wetland area, returning more farmland to wetland to protect the existing ecological system of wetlands.

In addition, according to mechanism of benefit niche, the full development cultivated land reclamation funds and effective policy guarantee are the important ways to increase comprehensive cultivated land benefit niche. Therefore, we should pay more attentions to apital investment and policy implementation. Among them, expanding money input should increase investment and fund-raising channels. Then, fund-raising channels should include the compensable land using fees, cultivated land reclamation fees, comprehensive agricultural development fees, comprehensive treatment fees of surface ground subsidence, special fund for mining subsidence of comprehensive treatment, and social and individual fund. It requests to enhance the implementation of the land management law and land reclamation law, and standard management of land development and reclamation program.

5 Environmental effect of cultivated land quantity niche regulation

The regulations of cultivated land quantity niche are brought forward in rural−urban area, agro−forest area

and consolidation−reclamation−exploitation area, that is to say, cultivated land protection of rural−urban area, ecological restoration of agro−forest area, ecological rehabilitation of consolidation−reclamation−exploitation and farming and forestry comprehensive development are consistent with the focal point of Jiaozuo ecological construction, which includes protection of Taihang Mountains Integrated Nature Landscape Protect Region, building of Yellow River Wetland Natural Protection, protection and management of mineral ecological environment, urban construction control, ecology construction of plain ecological landscape protect region and ecological demonstration area. Consequently, it can bring positive environment impact and put forward Ecological Gardens City Construction in Jiaozuo city.

1) The regulation of cultivated land quantity niche is conducive to the ecological function of northern mountain of Jiaozuo green corridor. In accordance with the quantity of slop farmland in Jiaozuo agro−forest area, natural conditions, returning farmland to forests, together with the developing of woodland, we can strengthen the ecological function of northern mountain green corridor on water conservation, nutrient preservation, carbon dioxide fixation, disaster reduction and the living environment improvement.

2) The regulation of cultivated land quantity niche can accomplish the ecological rehabilitation on subsidence land of coal extraction and build green shelters on the northern part of the city. By the way of land treatment and rehabilitation of subsidence land, it can build a landscape ecological system, which places ecological agriculture first, forestry second, and keeps self-regulation. It can increase efficient arable land and give full scope to ecological functions. East-west green corridor can increase vegetation, control soil erosion, preserve the ecological environment and so on. It can change the serious situation of ground water and soil which is polluted by ore and tailing accumulation. By planting cash crops (such as cotton and ramie) that absorb less heavy metals and growing popular and Chinese scholar trees that can reduce nutrient metal in soil, it can promote development of agriculture, and reduce the ground water and soil pollution.

3) The regulation of cultivated land quantity niche can accomplish the symbiosis of city and agriculture, reduce pollution, and protect groundwater resource. By controlling rural−urban area construction which occupies farmland, adjusting cultivated land and settlements, they can relieve the exacerbating trend of surface water pollution and solid wastes pollution, so as to make city and agriculture symbiosis. In addition, cultivated land systematic planning and construction of farmland irrigation facilities increase cultivated area, at the same time, they are beneficial to protecting underground water resource. Such as Jiaozuo Yellow River Diversion Project, Xixiayuan Water Project. They will prevent groundwater level recession and avoid expansion of funnel area in Wen County and Qingfengling areas of Mengzhou City.

4) The regulation of cultivated land quantity niche is beneficial to the formation of ecological corridor along Yellow River and the protection of wetland. By farming and forestry comprehensive exploitation of Yellow River sand and implementation of land conversion projects, there will be another ecological corridor featuring construction of ecological agriculture, building protective forest and protection of wetland. Especially, the wetland conservation on the wetland core of Yellow river plays an important role on recovering wetland natural landscape, controlling flood, protecting embankments, supplementing groundwater, improving regional climate and so on.

5) The regulation of cultivated land quantity niche is conducive to the overall improvement of the farmland ecological background and the regional ecological environment. And it is effective to change the moisture, rate of slope farmland in the studied area through regulation of cultivated land quantity niche. That improves the soil and water conservation capacity, surface water quality, soil pollution reduction, so that the overall quality of the farmland ecological background and the regional ecological environment will be improved.

6 Conclusions

1) The theories of cultivated land quantity regulation include the function-feedback mechanism between the changes of cultivated land quantity and benefit niche driving forces, niche-fitness theory, niche competition theory.

2) Different measures should be taken in different areas to regulate the benefit niche driving forces system in rural−urban area, agro−forest area and consolidation−reclamation−exploitation area. The economic and social niche should be improved to bring down cultivated land conversion in rural−urban area. The social niche should be reduced to realize ecological restoration in agro−forest area. The economic and social niche should be improved to increase cultivated land quantity by money input and policy guarantee in consolidation−reclamation−exploitation area. All these measures are of benefit to achieve the overall objectives of cultivated land quantity regulation.

3) The regulation of cultivated land quantity niche is very important to ecological construction and environmental quality improvement.

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