Land Use Regionalization in Poor Counties in Mountainous Areas Based on Targeted Poverty Alleviation

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Abstract　Land use regionalization is a strategic measure for the rational use，management and protection of land resources based on local conditions. Based on the needs of targeted poverty alleviation and rural revitalization strategy and the analysis on the natural and socioeconomic conditions，characteristics of land resources，and the current status of land use in Luquan County，corresponding regionalization indices were selected from four aspects：economic environment conditions，socioeconomic conditions，land resources and land use structure，and poverty alleviation and development level，a scientific and feasible index system for land use regionalization was constructed，and land use in Luquan County was regionalized by using systematic cluster analysis method. The results show that the 16 townships（towns）of Luquan County were divided into four land use regions，poverty alleviation region for development of new town and characteristic industries in the southwest（Ⅰ），agricultural development and ecological poverty alleviation region in central mountainous area（Ⅱ），poverty alleviation region for development of characteristic agriculture and tourism towns in eastern plateau mountainous area（Ⅲ），and poverty alleviation region for development of characteristic industries and protection of land economy in the northern alpine valley area（Ⅳ）. In addition，suggestions were put forward for the rational use of land in each region.

Key words　Land use regionalization，Targeted poverty alleviation，Poverty-stricken county in mountainous area，Luquan Yi and Miao Autonomous County

1　Introduction

Land use regionalization is an abbreviation for the rational development and utilization of land resources. It is considered to be a strategic measure for the rational development and utilization of land resources from space[1]. In recent years，targeted poverty alleviation and rural revitalization have become major strategic tasks in China[2-5]. The rational development，utilization，protection，improvement and management of land resources have very important practical significance for regional economic and social development，especially for the implementation and realization of strategies and major policies for targeted poverty alleviation in mountainous areas[6]. Luquan Yi and Miao Autonomous County（referred to as Luquan County）is a state-level poverty-stricken county in the mountains and valleys of the Jinsha River Basin，Yunnan，where the economic environment is fragile. The development，utilization，protection and improvement of its land resources have important practical significance for the current eradication of poverty and the smooth realization of the strategic goal of rural revitalization. In this paper，based on Luquan County's natural and socioeconomic conditions，land resource characteristics and land use status，combined with the county's targeted poverty alleviation strategy and the direction of rural revitalization，comprehensive land use regionalization was carried out，to provide reference for the rational development and utilization of land resources in accordance with local conditions and the promotion of targeted poverty alleviation and rural revitalization strategy.

2　Index system for land use regionalization

2.1　Selection of regionalization unit　In many regionalizations，such as agricultural regionalization and land use regionalization，generally，the integrity of a certain level of administrative boundaries must be taken into account[7]. The choice of regionalization unit directly affects the accuracy and rationality of regionalization results. Generally speaking，in order to implement a targeted differentiation policy，the smaller the regionalization unit is，the more the homogeneity within the area reflected is. However，the principle of data availability must also be taken into account to ensure the feasibility of land use regionalization. Based on the relevant requirements of land use regionalization and the feasibility of implementing relevant policies，township was selected as regionalization unit in this paper. Thus，the sample size was moderate，and related data could be acquired easily. At the same time，the integrity of administrative boundaries was maintained，enabling regional differentiated management.

2.2　Data sources and standardization processing　The data used in this paper were mainly composed of the following three parts：ecological and land data（Ⅰ）（from Luquan County's survey of changes in land use status in 2017），economic statistics（Ⅱ）（from *Luquan County Statistical Yearbook 2017*）and targeted poverty alleviation data（Ⅲ）（from statistics of the Targeted Poverty Alleviation Office of Luquan County on targeted poverty alleviation in 2017 − 2018）.

　　In order to eliminate the impact of the magnitude and dimensional differences in the values of the indices in the original data，the index data needed to be dimensionless and normalized. The calculation formula was as follows：

$$T_{ij\text{positive}} = \frac{X_{ij} - \text{Min}(X_{ij})}{\text{Max}(X_{ij}) - \text{Min}(X_{ij})} \quad\quad (1)$$

$$T_{ij\text{neigtive}} = \frac{\text{Max}(X_{ij}) - X_{ij}}{\text{Max}(X_{ij}) - \text{Min}(X_{ij})} \quad\quad (2)$$

where T_{ij} represents the score of the j-th index of the i-th unit in the index system; $\text{Max}(X_{ij})$ represents the maximum value of the j-th index in all evaluation units; and $\text{Min}(X_{ij})$ represents the minimum value.

2.3 Construction of index system for regionalization The key step in land use regionalization is the selection of indices. Different indices selected directly results in different regionalization results. Therefore, according to the purpose of land use regionalization in this paper, representative indices were selected carefully. Combining the social and economic development status and land use status of Luquan County, with reference to its progress in poverty alleviation, requirements of various development plans, and acquisition of data, 4 primary indices were selected, ecological environment, socioeconomics, land resources and land use, and direction of poverty alleviation and development and key ways to alleviate poverty, and 23 secondary indices were selected (Table 1).

Table 1   Index system for land use regionalization in Luquan County

Index cluster	Index	Connotation	Source of basic data
Ecological environmental indices	Forest coverage // %	Forest area/Total land area × 100%	Calculated from survey data about changes in land use in 2017
	Proportion of slope farmland with slope greater than 25°	Area of slope farmland with slope greater than 25°/Area of arable land × 100%	Calculated from survey data about changes in land use in 2017
	Proportion of bare land // %	Area of bare land/Total area of land × 100%	Calculated from survey data about changes in land use in 2017
	Proportion of waters // %	Area of waters/Total area of land × 100%	Calculated from survey data about changes in land use in 2017
Socioeconomic indices	Proportion of agricultural population // %	Agricultural population/Total population × 100%	Calculated from data in *Statistical Yearbook 2017*
	Per capita disposable income of rural residents // yuan/person	Income available to rural residents for discretionary use	Calculated from data in *Statistical Yearbook 2017*
	Output value of primary industry per capita // yuan/person	Gross output value of primary industry/Total population	Calculated from data in *Statistical Yearbook 2017*
	Average output value of primary industry in agricultural land // yuan/ha	Gross output value of primary industry/Area of agricultural land	Calculated from data in *Statistical Yearbook 2017*
	Per capita food production // kg/person	Total food production/Total population	Calculated from data in *Statistical Yearbook 2017*
	Growth rate of per capita disposable income of rural residents // %	Increase in per capita disposable income of rural residents/Per capita disposable income of rural residents in the base period × 100%	Calculated from data in *Statistical Yearbook 2017*
	Growth rate of agricultural output value per capita // %	Increase in per capita agricultural output value/Per capita agricultural output value in the base period × 100%	Calculated from data in *Statistical Yearbook 2017*
	Increase in yield of farmland // %	Current yield of agricultural land/Base yield of agricultural land × 100%	Calculated from data in *Statistical Yearbook 2017*
Land resources and land utilization indices	Land area per capita // ha/person	Total land area/Total population	Calculated from survey data about changes in land use in 2017
	Arable land area per capita // ha/person	Area of arable land/Total population	Calculated from survey data about changes in land use in 2017
	Construction land area per capita // m²/person	Area of construction land/Total population	Calculated from survey data about changes in land use in 2017
	Land utilization rate // %	Area of land used (agricultural land + construction land)/Total land area × 100%	Calculated from survey data about changes in land use in 2017
	Land reclamation rate // %	Area of arable land/Total land area × 100%	Calculated from survey data about changes in land use in 2017
	Proportion of construction land // %	Area of construction land/Total area of land × 100%	Calculated from survey data about changes in land use in 2017
	Proportion of residential land and industrial and mining land in construction land // %	Area of residential and industrial land /Total area of construction land × 100%	Calculated from survey data about changes in land use in 2017

(To be continued)

（Continued）

Index cluster	Index	Connotation	Source of basic data
	Proportion of slope farmland with slope greater than 15° //%	Area of slope farmland with slope greater than 15°/Area of arable land ×100%	Calculated from survey data about changes in land use in 2017
Direction of poverty alleviation and key ways to alleviate poverty	Incidence of poverty //%	Poor population/Total rural population × 100%	Calculated from data in *Statistical Yearbook 2017* and data about poverty alleviation and development
	Proportion of poor villages //%	Number of poor villages/Number of administrative villages ×100%	Calculated from data in *Statistical Yearbook 2017* and data about poverty alleviation and development
	Withdrawal rate of poor population //%	Poverty-free population/Total registered population ×100%	Calculated from data in *Statistical Yearbook 2017* and data about poverty alleviation and development

2.4 Determination of weight with entropy method There are many methods for determining weight, which are mainly divided into subjective weighing methods, objective weighing methods and combined weighing methods. In this paper, entropy method was adopted. The entropy method is to calculate the degree of difference by calculating the information of each index, and based on this, the weight value was determined. If the information entropy of the index is smaller, the degree of difference is greater, and the weight value is greater, and vice versa. The specific calculation steps were as follows:

The weight of the value of the i-th sample in the j-th index:

$$P_{ij} = \frac{T_{ij}}{\sum_{i=1}^{n} T_{ij}} \tag{3}$$

The entropy of the j-th index:

$$e_j = \frac{1}{\ln n} \sum_{i=1}^{n} (P_{ij} \ln P_{ij}) \tag{4}$$

The difference coefficient and weight of j-th index:

$$g_j = 1 - e_j \tag{5}$$

The weight of the j-th index:

$$W_j = \frac{g_j}{\sum_{i=1}^{m} g_j} \tag{6}$$

Using the analytical hierarchy process, the weights of various indices of Luquan County's main functional regionalization system were obtained (Table 2), and their CRs all passed the consistency test.

Table 2 Weight coefficients of indices for land use regionalization in Luquan County

Index cluster	Weight	Index	Entropy method (W_j)
Ecological environmental indices	14.346	Forest coverage //%	2.148
		Proportion of slope farmland with slope greater than 25°	1.623
		Proportion of bare land //%	1.303
		Proportion of waters //%	9.273
Socioeconomic indices	44.049	Proportion of agricultural population //%	18.126
		Per capita disposable income of rural residents //yuan/person	2.131
		Output value of primary industry per capita //yuan/person	6.244
		Average output value of primary industry in agricultural land //yuan/ha	3.027
		Per capita food production //kg/person	3.353
		Growth rate of per capita disposable income of rural residents //%	2.937
		Growth rate of agricultural output value per capita //%	2.439
		Increase in yield of farmland //%	5.791
Land resources and land utilization indices	30.358	Land area per capita //ha/person	3.706
		Arable land area per capita //m²/person	4.935
		Construction land area per capita //m²/person	6.122
		Land utilization rate //%	1.494
		Land reclamation rate //%	2.207
		Proportion of construction land //%	6.333
		Proportion of residential land and industrial and mining land in construction land //%	3.669
		Proportion of slope farmland with slope greater than 15° //%	1.891
Direction of poverty alleviation and key ways to alleviate poverty	11.247	Incidence of poverty //%	3.495
		Proportion of poor villages //%	5.037
		Withdrawal rate of poor population //%	2.715

3   Cluster analysis and regionalization results

3.1   Cluster analysis

According to the comprehensive score of each evaluation unit, the clustering method was adopted for clustering. According to the dendrogram (Fig. 1), the cluster analysis process and preliminary regionalization results of the 16 townships (towns) in Luquan County were intuitively obtained. At the distance of 4.5, the evaluation units of Luquan County were divided into five groups: Pingshan Street; Zhongping Town; Tuanjie Town; Malutang Township, Tanglang Township and Yunlong Township; Cuihua Town, Xueshan Township, Wumeng Township, Jiulong Town, Sayingpan Town, Zhuanlong Town, Jiaopingdu Town, Maoshan Town, Zehei Township and Wudongde Town. At the distance of 5, the 16 townships (towns) in Luquan County were divided into three groups: Pingshan Street; Zhongping Town; and Tuanjie Town, Malutang Township, Tanglang Township, Yunlong Township, Cuihua Town, Xueshan Township, Wumeng Township, Jiulong Town, Sayingpan Town, Zhuanlong Town, Jiaopingdu Town, Maoshan Town, Zehei Township and Wudongde Town.
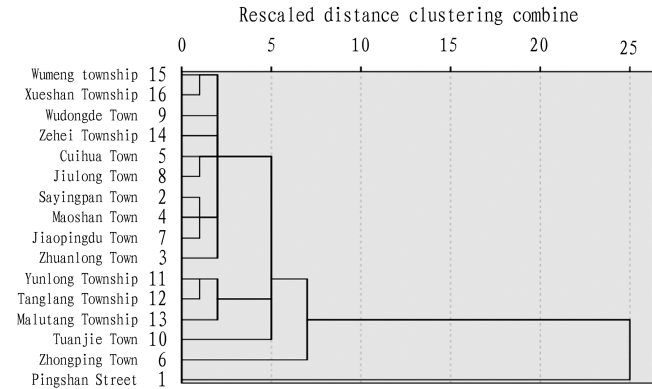

Fig. 1   Dendrogram of towns (townships) in Luquan County in terms of land use

3.2   Adjustment and correction of cluster analysis results

The quantitative analysis method has inherent defects in the actual application process. For example, there may be some volatility between the index data and the actual situation. As a result, the results of regionalization are extremely susceptible to interference by special values, leading to appearance of some classified individuals that are inconsistent with the actual situation. Coupled with the relevant raw data and socioeconomic development data used in cluster analysis, it is manifested by that the status of land use and socioeconomic development in the target area at a certain point in time cannot reflect the various impacts of future human activities on regional land use. Therefore, the above-mentioned hierarchical clustering results needed to be corrected from two aspects: natural factor and policy factor.

For correction from natural factor, the integrity of the administrative boundaries must first be maintained. At the same time, the natural conditions inherent in the administrative regions were taken into account to maintain similarity in the direction of land use among the regions. The specific adjustment plan was as follows. According to the typical climatic characteristics and topography of the Jinsha River Basin and the conditions of transportation facilities, Xueshan Township (No. 16), Wumeng Township (No. 15), Wudongde Town (No. 9), Zehei Township (No. 14), Tanglang Township (No. 12), Jiaopingdu Town (No. 7) and Malutang Township (No. 13) were classified into one cluster. According to regional integrity and tourism resources, Zhuanlong Town (No. 3), Cuihua Town (No. 5) and Jiulong Town (No. 8) were classified into one cluster.

According to the hierarchical clustering results obtained by SPSS software, combined with relevant requirements of government documents such as 13*th Five-Year Plan for Luquan County* and *General Land Use Plan of Luquan County* (2010 – 2020), and taking industrial structure adjustment, urban system optimization, accelerated urbanization process, urban land demand, land use development direction, *etc.*, not only the natural conditions of Luquan County must be considered, the social and economic development conditions and policy factor of Luquan County must also be considered. The specific adjustment plan was as follows. According to the development plan of Luquan County for new town, Pingshan Street (No. 1) and Maoshan Town (No. 4) were merged as the core area of the new town. According to the construction plan of the water source protection area of Yunlong Reservoir, Sayingpan Town (No. 2), Zhongping Town (No. 6), Yunlong Township (No. 11) and Tuanjie Town (No. 10) were merged.

3.3   Results of land use regionalization

In summary, by adjusting and correcting the results of cluster analysis, the land use in Luquan County was classified into four regions: poverty alleviation region for development of new town and characteristic industries in the southwest (I), agricultural development and ecological poverty alleviation region in the central mountainous area (II), poverty alleviation region for development of characteristic agriculture and tourism towns in the eastern plateau mountainous area (III) and poverty alleviation region for development of characteristic industries and protection of land ecology in the northern alpine valley area (IV). Basically, the purpose of dividing towns with common characteristics in the same land use division was achieved, indicating that the comprehensive land use regionalization results were reasonable. The final land use regionalization results are shown in Table 3.

Table 3   Results of land use regionalization of Luquan County

Region	Town (township) included	Area//ha	Proportion//%
I	Pingshan Street, Maoshan Town	54 480.14	12.87
II	Zhongping Town, Sayingpan Town, Yunlong Township, Tuanjie Town	94 138.60	22.23
III	Jiulong Town, Cuihua Town, Zhuanlong Town	122 880.85	29.02
IV	Wudongde Town, Jiaopingdu Town, Tanglang Township, Malutang Township, Zehei Township, Wumeng Township, Xueshan Township	151 891.80	35.88

4   Suggestions for reasonable use of land in various regions of Luquan County based on the targeted poverty alleviation strategy

4.1   Poverty alleviation region for development of new town and special industries in the southwest（Ⅰ）

This region serves as the political, economic and cultural center of Luquan County. It has the advantages of high level of economic development, perfect infrastructure and convenient transportation, and plays a role in driving the county's economic and social development. Therefore, aiming at this comprehensive area that gathers modern service industries such as administration, commerce, finance and logistics, according to the carrying capacity and development potential of resources and environment, the structure of the three industries should be adjusted rationally, and the degree of intensification of land use should be improved continuously. In terms of goal of land use control, it should accelerate the integration of urban and rural resources and optimize the allocation of space resources to promote the formation of urban-rural integration and coordinated development of the region. In terms of urban functions, it should guide the rational development of the population, and accelerate the administrative and public service functions, as well as the construction of core functions such as transportation hub, logistics, economy and trade, scientific and educational research and development, financial services, information services and cultural exchanges. From the perspective of construction land, scientific planning should be carried out in conjunction with the basic situation of development and the actual situation of land use in the county, and priority should be given to industrial agglomeration, such as developing industrial parks and concentrating industrial land, to improve the intensification of construction land. In terms of agricultural land, it should strictly maintain the quantity and quality of cultivated land and strictly comply with the cultivated land protection system to guarantee the food security of the county.

4.2   Agricultural development and ecological poverty alleviation region in central mountainous area（Ⅱ）

The Yunlong Reservoir in the region is an important centralized drinking water source in Kunming, and it provides 60% of water supply for Kunming's main urban area. Yunlong Reservoir water source protection area has been constructed, involving Yunlong, Sayingpan and Tuanjie. The principle of land use in this region is to protect the ecological environment of water source area, prohibit deforestation and steep slope reclamation, abolish projects that pollute the environment and destroy ecology. On the basis of ensuring the security of regional ecosystem, appropriate and moderate development should be carried out. In accordance with the requirements of water source area protection projects and ecological agricultural projects, it should do a good job in returning farmland to forest and grassland, adjust the structure of agricultural land reasonably according to local conditions, optimize resource allocation, promote the rapid development of ecological industry, increase the intensification of agricultural production and development in the dam area, promote the construction of farmland water conservancy infrastructure and ancillary projects, expand the area of irrigable land, solve the irrigation problem of farmland, develop characteristic industries according to local condi-

tions and effectively protect cultivated land.

4.3   Poverty alleviation region for development of characteristic agriculture and tourism towns in the eastern plateau mountain（Ⅲ）

This region has a relatively good natural ecological environment. The forest coverage rate in Zhuanlong Town is as high as 68%. There is Jiaozishan National Nature Reserve within the territory. The direction of land use regulation in this region is to develop tourist routes in Jiaozi Snow Mountain according to local unique natural resource environment and cultural advantages, create a tourism service area in Zhuanlong Town that integrates tourism, leisure and vacation, promote the integrated development of urban tourism and promote the development of tertiary industry such as tourism services, relying on the advantages of resources in Jiaozi Snow Mountain Scenic Area. Industrial support and local cultural characteristics, by accelerating the improvement of regional infrastructure to lead the people to alleviate poverty and drive the economic development of surrounding areas, appropriately adjust the intensity of land use, actively troubleshoot geological hazards, protect land resources, strengthen the protection of basic farmland and the development of characteristic agricultural products, strictly protect the existing ecological forests and vigorously develop economic fruit.

4.4   Poverty alleviation region for development of characteristic industries and protection of land ecology in alpine valley area（Ⅳ）

Aiming at the characteristics of prominent human-land contradictions, fragile economic environment and poor anti-interference ability in the alpine valley area, the basic principle of land use regulation in this region is to protect the ecology, take into account social and economic development and strictly prohibit industrial production that destroys the ecological environment, to ensure that the construction of ecological civilization and socioeconomic development in the region are coordinated, united and sustainable. The specific approaches are the following: delineating ecological protection red line, confirming the prohibited development areas, developing strict protection policies, developing characteristic industries adapted to the three-dimensional climate of the alpine valley area according to local conditions, enhancing the protection of agricultural land at a highly suitable level, carrying out intensive management, promoting the return of slope farmland to forests and grasslands, carrying out comprehensive treatment in ecologically fragile areas where soil layers are thin and soil rocky desertification and soil erosion are serious, strictly protecting the existing ecological forests in the region, vigorously developing suitable economic forests, improving forest coverage rate through afforestation, improving the ecological function and economic and social benefits of the region, conducting land remediation and environmental remediation for industrial and mining land where ecological environment is destroyed by mining, and increasing infrastructure construction and power development on the exiting basis.

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support in policies and other aspects. The field investigation and evaluation practice in the past 4 years shows that organizing a large number of graduate students on campus to reach poor mountainous areas to carry out household surveys is not only to complete the important task of third-party assessment for targeted poverty alleviation, and it can also effectively implement the original intention and mission of "serving the poor households wholeheartedly", effectively publicize the national targeted poverty alleviation policies, and open a valuable second class for students to enable them to learn knowledge, skills and experience not learned in class, receive a good patriotism education and improve their overall quality significantly.

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