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Original Research

Land Use Transition of the Mountain-Basin System under the Background of Rural Revitalization: Based on Four Typical Mountain-Basin Systems

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Abstract

Carrying out a comprehensive and comparative study on the characteristics of land use transition in typical mountainous areas in China can essentially reveal the dynamic changes in the relationship between man and land. It's significant to research on the land use transition of the mountain-basin system, for the land use transition and sustainable land use in mountainous areas. This study took four mountain-basin systems in Puding county of Guizhou province, Southwest China as a typical case. Based on high-resolution remote sensing images for 1973-2020, combined with field survey to verify data, we used the ArcGIS platform's land use transfer matrix and importance value index method to quantitatively analyze the characteristic of land use transition of typical mountain-basin systems in the past 50 years. Furthermore, this study probed the stage and diversity of land use transition and inspirations of rural revitalization. The results showed that: (1) The basin system was based on the transition of cultivated land, which was mainly transformed into agricultural facility land, garden land and transportation land. Affected by the transition of cultivated land, the land use function had transformed from a single traditional agricultural production function to a complex modern agricultural production function. The mountain system was dominated by the transition of cultivated land, which was transformed into forest land. With the shrinkage of cultivated land, its land use function was dominated by a single ecological conservation function. (2) There were significant differences in the stage and evolutionary path of the land use transition in the mountain-basin system, going through a single-function dominant stage, a single-function to multi-function transition stage and a multi-function combined stage. The land use of the basin system was transformed into non-agriculturalization, non-grain and intensification. Nevertheless, the land use in the mountain system

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became more extensive and marginalized. (3) The combined effects of physical factors, socioeconomic factors, policies and actors have driven the transition of land use in the mountain-basin system. The results provide a scientific reference for rural land use transition and sustainable development.

Keywords: rural revitalization, mountain-basin system, land use transition

Introduction

The rapid development of global urbanization has a profound impact on land use transition, which is particularly prominent in economically underdeveloped mountainous areas. The land use transition in mountainous areas is a process of interaction between land intensification and extensive land use. The land use in mountainous areas poses a huge challenge to the sustainable development of mountainous areas. Land use transition is a process in which land use morphological changes adapted to socioeconomic development driven by socioeconomic transition [1]. It is an important part of urban-rural transformation and an important way to realize the rural revitalization strategy, and an important link of agricultural and rural modernization and urban-rural integrated development [2].

In the 1990s, Mather proposed the forest transition hypothesis [3-4], and then British geographer Grainger proposed the concept of land use transition from the perspective of land use change [5]. At the beginning of the 21st century, the Chinese scholar Longhualou introduced land use transition into China. Since then, land use transition has become a hot issue of academics attention in China and other countries. In terms of research content, it is extensive, ranging from the definition and connotation, theory, framework, formation mechanism, influencing factors and spatial-temporal evolution [6-12]. Existing literature focuses on farmland transition [13], rural residential land transition [14], forest transition [15] and transition of urban-rural construction land [16]. In addition, with the in-depth research of land use transition and urban-rural transition [17], the production-living-ecological spaces transition research [18], ecological environmental effects [19]and economic transition [20], have been achieved the fruitful results. These subject areas include geography, ecology, economics and environmental science [21-24]. The research case areas involve many counties and regions, including: European regions, Asian regions, Brazil, China and Australia [25-29], which tends to be a typical basin, urbanized areas and agricultural development areas [30-32]. The research scale covers the world, countries, provinces (states), cities and towns, taking provinces or cities as the research focus [33-36]. However, existing research has mostly focus on the characteristics of spatial-temporal evolution, more and less on the stages and diversity of land use transition. Therefore, the understanding of the relationships among the system elements still needs to be deepened. In addition, there are relatively few studies on mountainous areas from a small scale, and the research perspective is mostly single.

Mountains account for 22% of the world's land area [37], and China's mountainous areas accounts for 65% of the land area[1], among them, southwest mountainous area of it accounts for 12% of total land area. In this region, there are many mountainous lands few flat lands, topography undulations and slopes, high and low topography interlaced, and other physical factors have formed a unique mountain-basin system [38]. The term mountain-basin system is derived from the concept of the basin and mountainous area, and has been studied in-depth until the 21st century. Li Yangbing believed that the mountain-basin system was a system composed of a series of basins with different spatial scales in basins, depressions and surrounding mountains [39]. Some scholars believed that the mountain-basin system was a human-centered dynamic open system within a certain range, connecting the land and economy between the basin and the mountain area through human flow, logistics, and information flow [40]. Other scholars believed that the mountain-basin system was a comprehensive system composed of a basin site with a certain scale, flat terrain and mountains areas around the basin site. This system took the man-land relationship as the core and has the characteristics of non-linearity, complexity, dynamics and comprehensiveness [38]. Thus, the mountain-basin system is centered on the relationship between man and land [40-41]. The mountain-basin system is formed by interaction of two subsystems under the physical geographical environment and socioeconomic background, and also is a natural history complex system of interconnection and dynamic succession [42]. In many mountainous areas where the mountain-basin system is the site of interaction between nature and society, and its evolution is influenced by endogenous power and external factors. Therefore, land use in the mountain-basin system is an important part of the land use transition in mountainous areas, and whether the land use transition is reasonable or not, is directly related to the sustainable development of mountainous areas.

A large amount of current literature show that the land use transition of mountain-basin system mainly analyzed the spatio-temporal characteristics and evolution differences of land use and landscape pattern, the land use coupling evolution framework, land use evolution characteristics and landscape

1 From China Digital Mountain Map, China Map Publishing House, 2015.

coupling. However, under the background of significant differences in resource endowment, location and socioeconomic conditions of the mountain system and the basin system presented different land use evolution paths in the process of land use transition, and they interacted with each other, resulting in the significant differences in land use function [38]. In particular, it is most pronounced in the mountainous areas of Southwest China [43-44]. which directly affected the socioeconomic development of the mountain-basin system. Therefore, it is necessary to carry out a comprehensive study on the characteristics of land use transition in a fine space, and compare and analyze the different characteristics of land use transition patters, for sustainable development of mountainous areas and the realization of man-land coupling and coordination in mountainous areas.

Based on the above questions, this study took four typical mountain-basin systems in Puding county, Guizhou province, Southwest China as a typical case, quantitatively analyzed the evolution characteristics of the land use quantity and function of the mountain-basin system in the past 50 years, using land use transfer matrix and importance value index. This study aims were to reveal the land use transition and development law of mountain-basin system in karst areas, Southwest China under the background of rural revitalization, promote sustainable development of mountainous villages using an effective way, in order to provide a scientific reference value for rural revitalization and sustainable development.

Material and Methods

Study Area

This study selected the Dayou mountain-basin system (DYM-BS for short), Taojia mountain-basin system (TJM-BS for short), Munai mountain-basin system (MNM-BS for short) and Chaixin mountain-basin system (CXM-BS for short), Puding county, Southwest Guizhou province, China, as study subject. Four study areas are located at 105°30'~106°E, 26°10'~26°20'N (Fig. 1). The area belongs to the subtropical monsoon humid climate, and has good

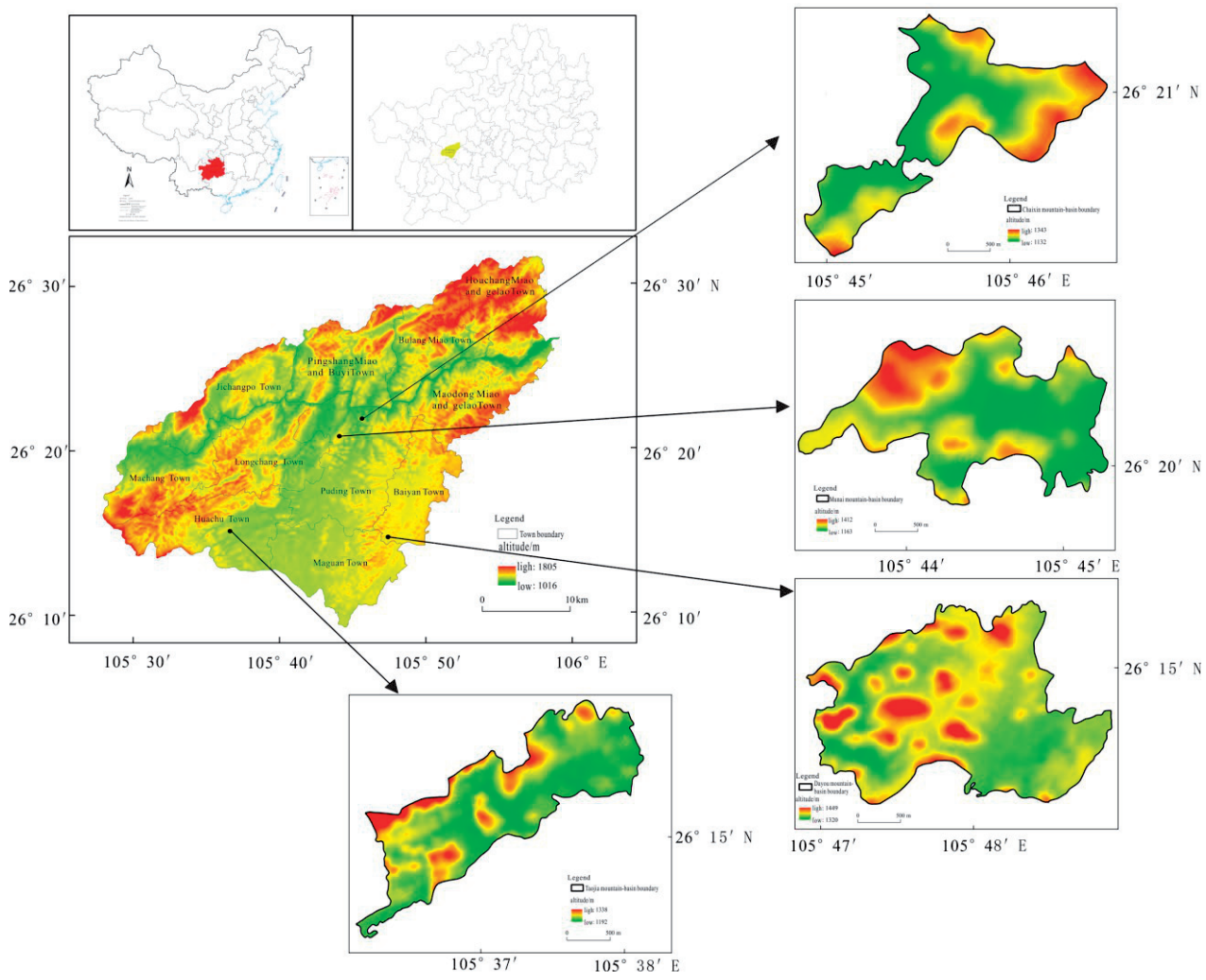

Fig. 1. Location of the study area.

hydrothermal conditions, with an average annual temperature of 15°, and an average annual rainfall of 1378 mm. The topography is dominated by peak clusters and depressions, karst landforms are widely distributed, and rocky desertification is serious. Before 2010, the four mountain-basin systems were mainly based on traditional agriculture, and the income of farmers came from grain planting. Since 2015, driven by both economic development and policies has promoted the rural transition of production-living-ecological. Different resource endowments and differences in the role of internal and external factors have led to the differentiation of the development of the mountain-basin system (Table 1). The DYM-BS and the TJM-BS rely on good location conditions and relatively large basin area, and actively developed characteristic plantings. Cash crops, such as chives and chayote, were large-scale. Among them, the "Baiqi" chives won the National Geographical Indication and were selected into the Chinese Agricultural Brand List in 2019. The CXM-BS relied on ethnic characteristics and modern leisure agriculture to develop rural tourism. Tourism services such as catering, shopping, and accommodation are becoming more mature. The CXM-BS won the "Chinese Minority Characteristic Village" in 2016, where was the key rural tourism place in Guizhou province in 2020. Due to the lack of funds, serious population loss, aging population, insufficient technical input in the MNM-BS, agricultural production has been restricted, and large areas of farmland have been marginalized and abandoned.

Definition and Identification of Basin System and Mountain System

There are few studies on the mountain-basin system in the existing research, and there's no universal academic definition of the concepts of basin system and mountain system. Existing studies have defined the mountain-basin system as Bazi. According to the topography of Yunnan province, flat areas with a slope of 8° and below and an area greater than 100 hm^2 are defined as Bazi [45]. Some scholars judged from the topography and geomorphology of Guizhou that a flat land with a slope of less than 6° and continuous in space was a basin [46]. Existing studies have defined the mountains from the angles of slope, altitude and relief amplitude [47-49]. For example, UNEP and the European Commission have defined mountain areas into 7 and 5 types based on the slope and the altitude. Other scholars also divided the mountainous areas of Sichuan, Guizhou, and Guangxi from the two aspects of slope and altitude based on the county scale, and divided them into four types as semi-mountainous county, quasi mountainous county, apparently mountainous county and completely mountainous county [39, 50-51]. Drawing on existing research results (Bazi, mountains, mountain-basin systems) [39, 45, 52-53], this study defined the basin and the mountain system based on the slope, elevation, high-resolution remote sensing images and field investigation of the study area.

According to the following characteristics the basin system is defined as the slope is below 6°, the terrain is flat, the shape is relatively regular, and the basin is continuous in space. It is a dynamic and open system that carries multiple functions such as urban development, industrial construction and agricultural production. The mountain system is to the area with a slope above 6°, surrounding the basin area, it is a complex and comprehensive system that carrying the function of environmental protection, production and living.

Referring to the existing research [39, 45-46], the 0.5-meter high-resolution Google Earth remote sensing image in 2020, 12.5-meters resolution digital elevation model(DEM), this study identified and interpreted the mountain system and the basin system boundary using ArcGIS 10.2 software, and carried out

Table 1. Development of the mountain-basin system industry.

The first class of mountain-basin system	The second class of mountain-basin system	Study area	The proportion of area /%	Industrial
Mountain-Basin system	Basin system	CXBS	0.10	Rural tourism Cash crops planting (Ginger)
		DYBS	0.25	Cash crops planting (chives)
		MNBS	0.09	Food crops planting Few fruit forest land (Grape)
		TJBS	0.29	Cash crops planting (Chayote)
	Mountain system	CXMS	0.90	Forest land Fruit forest land
		DYMS	0.75	Forest land Few cash crops
		MNMS	0.91	Forest land
		TJMS	0.71	Forest land Food crops planting

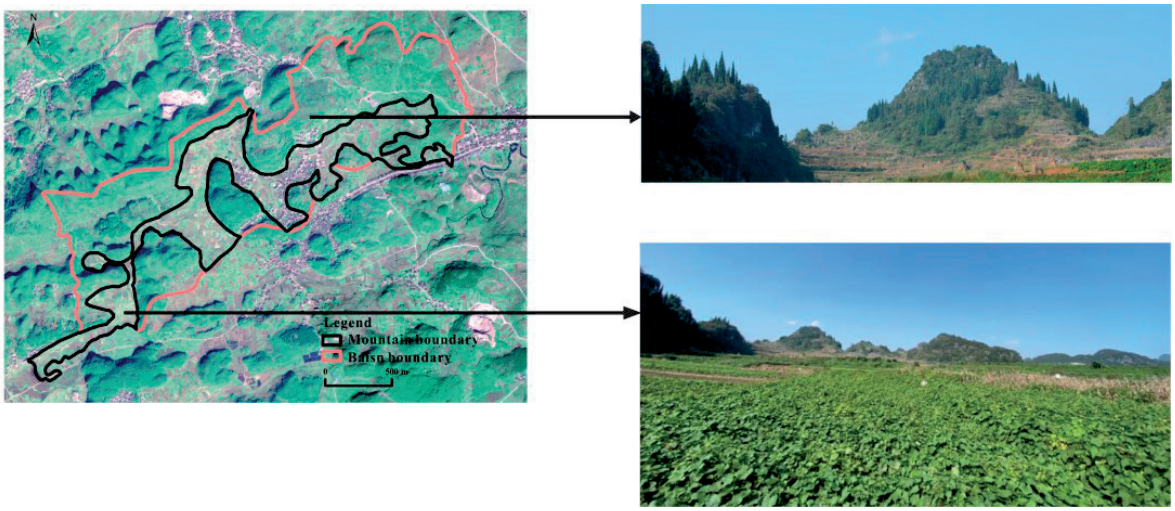

Fig. 2. Identification of the mountain system and the basin system.

on-site investigations and corrections of the mountain system and the basin system boundary in study area. Finally, the boundary between the mountain system and the basin system were obtained (Fig. 2).

Data Sources

The data of the study area comes from the 1:50000 topographic map for 1973, the 1.5 m high-resolution SPOT image for 2004, and the three phases of 0.5 m high-resolution Google Earth remote sensing images for 2010, 2015, and 2020. The geometric correction was performed on the images for 1973, 2004, 2010, 2015, and 2020 at four study areas using the ArcGIS 10.2 software. After registration preprocessing, the images for 2020 were visually interpreted, and then it has obtained land use vector data of the study area for 2020. Based on the land use vector data for 2020 at the four study areas, and the high-resolution remote sensing images for 1973, 2004, 2010 and 2015, the land use vector data of the four study areas for 1973, 2004, 2010 and 2015 was obtained through the method of comparative interpretation. Secondly, the topological inspection and modification of the land use data for each period were carried out, and the land use vector data for 1973, 2004, 2010, 2015, and 2020 at four study areas were obtained, respectively. From October 2020 to September 2021, the author conducted field investigation in the study area. At the same time, the author conducted investigation and interviews with the residents the time nodes of land use changes, important events, labor conditions and industrial development in the study area. Then, the author checked and modified the vector data based on the actual results of the final investigation. After field investigation, we ultimately obtained the land use vector data of four mountain-basin systems in five periods. The classification accuracy of the kappa coefficient is above 0.90, which meets the accuracy requirements.

Research Methods

Land Use Type Classification System of Mountain-Basin System

The land use pattern determines the land use type, and different land use types are the most direct manifestations of different land use patterns [54]. Due to differences in land use patterns and intensity, there are significant differences in land use types. Therefore, the correct identification of various land use types is an important basis for this research. Firstly, according to the "GB/T2010-2017" classification of land use status in China, the author referred to the existing research results [55] and combined the study area situation, the land use classification system can be divided into eleven first-level and fifteen second-level land use types. The first-level land use types include cultivated land, garden land, forest land, grassland, commercial land, industrial and mining storage land, residential land, public management, public service land, transportation land, water area and land for water conservancy facilities and other lands (Table 2). Secondly, visual interpretation and attribute definition of remote sensing images in the study area were carried out according to land use classification standards. Finally, the classification results were transformed into vector format.

Land Use Function Classification System of Mountain-Basin System

Different land use types reflect different land use function [56], and different land use patterns and intensity of use will form different dominant function. Therefore, based on the research results of "Rural Multi-functionality" [57], "Agricultural Multi-functionality" [58], and "Land Use Multi-functionality" [59]and combined the research content of this study, we constructed the land use function classification

Table 2. The classification of land use type in the mountain-basin system.

Code	First class	Code	Second class
01	Cultivated land	0101	Paddy field
		0102	Dryland
02	Garden land	0201	Orchard
		0203	Other garden land
03	Forest land	0301	Arbor
		0305	Shrub
		0307	Other forest land
04	Grassland	0403	Other grassland
05	Commercial land		
06	Industrial and mining storage land		
07	Residential land	0702	Rural residential land
08	Public management and service land		
10	Transportation land		
11	Water and water conservancy facilities		
12	other land	1202	Agricultural facility land

system of the mountain-basin system (Table 3). The land use function of the mountain-basin system is divided into five functions: traditional agricultural production function, modern agricultural production function, economic development function, social security function, and ecological conservation function. Among them, traditional agricultural production function is based on traditional farming methods, mainly producing food crops and agricultural products such as agricultural products, which can guarantee food security and survival needs. Modern agricultural production function is based on large-scale and intensive operation. And it mainly produces non-grain and non-agriculturalization crops, which is greatly affected by market supply and demand. It also provides products and function such as leisure and entertainment for citizens. Economic development functions refer to the promotion of rural economic development, agricultural improvement and the increasing of farmer's income. Social security function is the provision of residential and government-supplied public land, which guarantees rural life. Ecological conservation function is the provision of ecological product and service, which protects the ecological environment and realizes the dynamic balance of the ecological environment.

Land Use Transfer Matrix

Land use transfer matrix reflects the dynamic change information of the conversion at the beginning and the end of the study period in the study area. It can not only reflect the quantity of land use types in each period but also reflect the changes in transfers between different regions [55] (Eqs 1).

Table 3. The classification of land use function in the mountain-basin system.

Land use function	Land use types
Traditional agricultural production function	Paddy field, dryland, other garden land
Modern agricultural production function	Agricultural facility land, orchard
Economic development function	Industrial and mining storage land, commercial land, transportation land
Social security function	Rural residential land, public management and service land
Ecological conservation function	Other grassland, shrub, arbor, other forest land, water and water conservancy facilities

$$S_{ij} = \begin{vmatrix} S_{11} & S_{12} & S_{13} & \cdots & S_{1n} \\ S_{21} & S_{22} & S_{23} & \cdots & S_{2n} \\ S_{31} & S_{32} & S_{33} & \cdots & S_{3n} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ S_{n1} & S_{n2} & S_{n3} & S_{n3} & S_{5n} \end{vmatrix} \quad (1)$$

Where S represents area; n represent land use types; i and j are the land use types at the beginning and end of the study period, respectively.

Importance Value Index

The importance value is used to describe the importance of the types of changes in the study area, which reveals the dominant types of land use changes and reflects the reverse of land use function changes in the study area [60] (Equation 2).

$$IV = \left(\frac{D_i}{D} + \frac{B_i}{B} \right) \times 100\% \quad (2)$$

Where IV represent the dominant type and importance of functional changes; D_i represent the number of spots of a certain type of change; D represent the total number of spots of all changed spots in the study area; B represent the total area of all types of changes.

Results and Analysis

The Characteristics of Land Use Change

The area of cultivated land in four basin systems presented a trend of shape decrease for 1973-2020. Among this, DYBS has the largest decrease in the area of 77.97 ha. During the study period, the area of agricultural land in the three basin systems (CXBS, DYBS, TJBS) presented a trend of gradual increase , and the area of agricultural facility land increased the most, for 2015-2020, and the three basin systems accounted for about 20% of the area of the agricultural land. The proportion of MNBS's garden land is the largest among the four basin systems, with the proportion of garden land 28%. During the study period, the area of forest land of the three basin systems (DYBS, MNBS, TJBS) all decreased, with an average decrease of 6.7 ha. The area of rural residential land and transportation land presented a trend of slight increase, with an increase of about 1%-5% (Fig. 3). The area of public management and public service land and commercial

Fig. 3. The proportion of land use area in the basin system.
Note: CX indicate Chai xin basin system, DY indicate Da you basin system, MN indicate Mu nai basin system, TJ indicate Tao jia basin system.

service land presented a trend of slight increase, with the proportion of area less than 5%.

The area of cultivated land in the three mountain systems (CXMS, DYNMS, MNMS) presented a trend of increasing first and then decreasing. For 1973-2004, the area of cultivated land in the three mountain systems increased by 6.58 ha, 2.72ha and 0.22 ha, respectively. For 2004-2020, the area of cultivated land was decreased by 27.04 ha, 3.31 ha and 43.72 ha, respectively. The area of forest land in CXMS, MNMS and TJMS, increased significantly for 1973-2020, and the area of forest land increased to 21.48 ha, 17.79 ha and 9.26 ha, respectively. Among them, the area of forest land in the DYMS decreased slightly, and the area of forest land increased to 2.75 ha, the reason is that the area of forest land, this mountain system was largely transferred into the fruit forest. The increasing rate and area of rural residential land and transportation land were smaller than that of the basin system. The agricultural facility land and commercial service land accounted for a small area in the four mountain systems. Among them, agricultural facility land accounted for less than 5% (Fig. 4).

The Characteristics of Land Use Transfer

For 1973-2004, 2004-2010 and 2015-2020, in terms of CXBS, the transfer area of cultivated land accounted for 93%, 45% and 94% of the total transferred area, respectively (Fig. 5). For 1973-2004, 2004-2010 and 2010-2015, the cultivated land of DYBS was mainly transformed into residential land, transportation land, forest land and other land types. For 2015-2020, cultivated land was mainly transformed into many types of land, including agricultural facility land (70%), garden land (8%), transportation land (5%). For 1973-2020, the cultivated land in the MNBS was mainly transformed into garden land, agricultural facility land and transportation land, among 61% of the transfer area was garden land. In the TJBS, the transfer area of cultivated land accounted for 25%, 79%, 35% and 68% of the total transfer area during 1973-2004, 2004-2010, 2010-2015 and 2015-2020, and the main transfer were the area of forest land, rural residential land, water, and water conservancy facility land. Among four periods, the area transferred to rural residential land areas accounted for 24%, 79%, 74% and 3% of the cultivated land transferred, respectively.

CXMS has gradually increased the proportion of cultivated land transferred during 2004-2010 (84%), 2010-2015 (89%) and 2015-2020 (95%) in the total transferred area. It mainly transformed into forest land (Fig. 6). The cultivated land of DYMS was mainly transferred into forest land and garden land for 2004-2010, 2010-2015 and 2015-2020. Cultivated

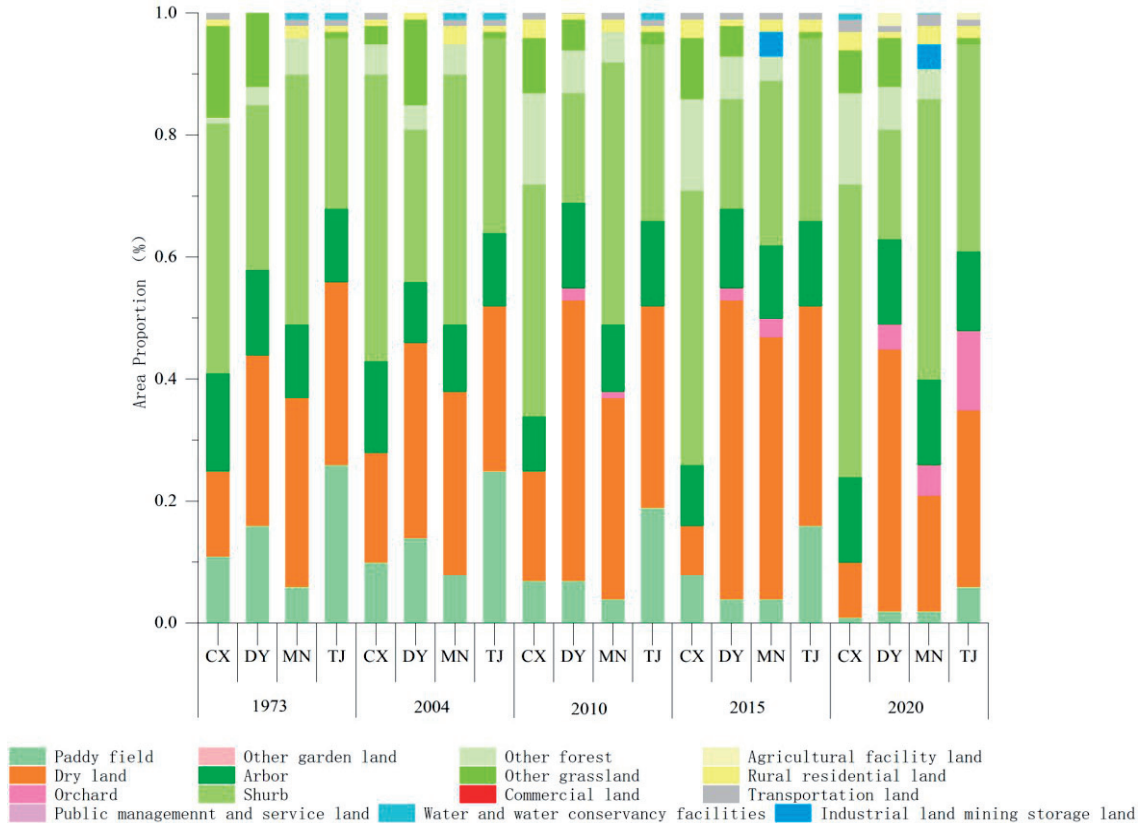

Fig. 4. The proportion of land use area in the mountain system.
Note: CX indicate Chai xin mountain system, DY indicate Da you mountain system, MN indicate Mu nai mountain system, TJ indicate Tao jia mountain system.

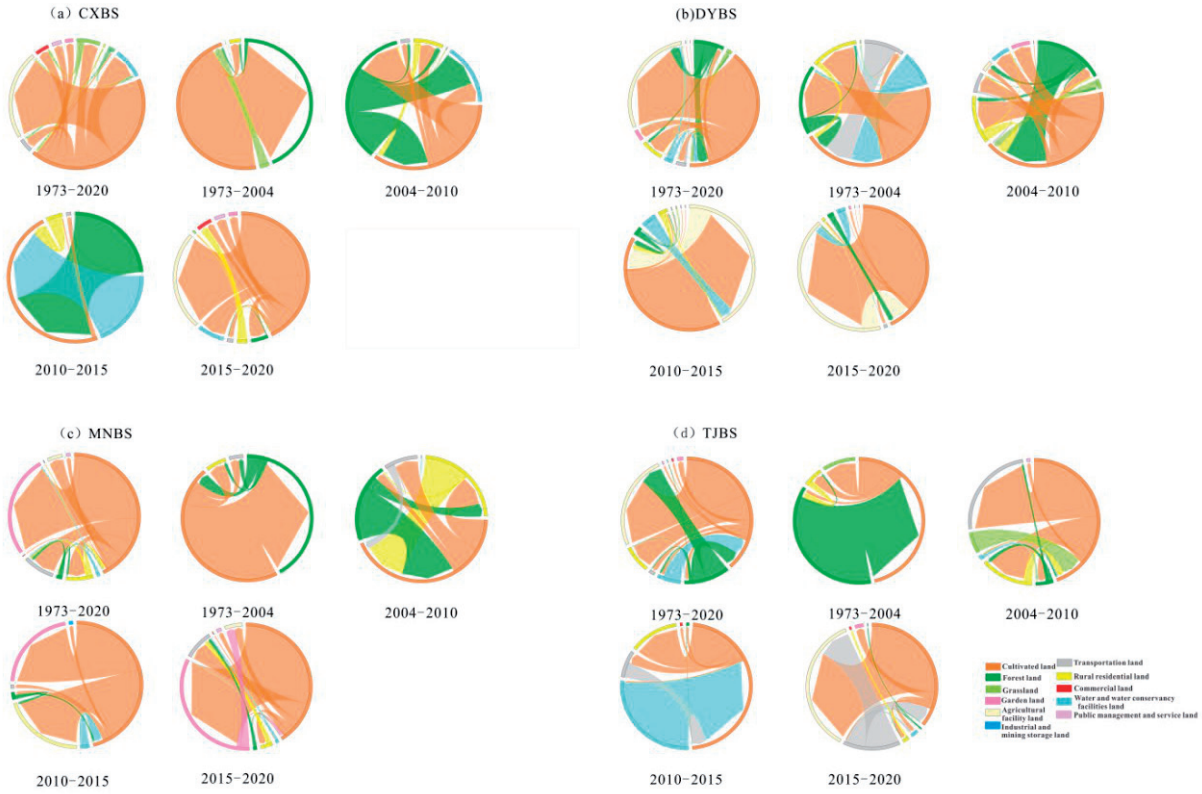

Fig. 5. Land use transfer in the basin system.
Note: CXBS indicate Chai xin basin system, DYBS indicate Da you basin system, MNBS indicate Mu nai basin system, TJBS indicate Tao jia basin system.

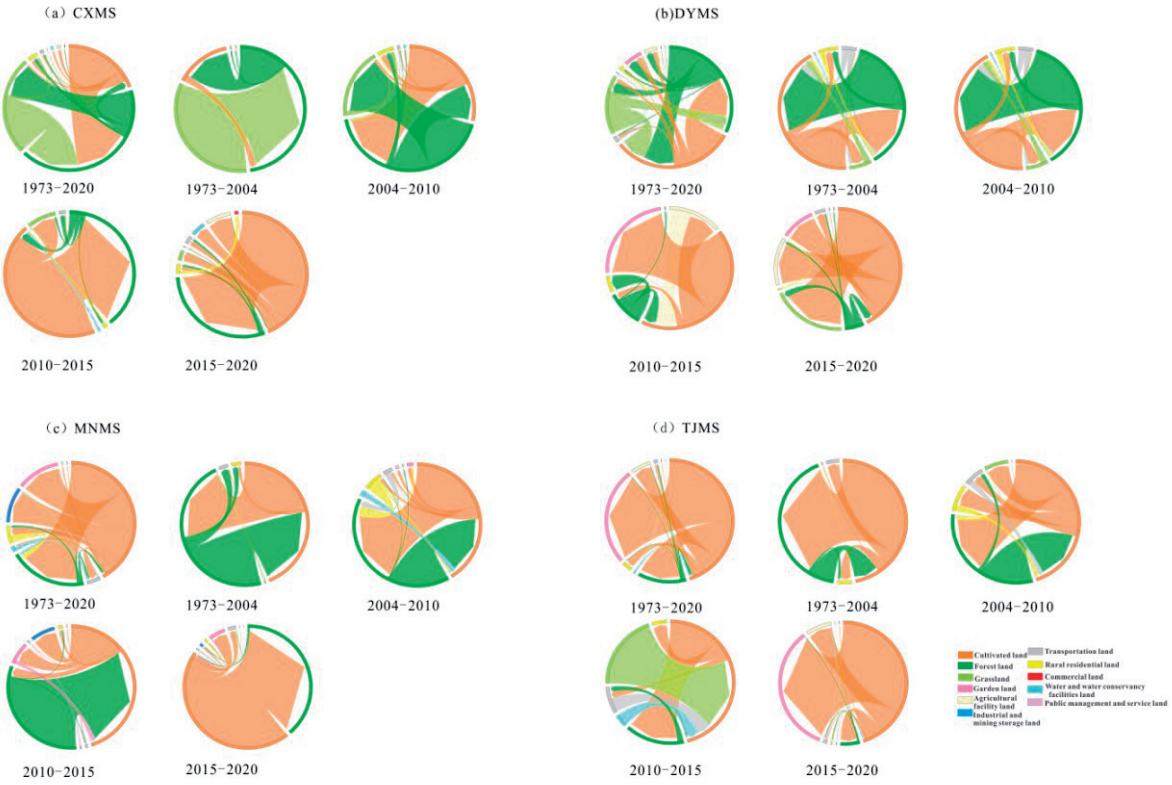

Fig. 6. Land use transfer in the mountain system.
Note: CXMS indicate Chai xin mountain system, DYMS indicate Da you mountain system, MNMS indicate Mu nai mountain system, TJMS indicate Tao jia mountain system.

land was transferred into agricultural facility land was relatively large for 2010-2020, with the transfer area ratio reaching more than 20%. For 2004-2010, 2010-2015 and 2015-2020, the cultivated land of MNMS was mainly transformed into forest land, garden land, transportation land and rural residential land. During 2004-2015, the cultivated land of TJMS was mainly transformed into forest land, transportation land, and rural residential land. For 2015-2020, the cultivated land was mainly transformed into garden land (74%). The CXMS, DYMS, MNMS and TJMS transferred a large amount of forest land to cultivated land for 1973-2004, with a transferring area of 7.70 ha, 13.04 ha, 14.43 ha and 1.06 ha, respectively.

The Evolution Characteristics of Land Use Function

For 1973-2015, the four basin systems were dominated by traditional agricultural production function. For 1973-2010, the traditional agricultural production function was mainly transformed into ecological conservation function and social security function (Fig. 7). During 2010-2015, traditional agricultural production function was mainly transferred into economic development function and modern agricultural production function. The function of traditional agricultural production was strengthened for 1973-2010, mainly from ecological conservation function to traditional agricultural production function. For 2015- 2020, modern agricultural production function was dominated in the four basin systems. During this period, The importance value index of the traditional agricultural production function transformed into the modern agricultural production function was more than 50% in the four basin systems. Among them, the DYBS was the highest, with an importance value index of 129%.

The four mountain systems were dominated by traditional agricultural production function and ecological conservation function for 1973-2015. In 2015-2020, the ecological conservation function was dominated (Fig. 8). During 1973-2020, in the CXMS, DYMS, MNMS and TJMS, the importance value indexe changed from traditional agricultural production function to ecological conservation function, which was 97%, 55%, 60% and 53%, respectively. The importance value index that the transformed of traditional agricultural production function into social security function has gradually declined. For 1973-2010, the importance value index of the transformed of ecological conservation function into traditional agricultural production function increased, and then the importance value index decreased during 2010-2020. The importance value index that the transformed of traditional agricultural production function into economic development has gradually increased. For 1973-2020, the importance value index TJMS is the largest when traditional agricultural production function was transformed into modern agricultural production function, with an important value index of 92%.

Discussion

The Stages and Evolution of Land Use Transition in the Mountain-Basin System

Through researched on land use change, land use transfer characteristic, land use function evolution in the four mountain-basin systems. Combined with field investigations, the study area was divided into a single-function dominance stage, a transition stage from single

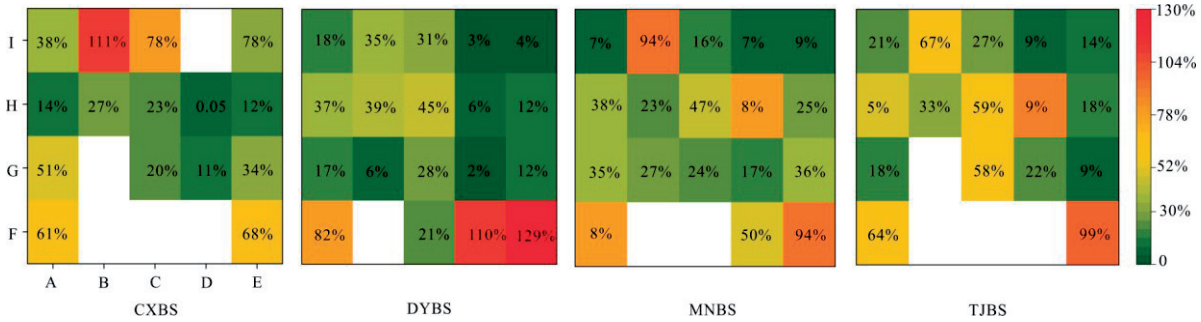

Fig. 7. The important value index of changes in traditional agricultural production functions in the basin system.
Note: A indicate the traditional agricultural production function from 1973 to 2020, B indicate the traditional agricultural production function from 1973 to 2004, C indicate the traditional agricultural production function from2004 to 2010, D indicate the traditional agricultural production function from 2010 to 2015, E indicate the traditional agricultural production function from 2015to 2020, J indicate the ecological conservation function 1973 to 2020, K indicate the ecological conservation function 1973 to 2004, L indicate the ecological conservation function 2004 to 2010, M indicate the ecological conservation function 2010 to 2015, N indicate the ecological conservation function 2015 to 2020, F indicate modern agricultural production function, G indicate economic development function, H indicate social security function, I indicate ecological conservation function, O indicate traditional agricultural production function, CXBS indicate Chai xin basin system, DYBS indicate Da you basin system, MNBS indicate Mu nai basin system, TJBS indicate Tao jia basin system.

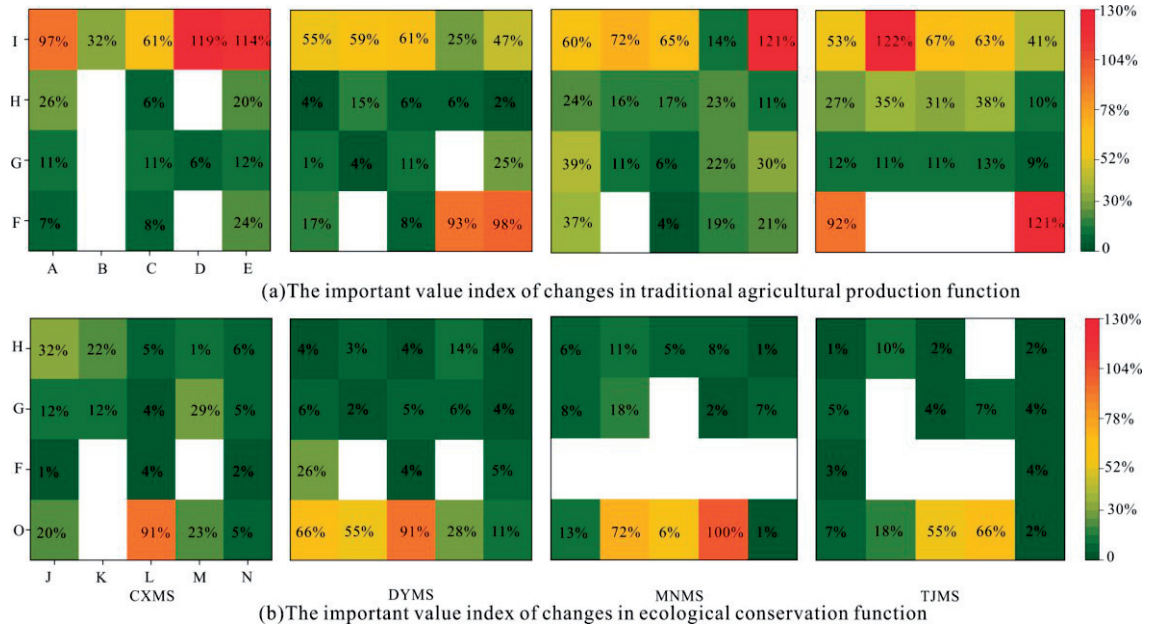

Fig. 8. The important value index of changes in traditional agricultural production and ecological conservation function in mountain system.

Note: A indicate the traditional agricultural production function from 1973 to 2020, B indicate the traditional agricultural production function from 1973 to 2004, C indicate the traditional agricultural production function from2004 to 2010, D indicate the traditional agricultural production function from 2010 to 2015, E indicate the traditional agricultural production function from 2015 to 2020, J indicate the ecological conservation function 1973 to 2020, K indicate the ecological conservation function 1973 to 2004, L indicate the ecological conservation function 2004 to 2010, M indicate the ecological conservation function 2010 to 2015, N indicate the ecological conservation function 2015 to 2020, F indicate modern agricultural production function, G indicate economic development function, H indicate social security function, I indicate ecological conservation function, O indicate traditional agricultural production function, CXMS indicate Chai xin mountain system, DYMS indicate Da you mountain system, MNMS indicate Mu nai mountain system, TJMS indicate Tao jia mountain system.

to multi-function and multi-functional equalization stage (Fig. 9).

Single-function dominance stage (1973-2010): In the early stage of the development of traditional agriculture, the land use intensity of cultivated land in basin system presented a trend of increase and the rural residential land presented a trend of expansion. The forest land of the mountain system was destroyed and reclaimed to grassland, and the area of forest land shrank. Both of them were dominated by traditional smallholder livelihood agriculture. The dominant function was the traditional agricultural production function, and the industrial development was survival-oriented. With the implementation of the household contract responsibility system, the sloping farmland has rapidly expanded, and forest land has been severely squeezed. The cultivated land and rural residential land significantly increased in basin system, while forest land was decreased. With the implementation of grain for green, development of western regions and construction of new rural areas, resulting in rapid expansion of rural residential land in the basin system. The cultivated land has decreased slightly in the mountain system, that was mainly transformed into rural residential land and forest land. The comprehensive control of rocky desertification and the implementation of water and soil erosion projects on sloping farmland as well as the impact of the policy of grain for green. As s result, in 2008, the area of forest land in the mountain system significantly increased, while the area of cultivated land presented a trend of decrease.

Transition stage from single to multi-function (2010-2015): After 2010, traditional agricultural production began to transform, and traditional agricultural planting turned to ecological-economic crop planting. Traditional small-scale livelihood agriculture was transformed into multi-functional agriculture. The transition of livelihood has led to the transition of traditional agricultural production function to modern agricultural production function and ecological conservation function. In addition, the industrial development was transformed from survival to market. Furthermore, the transportation conditions and agricultural technology have been improved, the output of agricultural labor has led to the abandonment of low-productivity sloping farmland and evolved to grassland and forest land. The government of Guizhou province encouraged the development of rural tourism and characteristic agriculture, which promoted the industrial development of the mountain-basin system in 2013. The government of Puding county issued the "Rural Land Circulation Operation Certificate"

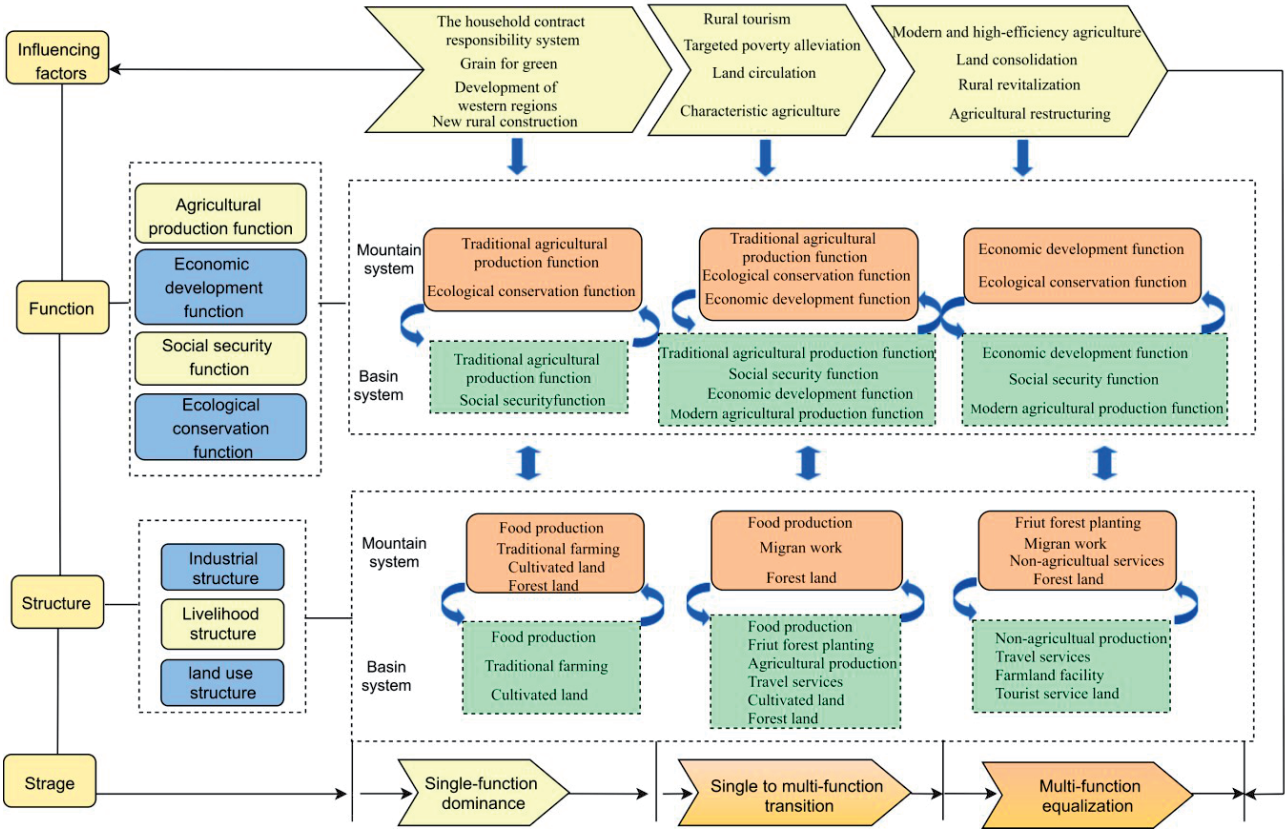

Fig. 9. The evolution stage of land use transition in the mountain-basin system.

to promote land circulation in 2014. Since then, the land circulation in the basin system has gradually increased, cash crops and traditional crops have been mixed, and the industry has gradually transformed. The loss of the labor force population and the serious aging of the labor force in the mountain system has reduced the agricultural production scale , forming a "shrinkage" land use.

Multifunctional equalization stage (2015-2020): In 2016, modern and high-efficiency agriculture was developed in mountainous areas in Guizhou province. With the agricultural demonstration park in Puding county as the carrier, the transition of cultivated land to agricultural facility land and garden land was promoted. In 2017, the land consolidation and basic farmland protection promoted the development of modern agriculture and the land circulation. In 2018, the rural revitalization strategy and the acceleration of the advancement of agricultural supply-side reforms have led to the rapid development of rural industries. The research area relied on the cultivated land resources of the basin to develop characteristic agriculture (chives and pinnacles), which has led to the rapid expansion of agricultural facility land and the shrink of traditional agricultural planting land. At the same time, the area of transportation land and the accessibility have improved. In 2019, With the rapid development of rural tourism, the study area relied on superior physical conditions and unique humanities to develop rural tourism. Rural tourism promoted land expansion for tourist facilities and commercial development, and the tertiary industry has developed rapidly. The characteristic agriculture (chives) was rapidly developed in Puding county, which promoted land use transition and large-scale planting in the study area. Under the background of combining of characteristic planting with breeding, a relatively complete industrial chain of planting, purchasing, transportation and sales that has been formed. which fundamentally changed the way of farmer's livelihoods and explored a characteristic road for rural collective development . In 2020, driven by ecological construction and economic development, sloping farmland was transformed into fruit forest and forest land. The cultivated land of basin system became large-scale and intensive. And farmer's livelihoods were diversified the multi-functional agriculture was dominant and the industrial development was market-oriented.

The Diversity of Land Use Transition in the Mountain-Basin System

Under the influence of different resource endowment, economic development level, social development speed, policies and other factors, there are significant differences in the transition direction of different land use types. That is, land use transition is diversified

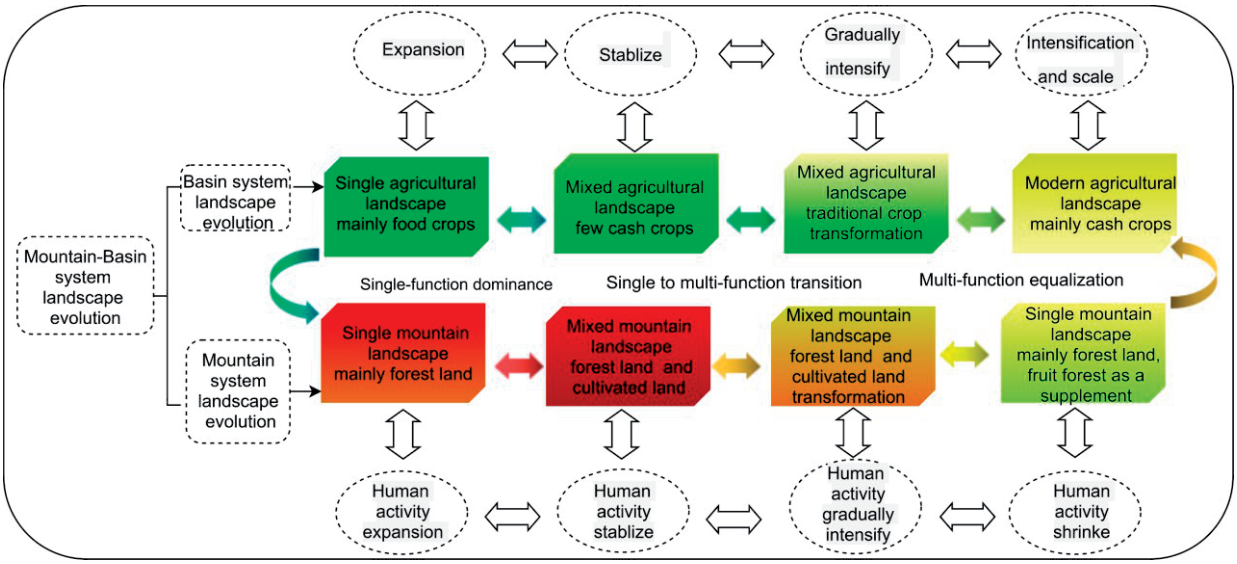

Fig. 10. The differential evolution in the mountain-basin system.

[43]. The mountain-basin system is affected by the interaction of endogenous dynamic and external factors, generating the differences in the spatial morphology and functional transition of the mountain-basin system. Therefore, the land use and landscape type between the basin system and the mountain system at different stages evolved, forming different evolution paths (Fig. 10).

The basin system includes flat terrain and concentrated cultivated land. Affected by food demand, natural landscape are gradually developed and utilized by humans, leading to the cultivated land is expanded, and production function is improved. The landscape type is dominated by a single agricultural landscape, and the planting structure is dominated by traditional crop. With the development of the economy and the improvement of agricultural technology, the utilization of cultivated land is gradually intensified, it changes from a single agricultural landscape to a mixed agricultural landscape. The area of cash crop land gradually expanded, and the traditional agricultural production function is gradually transformed. With the acceleration of modernization and marketization, the use of non-agriculturalization and non-grain cultivated land become prominent. The landscape type is mainly modern agricultural landscape, and the agricultural production is mainly cash crops. The cultivated land use intensifies, and degree of large-scale is improved. The type of landscape is gradually diversified, and the landscape type is dominated by modern multiple landscape.

The mountain system is affected by the population growth and survival demand, leading to the expansion of human activities and large-scale deforestation and land reclamation. The type of landscape is dominated by a single mountain landscape. Due to the impact of decreasing population and market demand, human activities have shrunk and farmland abandonment and marginalization have become increasingly prominent. The landscape type is mainly degraded cultivated landscape, including abandoned land, fruit forests. With the development of urban-rural integration, population and livelihood changes, which have led to the shrinkage of human activities and the transition of cultivated land. The overall process of transition is the gradual transition of traditional agricultural landscape into natural forest landscape dominated by forest land, shrubs and grassland. The landscape type is gradually single.

The Driving Mechanism of Land Use Transition in the Mountain-Basin System

In the context of the differentiated transition of the mountain-basin system, the transition of land use is not only affected by a single factor of physical but also influenced by socioeconomic factors, policies and actors. Various factors interact and contribute to each other, changes different land use requirements and land use transition of the basin system and the mountain system (Fig. 11).

(1) Physical factors are basic supporting conditions for the transition and development of land use and exert a fundamental part in the land-use change of the mountain-basin system [61]. Physical factors essentially affect the land use transition of the mountain-basin system through the path of "cultivated land resource endowment→labor migration→cultivated land use pattern". The intensive use of basins in good physical and socioeconomic conditions is high. On the contrary, the intensive use of basins is low.

(2) Socioeconomic factors are decisive roles in triggering land use transition [62]. The difference in socioeconomic conditions affects the land use pattern of the mountain-basin system through the path of "socioeconomic structure→labor migration→cultivated

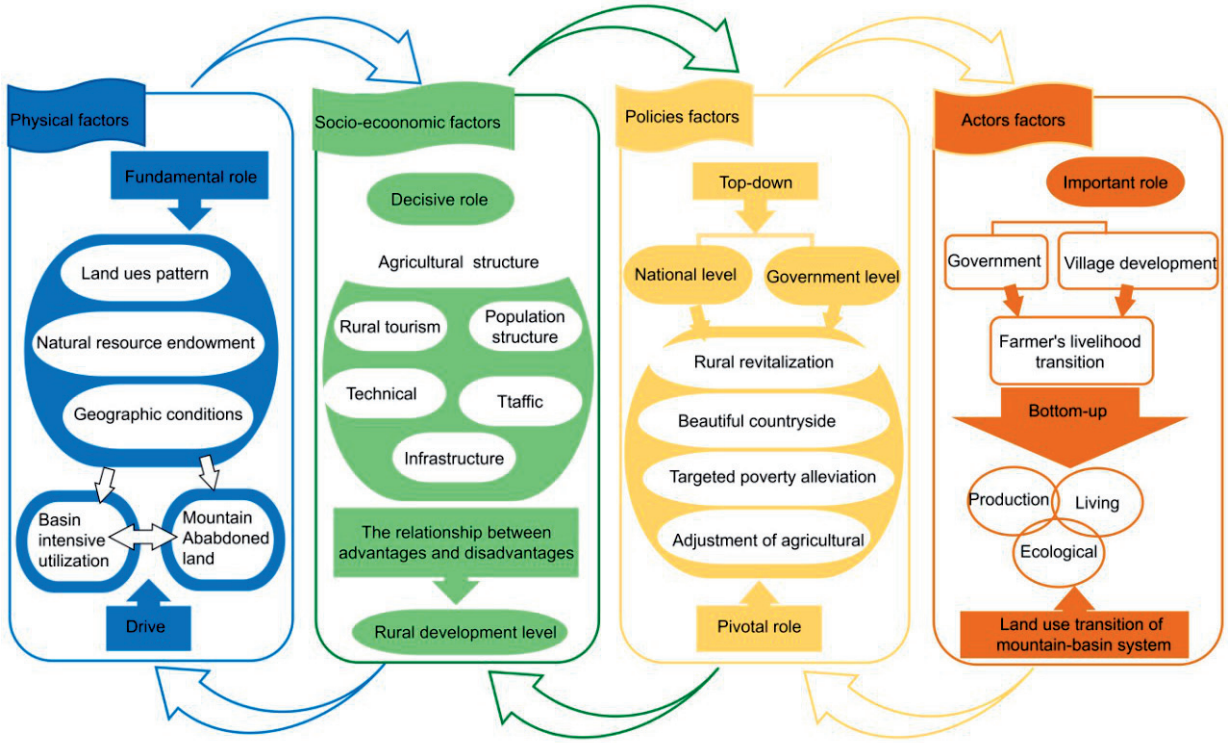

Fig. 11. The driving mechanism of land use transition in the mountain-basin system.

land use". The basin system relies on superior physical conditions and characteristic humanistic customs to develop the tertiary industry, and the way of livelihood is mainly in the service industry. The development of non-agricultural industries promotes land circulation and grain for green of basins in mountainous areas, leading to a win-win situation for ecological-economic effects.

(3) The policy plays a pivotal role in promoting land use transition [63]. At the national and government levels from "top-down" policies such as rural revitalization, beautiful countryside, targeted poverty alleviation and agricultural structure adjustment promoted the intensive use of land in the basin system and the improvement of production function.

(4) The different actors play important roles in driving land use transition [64]. The main manifestation is the transition of the government from the goal of protecting ecological safety to the comprehensive development goal of rural revitalization and protection of ecological safety, leading to the collective transition changed from survival and development-oriented to market demand-oriented. What's more, the farmer's livelihood transition from traditional agriculture to non-agricultural employment. Different actors promote the land use transition in the mountain-basin system from "bottom-up".

The Enlightenment from the Transition and Development of the Mountain-Basin System

The land use transition of the mountain-basin system presents the process of mountainous land use transition under the background of rural revitalization and reflects the diversified and differentiated characteristics of land use transition in mountainous. The land use transition of the mountain-basin system is an important part for promoting the transition and sustainable development of mountainous villages and also an important way to realize the revitalization of mountainous villages. Currently, at the critical period of rural development in China, the development of the mountain-basin system has also entered a critical period of transition development under the background of the rural revitalization strategy. To realize the general requirements of "industrial prosperity, ecological livability, rural customs and civilization, and prosperity" proposed by the rural revitalization strategy. Among them, the key issues are population, land, money and industry [65-66]. Therefore, based on the law of the land use transition in the mountain-basin system, we proposed the following suggestions: (1) Regional development needs to cultivate new business entities and stimulate development endogenous force. Regional development needs to cultivate of new entities such as large professional households, family

farms, farmer cooperatives and leading enterprises. Intensification of land use pattern, large-scale and diversification of operation. (2) Regional sustainable development needs to promote the circulation of land and realize the transition of resources into assets. In order to realize the operation of land transfer, it is necessary to establish a sound land transfer system and a scientific and reasonable land transfer platform. With the interaction of governments, enterprises, and farmers promote land circulation of "top-down"and "bottom-up", which is conducive to improving the efficiency of land use transition and revitalize the land economy. Then, the land utilization and multifunctional value are effectively improved. (3) The sustainable supply of funds is ensured and the long-term value-added of land is realized. Playing the impact of the market to improve the role of supply in resource allocation and economic development. Besides, the revitalization of rural areas is promoted to realize the prosperity of industries and the sustainable development of livelihoods. (4) Regional development needs to be based on regional conditions and the development of characteristic industries. Developing regionally appropriate characteristic planting, breeding and ecological-cultural tourism to realize the value of resources, and improve the value of regional agricultural production and ecological-cultural function is crucial to achieve a win-win situation for "ecological-economic" benefits.

Conclusions

This study explored the land use transition of the mountain-basin system from the perspective of land use transition, quantitatively analyzing the evolution characteristics of the land use quantity and function of the mountain-basin system in the past 50 years. It revealed the laws of land use transition and the development of the mountain-basin system in the karst areas of Southwest China under the background of rural revitalization. The following conclusions can be drawn out:

(1) The land use of the basin system tended to be intensified, and the area of agricultural facility land and garden land has increased significantly. The basin system was mainly based on the transition of cultivated land, which was mainly transformed into land for agricultural facility land, garden land, and transportation land. Affected by the cultivated land transition, the land use function was mainly transformed from a single traditional agricultural production function to a compound modern agricultural production function.

(2) Land use in the mountain system gradually tended to be extensive and marginalized. Cultivated land have been decreased, and forest land have been increased significantly. The area of cultivated land transferred was the largest, and the cultivated land was mainly transformed into forest land. Affected by the cultivated land transition , land use function transformed from traditional agricultural production function and ecological conservation function to a single ecological conservation function.

(3) There were significant differences the stage and evolution path of the land use transition in the mountain-basin system. It has gone through three stages: a single-function dominance stage, a transition stage from single to multi-function and a multifunctional equalization stage. The land use of the basin system was transformed into non-agriculturalization, non-grain and intensification. In contrast, land use in the mountain system has seen extensification.

(4) Physical factors are the basic supporting conditions for the development of land use transition; socioeconomic factors play decisive roles in triggering land use transition; policies are the pivotal role to promote land use transition; The different actors play important roles in driving land use transition. Various factors interact and contribute to each other and drive changes in different land use requirements, which makes the land use transition of the basin system and the mountain system.

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Conflicts of Interest

The authors declare no conflict of interest.

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