A study on the evolution mechanism of agricultural landscape pattern of Dadu River Valley in Danba Region

Linlu Tian*, *Jiajin* Wu, *Minqing* Li, *Chunwei* Xia, *Jianpeng* Cao, and *Changliu* Wang

Southwest Minzu University, Chengdu, Sichuan, China

Abstract. Taking the Dadu River Basin in the Danba area of Ganzi Prefecture, Sichuan Province as the research area, based on the 2013 and 2016 Landsat8 remote sensing images, the temperature vegetation drought index (TVDI) method is used to divide the Dadu River dry valley into 6 arid gradient regions. Using ArcGIS10.5 software and Fragstats4.2 software to calculate the landscape pattern index of different arid gradient areas in different years, combined with the survey results of agricultural policies, development models, and agricultural landscape patterns in key regions, analyze the evolution of agricultural landscape patterns under different drought gradients. The results show that, except for other forestlands, the degree of landscape fragmentation is decreasing year by year on the gradient of light and moderate drought, and the degree of spatial heterogeneity is higher. On the gradient of extreme drought, the degree of landscape fragmentation is higher, and the degree of spatial heterogeneity is lower.
Keywords: Drought radient, Agricultural landscape pattern, Danba Area.

1 Introduction

Dry valleys are a special type of mountainous regions in southwest China. They belong to the fragile ecological environment and are one of the hotspots of ecological research [1]. Dadu River is a typical arid valley in western Sichuan, and it is also an important agricultural production area in the Danba area. Studying the mechanism of an agricultural landscape pattern change in arid valleys, analyzing and discussing the influencing factors of changes in the range of local arid valleys, can provide the theoretical and scientific basis for preventing the destruction of river basin biodiversity and the degradation of ecological functions, and maintaining regional ecological security. It is conducive to optimizing the structure of the agricultural landscape and providing support for the restoration of the dry valley ecosystem. In recent years, there have been many domestic and foreign researches on dry valleys and agricultural environmental changes, but they mainly focus on case studies for some large-scale and wide-range ecological fragile areas, high-intensity land-use areas and special areas. However, there are few related studies on the evolution of agricultural landscape pattern under the drought gradient index. This study combines the local status quo and

*Corresponding author: tlliris@foxmail.com

policies to study the changes in the agricultural landscape pattern in the dry valley of the Dadu River in Danba Area. Two research years of 2013 and 2016 are selected to try to reveal the factors affecting the changes in the agricultural landscape pattern and to promote the maintenance of the ecological security and sustainable development of agriculture in Pakistan provide a reference.

2 Study area and research method

2.1 Overview of the study area

With an alpine canyon landform and a population of 58563, Danba, a multi-ethnic area covering an area of 5649 square kilometers, is located between the western Sichuan and the eastern Ganzi Tibetan Autonomous Prefecture and governs 3 towns including Zhanggu town, standing near the Dadu river with an altitude of 1860 meters, 12 townships and 185 villages. (as shown in Figure 1).

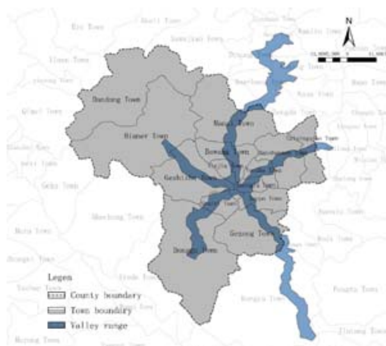

Fig. 1. The arid valley of Dadu River in Danba area.

2.2 Data source and processing

2.2.1 Drought index classification

Study data came from two periods of Landsat 8 remote sensing data images in 2013 and 2016 (Spatial resolution 30M), which were pretreated by atmospheric correction and radiation calibration with ENVI software to calculate the temperature vegetation drought index (TVDI) [2] (areas with an index range of 0.5-1 are arid) which was divided into three gradients (light drought, moderate drought and extreme drought) and six grades (1-6).

2.2.2 Distribution index

To a certain extent, distribution index can eliminate the differences caused by different area and proportion of land-use types under drought gradient. In our study, distribution index was used to investigate the distribution characteristics of land-use types under drought gradient. Calculation equation [3]:

$$P = \frac{\left(S_{id} \div S_{i}\right)}{\left(S_{d} \div S\right)} \tag{1}$$

In the Equation (1), P is the distribution index; S_{id} represents the distribution area of the i th land-use type in the d-level drought position. S_i represents the total area of the i th land-use type; S_d represents the total area of d-level drought. S represents the total area of the research area. When P < 1, this land-use type showed an inferior distribution in the d-grade drought position. When P >1, it indicates that this land-use type has a dominant distribution at the d drought level, and the larger the P value is, the more obvious the distribution advantage is.

2.2.3 Atlas analysis

In our study, the ArcGIS10.5 software was used to superposition the land-use data of the two periods to obtain the change information atlas. Land-use types are mainly divided into grassland, forestland, other forestland, paddy field, dryland, river channels, bottomland, reservoirs, urban and rural residential land, and other construction land. Especially, forestland refers to woodland, dredging forestland and shrub forest, meanwhile, other forestland refers to immature forest land, cut-over land, nursery and other kinds of field.

2.2.4 Landscape pattern index

Landscape pattern index, which can reflect the spatial pattern characteristics of landscape numerically, can be used to evaluate the specific performance of different landscape types in the same landscape spatial pattern. In our study, indexes, mainly including Patch Density (PD), Edge density (ED), Landscape shape index (LSI), Landscape contagion index (CONTAG), Simpson's diversity index (SIDI) and Patch richness (PR) were selected from patch, shape index, contagion index and diversity index for calculation. Landscape pattern characteristics and their ecological significance refer to references [4-7].

3 Result and analysis

3.1 Distribution of drought indices of different grades

Based on temperature vegetation drought index (TVDI), the study area is divided into three drought gradients: light drought, moderate drought and extreme drought, and six drought grades (Table 1 and Table 2). The drought gradient in the study area in 2013 was mainly moderate drought, accounting for 56.1%; Light drought followed, accounting for 38.1%; The proportion of extreme drought was the smallest, which was 5.8%. In 2016, the drought gradient was dominated by moderate drought, accounting for 56.8% of the area; Light drought followed, accounting for 39% of the area; The proportion of extreme drought was the smallest, which was 4.2%. Through the comparison of the two periods, it is found that in 2016, the area of extreme drought decreased significantly, while the area of moderate drought increased. The results showed that the drought degree in the study area decreased from 2013 to 2016.

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Table 1. Statistics on the Grading Range and Area of Drought Gradient in 2013.

Drought gradient		Classification interval	Area(ha)	Area proportion(%)
Light drought	1	0.55~0.625	1208	16.5
	2	0.625~0.7	1580	21.6
Middle drought	3	0.7~0.775	1896	25.9
	4	0.775~0.85	2212	30.2
Special drought	5	0.85~0.925	395	5.4
	6	0.925~1	24	0.4

Table 2. Statistics on the Grading Range and Area of Drought Gradient in 2016.

Drought gradient		Classification interval	Area(ha)	Area proportion(%)
Light drought	1	0.55~0.625	1264	17
	2	0.625~0.7	1580	22
Middle drought	3	0.7~0.775	1975	27
	4	0.775~0.85	2191.79	29.8
Special drought	5	0.85~0.925	316	4
	6	0.925~1	8	0.2

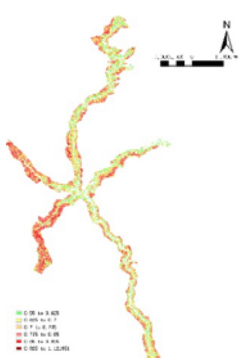


Fig. 2. Drought gradient in 2013.

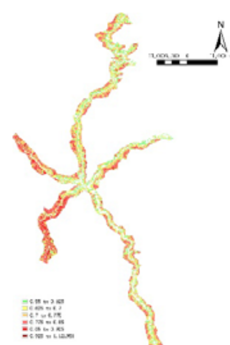
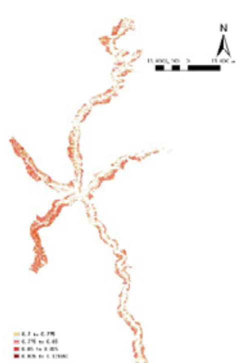


Fig. 3. Drought gradient in 2016.



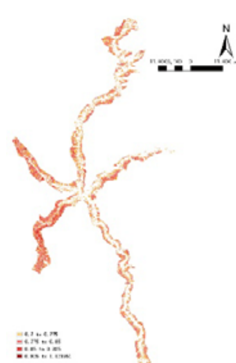


Fig. 4. The 3th-6th grade Drought gradient in 2013 **Fig. 5.**The 3th-6th grade Drought gradient in 2016.

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3.2 Distribution of different agricultural landscape types on drought gradient

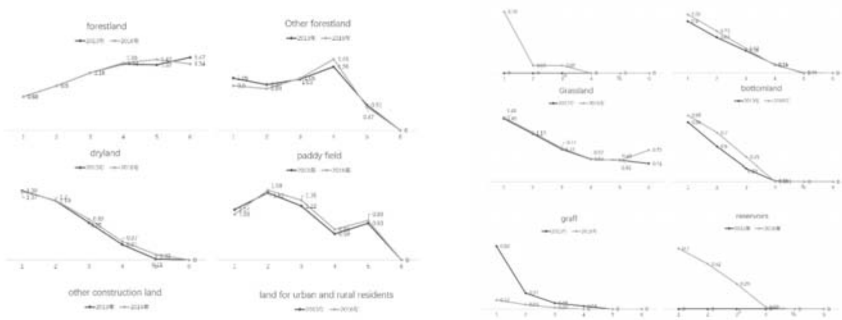

Fig. 6. Distribution index of each land-use type on drought gradient

In 2013 and 2016, the change trends of other forestland, forestland, urban and rural residential land, dryland, grassland, paddy field and bottomland were consistent under different drought gradients, and the dominance degree decreased with the increase of drought degree (Figure 6). The distribution index of grassland in the sixth grade in 2016 increased greatly, because the Danba area adjusted the structure of grassland reasonably and increased the area of grassland under the adjustment and expansion of agricultural land area. The distribution index of forestland increased with the increase of drought grade, and presented a dominant distribution in 3-6 sections. The distribution index of other construction land increased in 2016. Because the Danba area gave priority to ecological and environmental land in the adjustment of land use structure, moderately expanded the scale of industrial and mining land in cities and towns, and promoted the construction of beautiful countryside and new countryside. In terms of cultivated land, the distribution index of paddy field and dryland in 2016 was higher than that in 2013; Because the Danba area began to demarcate basic farmland protection areas according to the demand of economic and social development for cultivated land and the quality of cultivated land resources, strictly implemented the basic farmland protection system, and ensured that a small amount of basic farmland was added in addition to promoting the protection of basic farmland. In terms of water area, the number of reservoirs increased significantly in 2016, because The Danba area rectified the water environment under the background of ecological villages and towns, aiming at improving the ecological environment of villages and towns.

3.3 Transformation of land use type

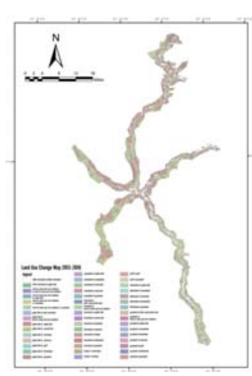

Fig. 7. Distribution index of each land-use type on drought gradient

As shown in Table 3, in 2013, the largest decreases in the area among land-use types were forestland, grassland and dryland, with 2123.82 hectares, 2059.29 hectares, and 928.62 hectares respectively. 2016 saw the main increases in land-use types of forestland, grassland, dryland and reservoir, with 1883.18 hectares, 1934.46 hectares, 909.81 hectares, and 379.44 hectares respectively.

The General Plan for Land-Use in Danba area (2006-2020) proposes to protect arable land and basic farmland, and carry out the return of farmland to forest and grass; clarify the spatial structure of the town system and the spatial distribution system of industry, optimise the spatial layout of urban and rural areas, and increase construction land appropriately. These initiatives have led to a significant increase in the area of forestland, grassland and construction land. Data from 2013 to 2016 show that a large amount of grassland was used for forest land restoration, as well as the construction of reservoir. Under the influence of the returning farmland to forest policy, the area of dryland was reduced, while combining with national forestry key construction projects such as natural forest protection and returning farmland to forests, and subsequent resource cultivation and development policies, implement artificial afforestation to increase the area of forest land. Moreover, in the context of the construction of ecological towns and villages, the land type of reservoir appeared in 2016, which played a role in the renovation of the water environment and the improvement of the ecological environment of the towns

Table 3. Table of land transfer matrix for 2013 and 2016

Land-use types		In 2013									total	Into the area	Rate of change
		grassland	Land for urban and rural residents	paddy field	graff	forestland	other forestland	dryland	bottomland	unused land			
In 2016	grassland	14982.65	6.12	547.20	0.63	1367.91	0.00	0.00	2.25	10.35	16917.11	1934.46	0.11
	Land for urban and rural residents	9.54	41.22	14.67	0.00	2.70	0.00	0.00	0.00	0.00	68.13	26.91	0.39
	paddy field	424.17	18.09	3902.76	0.00	457.92	3.96	0.00	2.61	3.06	4812.57	909.81	0.19
	graff	3.60	0.00	2.34	0.18	0.00	0.00	0.00	0.00	0.00	6.12	5.94	0.97
	forestland	1501.11	0.09	343.53	0.00	39263.01	0.00	11.52	5.94	0.99	41126.19	1863.18	0.05
	Other construction land	0.18	0.00	0.00	0.00	1.71	0.00	0.00	0.00	0.00	1.89	1.89	1.00
	other forestland	0.00	0.00	2.34	0.00	0.00	11.07	0.00	0.00	0.00	13.41	2.34	0.17
	reservoirs	109.08	0.00	14.13	0.00	255.42	0.00	0.00	0.00	0.81	379.44	379.44	1.00
	dryland	0.00	0.00	0.00	0.00	13.68	0.00	63.54	0.00	0.00	77.22	13.68	0.18
	bottomland	9.27	0.00	1.71	0.00	11.70	0.00	0.00	15.30	0.00	37.98	22.68	0.60
	unused land	2.34	0.00	2.70	0.00	12.78	0.00	0.00	3.42	31.23	52.47	21.24	0.40
Total		17041.94	65.52	4831.38	0.81	41386.83	15.03	75.06	29.52	46.44	63492.53		
Transfer area		2059.29	24.30	928.62	0.63	2123.82	3.96	11.52	14.22	15.21			
Rate of change		0.12	0.37	0.19	0.78	0.05	0.26	0.15	0.48	0.33			

3.4 Drought gradient changes in agricultural landscape patterns

3.4.1 Analysis of agricultural landscape patterns based on the patch type level

Patch density and edge density can reflect the degree of fragmentation of the landscape pattern. Figure 6 shows that the patch density and edge density of the agricultural landscape in the study area were lower in 2013 than in 2016 on the 3rd-4th drought gradient, and significantly higher in 2013 than in 2016 on the 5th-6th drought gradient. The result indicates that in order to strive to achieve the goal of "all mountains are green", Danba area implemented key project afforestation actions, making full use of unsuitable arable land and unused land for afforestation, as well as closing hills for afforestation, which had a positive impact on the agricultural landscape pattern of the study area.

3.4.2 Analysis of agricultural landscape patterns based on drought gradients

In order to further understand the agricultural landscape pattern of Dadu River Basin in Danba area at the landscape level, four landscape indices, landscape shape index (LSI), landscape contagion index (CONTAG), Shannon’s diversity index (SIDI), and landscape patch richness (PR), were selected to describe it. As shown in Figure 8, PR, SIDI [8] and LSI in 2016 were greater than those in 2013. CONTAG in 2016 was higher than that in 2013 on the third to fourth drought gradient, which was opposite on the fifth to sixth gradient. The overall spatial heterogeneity of agricultural landscape in 2016 was high, indicating that the landscape richness increased on all aridity gradients and ecological benefits were enhanced, suggesting that ecological restoration projects carried out in Danba area played an important role during this period.

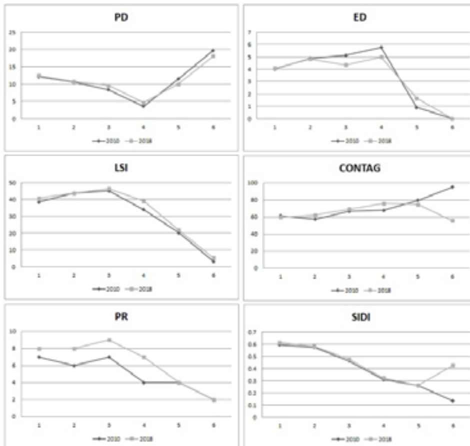

Fig. 8. Landscape pattern index analysis on drought gradients.

4 Conclusion

The results of this thesis indicate that the changes of agricultural landscape patterns under different drought gradients. The results show that under different drought gradients, the distribution index dominance of most land use types decreases with the increase of drought degree. The effect of ecological construction was significant in the study years, and the area of land use types used for ecological effects increased. Meanwhile, the analysis of landscape pattern index on different drought gradients showed that the ecological benefits in the study area increased. Primary success was achieved in Danba area during the two study years by carrying out the Tianbao project, reforestation project and ecological restoration project.

For the optimization of agricultural landscape patterns in the future, on the light drought gradient, the rational arrangement of various agricultural landscape types should be strengthened to reduce the erosion of urban and rural construction to increase the landscape continuity; on the moderate drought gradient, it is necessary to optimize the relationship between urban-rural construction and natural environment to alleviate the landscape fragmentation; on the extreme drought gradient, the production advantages and ecological benefits of forest land need to be carried forward.

In addition, what ought to be done is strengthening the publicity of the policy of returning farmland to forest, controlling adverse impact on construction land of the agricultural landscape. Make good results in species richness to reduce soil erosion and enhance ecological benefits. And the national policy of supporting forestry industry should be implemented to increase farmers' income and promote the ecological security. At the same time, rational use and protection of natural resources, maintenance of the ecological environment, to promote sustainable development of agriculture.

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