Analysis of the Spatial Pattern and Driving Forces of Linpan in Western Sichuan

Juan Du [1], Xu Zhou [1], Guangyong Li [2], Huihui Zhou [1], Shu Tao [1], Weiqing Su [1], Yu Gao [3]

[1] National Geomatics Center of China, 28 Lianhuachi West Road, Haidian District, Beijing, China - dujuan@ngcc.cn;zhouxu@ngcc.cn;zhouhuihui@ngcc.cn;taoshu@ngcc.cn;swq@ngcc.cn

[2] School of Grassland Science, Beijing Forestry University, 35 Qinghua East Road, Haidian District, Beijing, China - lihonglei1979@163.com

[3] Ministry of Natural Resources Information Center of the People's Republic of China, 28 Lianhuachi West Road, Haidian District, Beijing, China - gaoyu@infomail.mnr.gov.cn

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Abstract

This study aims to explore the landscape pattern and its driving forces of Linpan in western Sichuan, aiming to gain a deeper understanding of the spatial distribution of this unique rural settlement form. The landscape indices and redundancy analysis method were employed to investigate the landscape pattern and driving forces of Linpan in the western Sichuan region. By extracting the spatial information of Linpan in the study area, quantitative analysis of their landscape pattern was conducted using landscape indices. The results reveal certain characteristics of the landscape pattern of Linpan in the study area, where Longquanyi exhibits the highest degree of landscape fragmentation, with the highest patch density and smaller average patch size, yet the highest landscape diversity, while Wenjiang shows the lowest diversity, and Xinjin exhibits a more dispersed distribution of patches, and Dujiangyan has the highest number of patches. Using redundancy analysis, this study reveals the influence of natural and social driving forces on the landscape pattern of Linpan in Western Sichuan. The results indicate that urbanization rate, patch density, mean patch size, and average elevation are significant factors influencing the distribution and morphology of Linpan. These factors affect the spatial layout and connectivity of Linpan, driving changes in the land use structure, and profoundly impacting the landscape pattern of Linpan. To achieve the ecological sustainability, it is essential to comprehensively consider the impacts of both natural and human factors, scientifically plan and manage Linpan, and promote their harmonious coexistence with the surrounding environment.

1. Introduction

Linpan is a traditional rural settlement unit formed by the enclosure or embedding of farmhouses with surrounding forests, integrating living, production, and ecological functions. These settlement units are relatively small in scale, typically exhibiting a regular morphology, often appearing nearly circular, and are widely distributed in the Chengdu Plain area(Liu, Wang, and Guo, 2017; Guo, Xu, and Liu, 2017; Liu, Wang, and Guo, 2018). Linpan’s schematic diagram isshown in Figure 1. As a unique composite ecological system, Linpan provides a variety of important ecological services such as ecological support, resource provision, and environmental regulation(Liu, Wang, and Guo, 2018), playing a crucial role in the sustainable development of the ecological environment in the Chengdu Plain(Zhou, and Chen, 2017). The study of Linpan can be traced back to the 1980s, but systematic research began gradually after 2004. In recent years, with Chengdu's commitment to building a world-class modern rural city, an ecological civilization city, and beautiful countryside(Zhang, 2020), Linpan, as a unique rural settlement form, has attracted the attention and research of many scholars. International scholars mainly focus on the accessibility and population density of Linpan landscapes in the process of urbanization, the elastic planning of Linpan landscapes, and the protection planning of Linpan under land consolidation policies(Wang, 2015; Tippins, 2015; Jia, and Cui, 2013). Domestic scholars mainly focus on geological origins, typological zoning(Liu, 2022), cultural landscapes(Chen, Yang, and Luo, 2019; Peng, and Mu, 2021), plant species and distribution characteristics(Liu, Wang, and Guo, 2018), scene theory research(Deng, Li, and Wang, 2023), accessibility(Zhang, 2020), landscape pattern changes, and driving force analysis(Zhou, and Chen, 2017). For example, Guo Yingman(Guo, Xu, and Liu, 2017;) identified the spatial pattern and distribution characteristics of Chengdu Plain Linpan in the process of urban-rural integration, using Pixian Linpan as the research object, and employed kernel density estimation, spatial correlation index, geographic detector model, and GIS-related spatial analysis to quantitatively reveal the spatial distribution patterns of Linpan. Meanwhile, Zhou Yuan(Zhou, and Chen, 2017) utilized gradient analysis and Logistic regression model to analyze the landscape spatial change characteristics and driving forces of Linpan in the second ring of Chengdu. With the rapid advancement of urban-rural integration and the construction of new rural communities, Linpan are primarily concentrated in the second and third ring areas of Chengdu. The second ring is adjacent to the central urban area, experiencing more direct influence from it. Considering the overall planning of Chengdu, this study selected Longquanyi , Wenjiang , Xinjin , and Dujiangyan from the second and third ring areas. Through the utilization of landscape pattern indices, redundancy analysis, and other methods, this research aims to elucidate the characteristics and regularities of their landscape patterns. This endeavor seeks to provide a scientific basis for optimizing Linpan landscape patterns and promoting ecological conservation efforts.

Figure 1. Linpan’s schematic diagram

2. Research Methods and Data Processing

2.1 Study Area Overview

Chengdu is located in the central part of Sichuan Province, China, on the western edge of the Sichuan Basin . It is an important city in southwest China and serves as the capital of Sichuan Province. Chengdu is renowned as the "Land of Abundance" and is the economic, cultural, financial, and transportation hub of the region. Chengdu has a subtropical monsoon climate with distinct seasons and moderate humidity. The average annual temperature is around 16 ℃ , and the average annual precipitation is abundant, approximately 1000mm. For this study, the research area consists of Longquanyi , Wenjiang , Xinjin , and Dujiangyan, which are located in the second and third concentric circles around the central urban area of Chengdu(Figure 2). These areas are significantly influenced by Chengdu's central urban area and are crucial for understanding the landscape patterns and driving forces of Linpan.

2.2 Data Source

The data for Linpan were extracted and processed based on the 2022 National Land Change Survey data. This survey was conducted on the basis of the results of the third national land survey, which conducted at a unified point in time. It utilized the latest satellite remote sensing images and involved county-level field surveys to assess annual changes in land use, including arable land, orchard land, woodland, and other primary categories.

Based on relevant research findings, this study selects natural and socioeconomic factors, including average elevation, terrain undulation, total population, urbanization rate , population aging rate, per capita arable land area, and road area proportion. The average elevation refers to the mean value of the elevation points within a specific area, while terrain undulation describes the degree of elevation variation on the terrain surface, which can be calculated using the maximum-minimum elevation difference method. These two factors respectively reflect the overall elevation and the complexity of the terrain in the area, calculated based on 10-meter DEM data produced by geographic national conditions monitoring. The road area proportion is the ratio of road area to the county or district area, reflecting the distribution and density of transportation facilities within the region. The population aging rate is the proportion of the population aged 65 and above, and the per capita arable land area is the amount of arable land per person. Both road area and arable land area are calculated based on the 2022 national land change survey data. The remaining statistical indicators are sourced from the "Chengdu Statistical Yearbook 2023" and the "Tabulation on 2020 China Population Census by Township," covering data such as total township population, urbanization rate of the permanent population, and the number of people aged 65 and above.

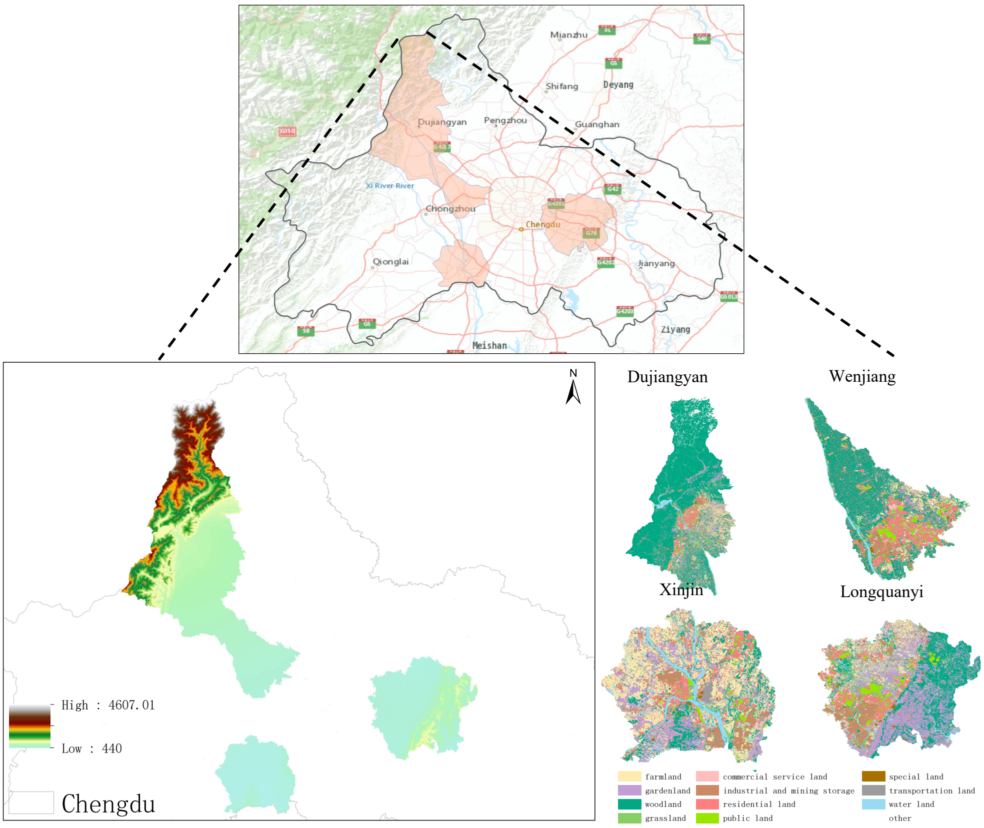

Figure 2. Study Area Map

2.3 Research Method

2.3.1 Linpan Extraction Method: Due to the numerous studies conducted on Linpan settlements, there is currently no unified definition of Linpan, and the details vary slightly(Table 1). Based on this, the common definitions of Linpan are classified into two categories: one that includes homesteads and their surrounding trees, and another that encompasses not only homesteads and trees but also farmland and other productive and living environments. This study contrasts Linpan extraction based on these two definitions. For Linpan in Western Sichuan, regardless of the differences in definition details, homesteads are undoubtedly the main component of Linpan. Therefore, this paper identifies and extracts Linpan based on the 2022 Land Change Survey data, where "Rural Residential Land" refers to land used for residential purposes in rural areas, serving as the "foundation" for Linpan extraction.According to the research by Xiao Zhengli et al.(Xiao, Jing, and Liu, 2021) , "Rural settlements within 50 meters have close ties based on kinship and geographical proximity, forming a community with common interests and goals." Therefore, based on the extracted rural homesteads, a 50-meter buffer zone is established. By merging land type patches that fall within the buffer zone and extracting the convex hull of land type patches within the buffer zone, different methods of Linpan extraction are implemented. This process is illustrated in Figure 3.

2.3.2 Landscape Indices: Landscape indices are a set of metrics used to quantitatively describe the spatial pattern characteristics of landscapes. Through numerical methods, they reflect the composition, structure, and spatial configuration features of landscapes. In this study, landscape-level indices such as the number of patches (NP), patch density (PD), mean patch size (MPS), patch size standard deviation (PSSD), proportion of landscape occupied by patches (PLAND), and Shannon diversity index (SHDI) were selected to analyze the landscape pattern of various land cover types in the study area(Table 2). The aforementioned indices were calculated using Fragstats 4.2.

2.3.3 Redundancy Analysis: Redundancy Analysis (RDA) is widely used in ecological research to explore the relationship between a set of response variables (such as species data in ecology) and a set of explanatory variables (such as environmental factors). RDA combines the features of regression analysis and principal component analysis (PCA), allowing for the examination of how explanatory variables jointly influence response variables while considering multicollinearity. RDA biplot visually represents the relationships between variables by projecting sample points, response variables, and explanatory variables onto a two-dimensional space. The distribution of sample points reflects their positions and relationships in the explanatory variable space, while the projection directions and distances of response and explanatory variables reveal their correlations and influences.

Definition	Focus	Author
The rural residences and woodland environments of the Western Sichuan Plain form circular green islands within the fields, creating a composite rural dispersed settlement unit that integrates living, production, ecology, and landscape.	The rural dwellings and woodland environment	Fang Zhirong(Fang, 2013)
The Linpan is enclosed by woodlands and residential courtyards, with the woodlands forming the main body. The residential courtyards are nestled within tall trees, bamboo groves, and shrubs, surrounded by expansive farmland.	The homesteads and woodland	Xu Xiaogang(Xu, 2008)
In rural areas of western Sichuan, the courtyards seamlessly blend with surrounding woodlands, rivers, and outer farmlands, forming a rural living environment resembling green islands amidst the fields.	Rural courtyards, woodlands, rivers, and surrounding farmland	Li Shiqing(Li, 2009)
Building upon the foundation of the Dujiangyan irrigation system, rural settlements in the area are characterized by the integration of pastoral scenery, woodlands, and courtyard residences. Rooted in agricultural production and family relationships, these rural living spaces possess unique ecological value and embody the cultural characteristics of western Sichuan.	Courtyards, pastoral scenery, woodlands	Chen Qibing

Table 1. Different Definitions of Linpan

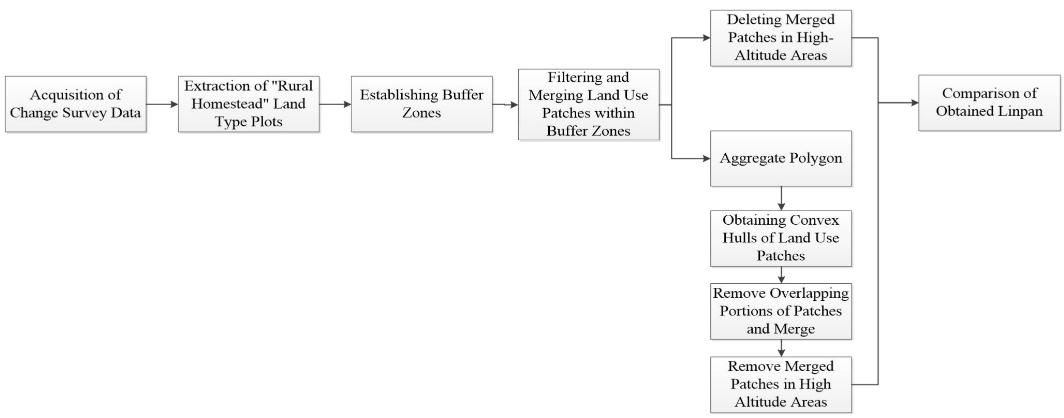

Figure 3. Different Linpan Extraction Methods

Name	Abbreviation	Definition	Meaning
Number of patches	NP	The number of patches in the landscape.	Reflects the abundance of patches in the landscape.
Patch density	PD	The number of patches per unit area.	The patch density describes the degree of patchiness within a landscape and is commonly used to compare the fragmentation levels of different landscapes.
Mean patch size	MPS	The average size of all patches within a landscape.	The average patch size in a landscape, which reflects the average scale of patches in the landscape. Generally, a larger average patch size indicates higher landscape connectivity.
Patch size standard deviation	PSSD	The square root of the average of the sum of squared differences between all patch areas and the mean patch area.	This reflects the degree of dispersion of patch areas in the landscape, i.e., the variability of patch area sizes.
Proportion of landscape	PLAND	The proportion of a specific type of patch in the entire landscape.	Reflects the spatial distribution and importance of a specific type of patch in the landscape.
Shannon's diversity index	SHDI	Taking into account the concepts of information entropy, it considers both species richness (the number of species) and evenness (the relative abundance of each species).	It reflects the degree of diversity in a landscape or ecosystem.

Table 2. Name,Abbreviation,Definition and Meaning of landscape indices

3. Results and Analysis

3.1 Results of Forest Settlement Extraction and Land Cover Analysis

The two methods described in section 2.3.1 were used for Linpan extraction, and a comparative analysis of the results revealed that both methods could effectively identify the extent of Linpan. However, the second method yielded a larger extraction range and included a greater variety of land cover types, as shown in the figure 4 below. The second method (right image) not only encompassed residential courtyards and surrounding forests but also included peripheral agricultural land. However, it was challenging to confirm the inclusion of peripheral farmland. Therefore, this study opted to analyze the Linpan extracted using the first method, i.e., based on the definition outlined in section 2.3.1.

Figure 4. Comparison of Different Methods for Extracting Linpan(Left: Linpan boundary; Middle: Land cover types within the Linpan extracted by the first method; Right: Land cover types within the Linpan extracted by the second method)

Linpan's land cover was summarized according to primary land cover types, analyzing aspects such as patch frequency, patch area, and patch size, as shown in Figures 5 and 6. Figure 5 illustrates that land cover distribution within the four districts varies, but rural residential land (7), wood land (3), orchard land (2), and arable land (1) are the main land cover types across all areas. Wood land is the predominant land cover type in Dujiangyan and Wenjiangs, followed by rural residential courtyards, while arable land is secondary to rural residential courtyards in Xinjin and Longquanyis. In terms of the average patch area of rural residential courtyards, Xinjin has the largest patches, with less noticeable differences among the remaining three areas, with Longquanyi having the smallest patches.

Combining Figures 5 and 6, it can be observed that Dujiangyan district has the largest residential courtyard area and the highest number of forest patches, while the other districts have the most extensive residential courtyard areas and quantities. In conclusion, rural residential land are the main land cover type within Linpan, followed by wood land or arable land. Different districts exhibit distinct characteristics. Regarding the average patch area of rural residential land, Xinjin has larger patches, while Longquanyi has more fragmented patches. Longquanyi, Wenjiang, and Xinjins show consistent trends in patch area and frequency distribution for arable land, orchard land, wood land, and rural residential land, while Dujiangyan district has slightly different trends, with larger rural residential courtyard areas and more forest patches.

3.2 Analysis of Landscape Indices

The landscape indices were computed for the study area, as shown in the figure 7 below. There are significant differences in patch number, with Dujiangyan having the highest number of patches, showing a noticeable contrast with the other three areas. Patch density and mean patch size both reflect landscape fragmentation, with a negative correlation between the two. The magnitudes of patch density and mean patch size are consistent in Wenchuan, Xinjin, and Dujiangyan cities, while Longquanyi exhibits the highest degree of landscape fragmentation, characterized by the highest patch density and smaller average patch size, as previously discussed in Section 3.1. The standard deviation of patch area is highest in Xinjin, indicating a more scattered distribution of patches. Regarding Shannon's diversity index, Longquanyi has the highest value, while Wenjiang has the lowest, suggesting variations in landscape diversity across different areas.

In summary, Longquanyi has fewer patches, smaller patch sizes, and a more concentrated distribution, displaying a small and fragmented landscape pattern. The other three areas exhibit similar patch sizes and diversity indices, with Dujiangyan having the highest patch number and Xinjin showing the most scattered distribution.

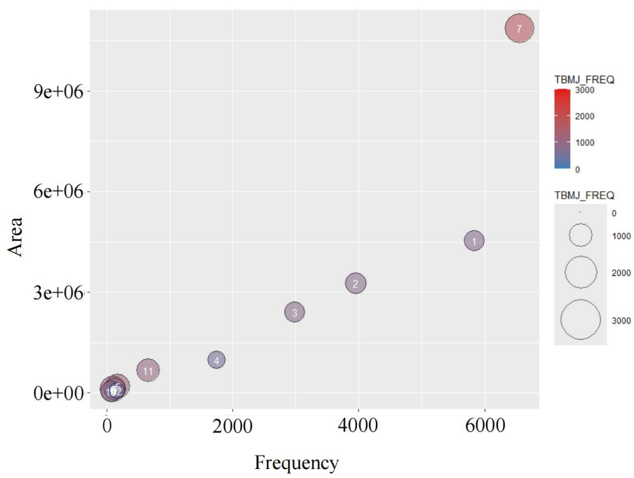

Figure 5(a). Distribution of Land Cover Types within Longquanyi

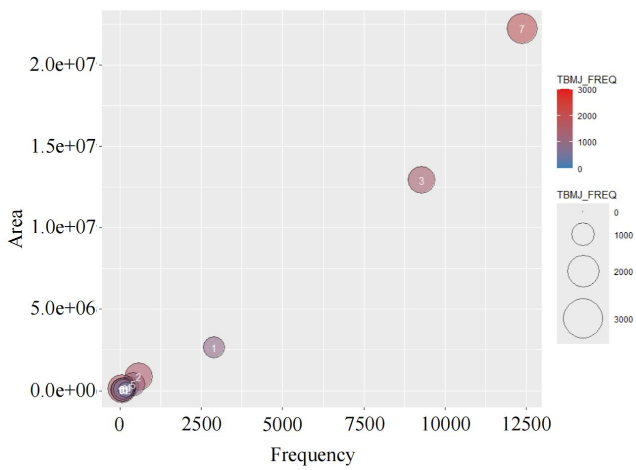

Figure 5(b). Distribution of Land Cover Types within Wenjiang

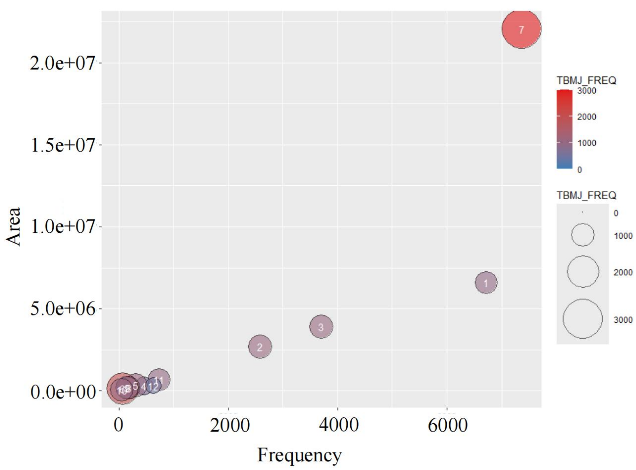

Figure 5(c). Distribution of Land Cover Types within Xinjin

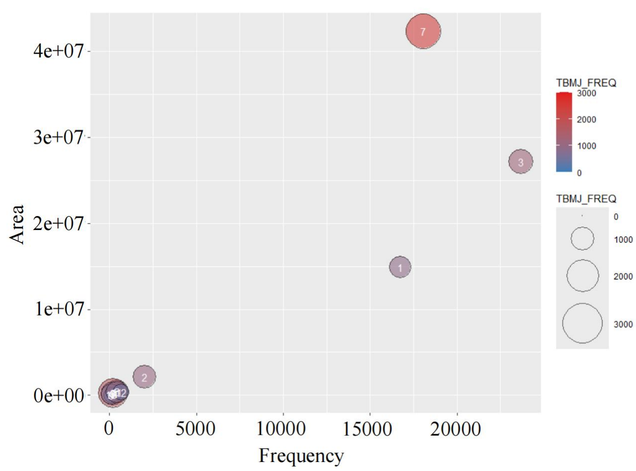

Figure 5(d). Distribution of Land Cover Types within Dujiangyan

Figure 5. Distribution of Land Cover Types within Linpan (Note: The numbers in the figure represent the following land cover types: 1-Arable land; 2-Orchard land; 3-Wood land; 4-Grass land; 5-Commercial and Service Land; 6-Industrial and Storage Land; 7-Residential Land(Rural Residential Land); 8-Public Management and Public Service Land; 9-Special Use Land; 10-Transportation Land; 11-Water Areas and Water Conservancy Facilities; 12-Other Land)

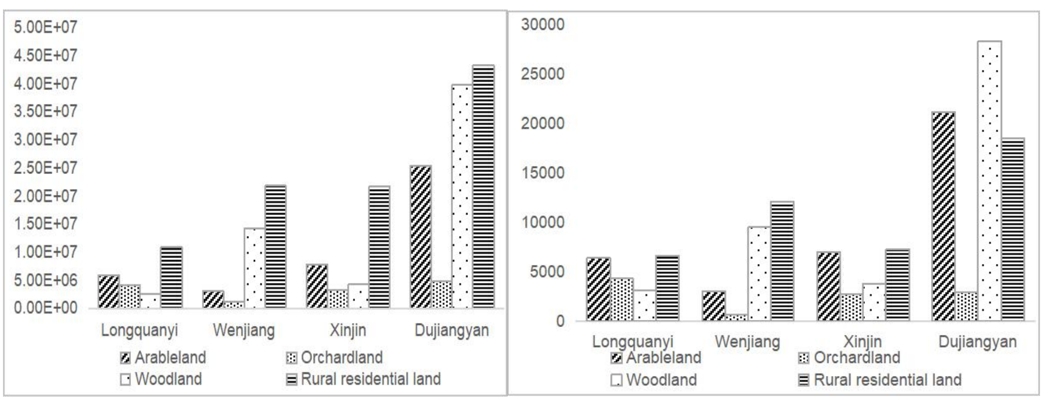

Figure 6. The Area and Frequency of Arable land, Orchard land, Wood land, and Rural Residential Land in the Study Area

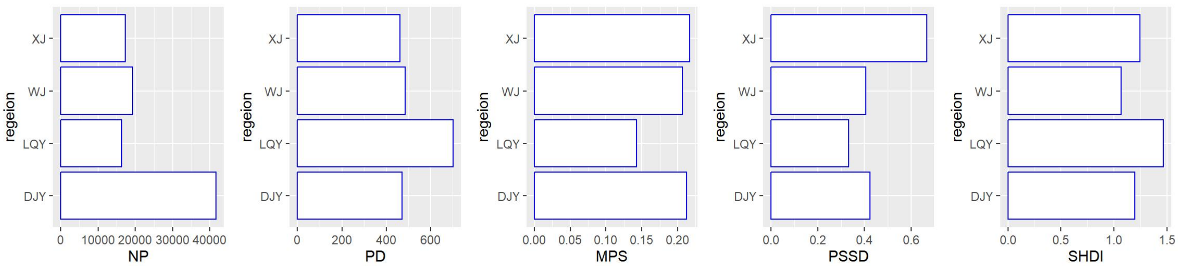

Figure 7. Comparison of Landscape Indices in the Study Area(XJ-Xinjin; WJ-Wenjiang; LQY-Longquanyi; DJY-Dujiangyan)

3.3 Analysis of Land Use Type Drivers

Based on the analysis in Section 3.1, it is evident that the primary land types within the Linpan in the study area are rural residential land (7), wood land (3), orchard land (2), and arable land (1), which aligns with the definition of Linpan. However, since the analysis was conducted at the county level, the results are not significant. Therefore, this section discusses the influencing factors of land type distribution at the township level. The land categories are merged and classified as shown in Table 3, and the proportion of landscape area occupied by patches (PLAND) is calculated. Similarly, the relevant landscape indices from Section 3.2 are calculated at the township level.

Type	Covered Land Types
Arable land	Arable land
Orchard land	Orchard land
Woodland	Woodland
Rural Residential Land	Rural Residential Land
Water	Water
Other	Commercial and Service Land; Industrial and Storage Land; Public Management and Public Service Land; Special Use Land; Transportation Land; Areas and Water Conservancy Facilities; Other Land

Table 3. Aggregated Land Use Classification

By performing redundancy analysis (RDA) on the PLAND of various land use types and the natural and socio-economic factors of the townships, we can discern significant correlations. As shown in Table 4, the land use structure characteristics have an explanatory power of 43.64% on Axis I and 10.07% on Axis II. This indicates that the explanatory variables account for a high proportion of the variance in land use type structure. The cumulative explanatory power of the land use structure characteristics and the natural and socio-economic factors reaches 85.6%, suggesting that the first two axes effectively capture the variation in land use structure and its relationship with natural and socio-economic factors.

Statistic	Axis 1	Axis 2	Axis 3	Axis 4
Variance explains of Land cover structure characteristics/%	0.4364	0.1007	0.0601	0.0209
Cumulative percentage variance of Land cover structure characteristics	43.64	53.7	59.71	61.8
Correlation between land cover structure characteristics and natural-social factors	0.8999	0.6813	0.669	0.5222
The correlation between land cover structure characteristics and natural-social factors	69.55	85.6	95.17	98.5

Table 4. Redundancy Analysis of Land Use Structure Characteristics

From the RDA results, it is evident that urbanization rate and the number of patches have the longest arrow lines, making them significant driving forces influencing land use type structure. There is a strong correlation between population size and the number of patches, aging population rate and mean elevation, and urbanization rate and mean patch size. Specifically, higher population numbers correlate with more patches formed by human activities; higher elevations correlate with higher aging population rates; and increased urbanization levels correlate with larger patches in the landscape structure.

Terrain undulation and mean elevation show a strong negative correlation with population size and the proportion of road area, indicating fewer people reside in high elevation, complex terrain areas. Additionally, road area proportion has a significant negative correlation with mean patch size, implying that higher road coverage reduces landscape connectivity.

The PLAND of forest land and rural residential land show negative or non-significant correlations with other land types, suggesting a trade-off relationship between forest land, rural residential land, and other land types within the Linpan landscape. This is partly due to the Linpan extraction method used in this study. The PLAND of arable land has a clear negative correlation with the PLAND of rural residential land and a relatively strong positive correlation with the PLAND of water areas, indicating a co-existence of arable land and water areas within the Linpan landscape.

Terrain undulation, urbanization rate, and mean elevation are significantly correlated with the PLAND of forest land, suggesting that these factors influence the structural distribution of forest land within Linpan. The per capita arable land area is significantly correlated with the PLAND of arable land, indicating that changes in per capita arable land area affect the structure of arable land. For rural residential land PLAND, road area proportion and aging population rate are the two relatively influential factors.

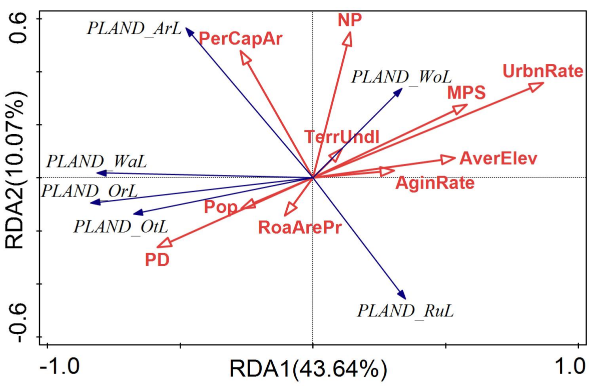

Figure 8. Redundancy Analysis Plot (Solid blue arrows represent response variables, while hollow red arrows represent explanatory variables. PerCapAr-Per capita arable land; Pop-Populaiton; PD-Patch density; RoaArePr-Road area proportion; AginRate-Aging Rate; AverElev-Avergae elevation; UrbnRate-Urbanization rate; MPS-Mean patch size; NP-Number of patches; TerrUndl-Terrain undulation. PLAND_ArL, PLAND_OrL, PLAND_WoL, PLAND_RuL, PLAND_WaL, PLAND_OtL representing arable land, orchard land, woodland, rural residential land, water bodies, and other land classes respectively)

The importance of the driving forces behind land use types varies. By conducting a Monte Carlo test on ten natural and socio-economic factors, we obtained the ranking of driving force importance, as shown in Table 5. The urbanization rate, patch density, mean patch size, and mean elevation account for 34.1%, 15.8%, 15.6%, and 14.2% of the explanatory power of all natural and socio-economic factors, respectively. These are the four most significant influencing driving factors.

Factor	Variance explains of Factors	F	P
Urbanization rate	34.1	16.1	0.002
PD	15.8	5.8	0.004
MPS	15.6	5.7	0.01
Avergae elevation	14.2	5.1	0.004
Per capita arable land	7.1	2.4	0.058
Aging rate	6.5	2.2	0.096
NP	5.3	1.7	0.164
Population	4	1.3	0.248
Terrain undulation	3.6	1.2	0.266
Road area proportion	1.7	0.5	0.684

Table 5. The Importance Ranking and Significance Test Results of Natural and Social Factors Explanations

4. Discussion and Conclusion

Linpan in the western Sichuan region are a unique form of rural settlement widely distributed in the Chengdu Plain area. The formation of Linpan is closely related to the surrounding natural environment and socio-economic conditions. In this study, the quantitative analysis of landscape patterns and redundancy analysis revealed the characteristics of landscape patterns in the study area and analyzed the main driving forces influencing the landscape patterns of Linpan.

The analysis of landscape indices provided detailed information on the distribution, density, and morphology of Linpan. Larger numbers and densities of patches usually indicate extensive and dense distributions of Linpan, while larger average patch sizes indicate larger and relatively stable forest village sizes. The study revealed that rural residential land is the main component of Linpan, followed by wood land and arable land. Different regions exhibit distinct characteristics in terms of land use, with Longquanyi showing the highest degree of landscape fragmentation, highest patch density, and smallest average patch size, but also the highest landscape diversity. Conversely, Wenjiang exhibits the lowest diversity, and Xinjin has a more dispersed patch distribution. Dujiangyan has the most patches, significantly differing from the other three areas, characterized by large rural residential land areas and numerous wood land patches. Overall, the predominant land type in Linpan varies across regions, with rural residential land being the primary land use. This is followed by wood land and arable land. The analysis suggests that Longquanyi has the highest degree of landscape fragmentation, patch density, and diversity, while Wenjiang has the lowest diversity. Xinjin exhibits a more dispersed patch distribution, and Dujiangyan has the most patches, with large rural residential land areas and numerous wood land patches.

The driving factors studied in this paper include natural factors such as average altitude, terrain undulation, and social factors such as total population, urbanization rate, and road area ratio. Urbanization rate, patch density, average patch size, and average altitude have significant impacts on the distribution and morphology of Linpan, affecting its spatial layout and connectivity. These factors drive changes in the land use structure within Linpan, constraining its development and negatively impacting its sustainability. Additionally, the increase in roads also leads to fragmentation of Linpan's spatial structure, resulting in the fragmentation of the original contiguous Linpan landscape and a decrease in ecological connectivity.

With the rapid advancement of urbanization, the traditional Linpan in Chengdu, Sichuan, have gradually declined, exhibiting phenomena such as aging and "hollowing out". Many forest village settlements have been integrated, and hollow Linpan have been converted into farmland or other development land. As a result, the original residents have moved out, leading to an increase in population density in large and medium-sized Linpan and urban areas. The density of buildings within forest village settlements has increased, while ecological green spaces and agricultural land have diminished(Chen, Zhang, 2013). This not only alters the traditional structure of Linpan but also brings about profound changes in the ecological environment and land use patterns in forest village areas.

The Linpan in western Sichuan, as a unique form of ecological settlement, possess cultural, ecological, lifestyle, social, and aesthetic values. Since 2018, the protection and restoration of Linpan in western Sichuan have been identified as one of the key projects in Chengdu's rural revitalization strategy. Chengdu has standardized the construction of Linpan and issued guiding documents such as the "Chengdu Forest Village Protection, Restoration, and Utilization Plan (2018-2035)", strengthening the effective management of Linpan. In the ecological protection and restoration of Linpan, it is essential to consider the original terrain and land use characteristics as objective criteria and conditions. Factors such as the current rural population and trends in urbanization should be taken into account when determining the scale and measures for the protection and restoration of Linpan, tailored to local conditions. Exploration of different types of forest village settlements is warranted, balancing the development and adjustment of industrial structure while ensuring the sustainable development of the ecological environment and biodiversity. Comprehensive consideration should be given to the transformation of the "forest village economy" and ecological value, along with continuous efforts to establish a comprehensive ecological monitoring system, enabling regular assessment of ecological protection and restoration efforts, thereby achieving harmony between humans and the environment.

References

Chen M.K., Zhang F.R., 2013: Study on Protection and Development of Linpan at Western Sichuan Under The Science of Human Settlements. Beijing: Tsinghua University, 26-54.

Chen Q.Y., Yang J.X., Luo S.X., et al, 2019: Identification and Extraction of the Linpan Cultural Landscape Gene. *Tropical Geography* 39(02): 254-266. DOI: 10.13284/j.cnki.rddl.003121.

Deng L., Li Y., Wang Z.B., et al, 2023: Renewal Path of Public Space in Linpan in Western Sichuan Based on Scene Theory: Taking Chengdu XieJia Linpan as an Example. *Urban Architecture Space* 30(11): 55-59.

Fang Z.R., 2013: Study on the Culture of Linpan Settlements in Western Sichuan. Nanjing: Southeast University Press, 46-52. (Essence of Linpan Culture in Western Sichuan. Chongqing University, 2012.)

Guo Y.M., Xu P., Liu Q., et al, 2017: Spatial Distribution Characteristics of Linpan in Chengdu Plain: A Case of Pi County. *Journal of Southwest China Normal University (Natural Science Edition)* 42(05): 121-126. DOI: 10.13718/j.cnki.xsxb.2017.05.019.

Jia L L, Cui H, 2013, Status Analysis of Linpan Protection in Land Consolidation of Chengdu Plain. Applied Mechanics and Materials, 357-360: 2118-2121.

Li S.Q., 2009: Overview of Village and Town Construction in Chengdu. Chengdu: Southwest Jiaotong University Press, 50-54.

Liu Q., Wang Y.K., Guo Y.M., et al, 2017: Research Progress of Linpan in Chengdu Plain. *Chinese Agricultural Science Bulletin* 33(29): 150-156.

Liu Q., Wang Y.K., Guo Y.M., et al, 2018, Morphological characteristics and composition of plant species and their distribution patterns in Linpan of Chengdu plain. *Acta Ecologica Sinica* 38(10): 3553-3561.

Liu Q, 2022: Research on the Geological Classification of Linpan in the Chengdu Plain and their Characteristics and Ecological Functions Based on Geological Background. *Chengdu University of Technology*, DOI: 10.26986/d.cnki.gcdlc.2021.000036.

Peng K., Mu L.l., 2021: Genetic Identification of Native Landscape of Linpan in Western Sichuan: A Case Study of Longquan Village, Dujiangyan: A Case Study of Longquan Village, Dujiangyan. *Small Town Construction* 39(03): 99-109.

Tippins J L, 2015: Planning for Resilience: A Proposed Landscape Evaluation for Redevelopment Planning in the Linpan Landscape. Seattle: University of Washington, 68-88.

Wang X Y, 2015: Accessibility and Population Density in the Linpan Landscape: A Study of Urbanization in the Chengdu Plain, Sichuan, China. Seattle: University of Washington, 27-63.

Xiao Z.L., Jing S.H., Liu H.L., 2021: Zhou Yong, Chen Yuping. Population Dynamics and Spatial Density Distribution of Monochamus alternatus Based on GIS Spatial Statistics and Trapping Method—A Case Study of Yuan'an County in Hubei. *Forest Inventory and Planning* 46(04): 54-60.

Xu X.G., 2008: Research on the Protection and Utilization of Ecological Resources of Linpan in Western Sichuan. Beijing: Chinese Academy of Forestry.

Zhang B.S., 2020: Accessibilityto Typical Linpan in Dujiangyan Essence Irrigation Area from the Perspective of Space Syntax. *Journal of Chinese Urban Forestry* 18(01): 71-76.

Zhou Y., Chen J., 2017: Landscape Pattern Change and Its Driving Forces in the Linpan of Western Sichuan. *Journal of Sichuan Agricultural University* 35(02): 241-250+255. DOI: 10.16036/j.issn.1000-2650.2017.02.016.