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A GIS-based study of desert classification in Dangxiong County

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Abstract: Desertification as an environmental problem, monitoring its development trend, grasping its dynamic change pattern, and assessing and grading the degree of land desertification have become important contents of international desertification research. Only in this way can we obtain accurate, timely and comprehensive information on the evolution of desertified land and services for the management and decision-making of control forecasting. In this study area, we used Landsat TM remote sensing data as the data source, the human-computer interaction visual interpretation method and the spatial analysis function of GIS to obtain desertification-type data. On this basis, we analyzed the current situation and dynamic changes in desertification in the study area.

1. Introduction

At present, natural environmental problems are becoming increasingly serious, and these problems have attracted the common attention of scientists in global resources and the environment. Among them, desertification is one of the key concerns of scientists and is at the top of the ten environmental problems affecting people's production and life. Many experts have studied the mechanism of occurrence, development process, dynamic monitoring and evaluation of the desertification phenomenon through many theoretical studies and field investigations. These studies have eased the pressure of desertification to a certain extent. However, most of these studies only use qualitative analysis methods to analyze the factors that may have contributed to desertification and cannot accurately reflect the phenomenon's essence.

2. Overview of the study area

2.1 Information collection

Dangxiong County is located in the northern end of Lhasa City, the junction of southern Tibet and northern Tibet, 90 °45'-91 °31'E, 29 °31'-31 °04'N, with an average altitude of 4,300m and a total land area of 10,133.29m^2. Dangxiong County borders Bango and Nagqu counties

in the north, Linzhou and Dulong Deqing in the south, a corner of Jiali in the east and Nimu County in the southwest. The famous Nyingchi Tanggula mountain system runs along the northwest of the county.

The composition of the natural environment in Dangxiong County is very complex. The combination of different geographical locations, geology, topography, climate, hydrology and vegetation has created unique landscapes and environments in different regions, which profoundly impact human activities. The environmental elements of Dangxiong County are an interdependent and complex organic whole. On the one hand, the entire ecosystem can be affected by disturbances. Therefore, these natural environmental factors play a crucial role in the construction of Dangxiong County. The complexity of the landscape environment is one of the main differences between Dangxiong County and the plain areas. The surrounding environment of Dangxiong County consists mainly of mountains, hills and valleys. The main features of its geomorphic environment can be divided into the following aspects:

Firstly, the city's topography is complex, the terrain is high and low, and the proportion of sloping land suitable for development is small. Most sloping land has a large slope, which is unsuitable for urban construction. Secondly, there is very little continuous flat land in the mountains, only small scattered areas of flat land, and even if there are large areas of flat land, they are mainly located in the dam area. However, the dam area is the base of food production in the mountainous area, and the basic farmland protection zone is mainly located in the dam area. According to the basic farmland protection regulations, the dam area cannot change its land use type for urban construction within a short time. These geomorphological features largely contribute to the unsatisfactory suitability of land for construction.

Due to the complexity of the mountainous terrain, the climate and environment in mountainous areas are complex and variable, and there may be different levels of sunlight, temperature and precipitation in two areas in close geographical proximity. Firstly, due to the great undulations of the mountainous terrain, there are sunny and sun-backed conditions. Therefore, they are exposed to different sunlight intensities simultaneously, resulting in different temperatures and slope currents. Secondly, they are also influenced by the undulating topography of the mountains and their relative elevation. Finally, the mountain climate is inherently unstable, with frequent small rainstorms, hailstorms and other catastrophic weather. This complex and volatile climate causes not only meteorological disasters but also serious geological disasters. Therefore, to ensure the safety and feasibility of construction in mountainous areas, we must consider the complex and variable climatic factors in evaluating construction suitability in mountainous cities.

The hydrological environment is different in mountainous and plain areas. Due to the topography, watershed systems are relatively well-developed, and rivers are densely distributed. In addition, mountainous areas have relatively steep slopes, steep topography and large ground fragmentation. During the rainy season, the amount of rainfall is relatively concentrated. Therefore, water gathers quickly and rapidly, and the impact of water on the ground is significant, which can easily cause serious natural disasters. Therefore, the hydrological environment is also a factor that needs to be considered in assessing the suitability of mountainous areas for construction sites and is related to the stability and safety of buildings and the strength of protection after construction.

Compared with the plains, Dangxiong County has a higher degree of heterogeneity, weaker resistance to disturbance and a fragile ecological environment, leading to frequent natural disasters. The major natural disasters can be divided into two categories: floods and geological disasters, including flash floods, landslides, cave-ins, earthquakes, debris flows and soil erosion. The reasons for the frequency of disasters can be divided into natural and

manufactured factors. Topography and geological factors: Topography is one of the most important factors limiting the suitability of urban construction. Mountainous areas have large proportions, high and steep slopes, wide ditches and loose surface soil. Such topographical conditions will accelerate the return of rainwater or rivers, with fast water flow, high scouring intensity and strong ability to carry sand, which will lead to frequent flash floods, landslides or mudslides, etc.

Climatic factors: The climate of Dangxiong County is volatile, and the dry and rainy seasons are relatively concentrated. As the economic development of Dangxiong County is relatively backward, the awareness of protecting the ecological environment is weak. Driven by economic interests, people do not cherish natural resources, and excessive and indiscriminate deforestation destroys many forests, reducing the surface vegetation cover, intensifying soil erosion, and frequenting mudslides and other disasters.

2.2 Research Methodology

The principles and indicators of the division of desertification classification established in this study, firstly, take the climatic zones as the division indicators. There are mainly six climate zones in Lhasa city: plateau boreal monsoon semi-humid semi-arid climate zone, plateau boreal monsoon arid climate zone, plateau temperate monsoon semi-arid climate zone, plateau temperate monsoon semi-humid semi-arid climate zone, plateau sub-boreal monsoon semi-arid climate zone, plateau sub-boreal monsoon semi-humid semi-arid climate zone.

Among them, plateau temperate monsoon semi-arid climate zone is mainly the valley area of rivers such as the Lhasa River and the pre-mountain flood plain at an altitude of less than 4200m. The plateau monsoon semi-arid climate zone is mainly the valley area of Lhasa River and other rivers at an altitude of fewer than 4200m and the alluvial plains in front of the mountains, while the plateau sub-boreal monsoon zone is mainly the area at an altitude of 4200-4500m. The plateau boreal monsoon arid climate zone is mainly located in the high mountain areas above 4500m above sea level. According to the climatic zoning, the plateau temperate monsoon semi-arid climate zone and the plateau sub-boreal monsoon semi-arid climate zone are defined as arid desert zones. The plateau boreal monsoon arid climate zone is defined as alpine desert zones.

3. Analysis of results

3.1 Dangxiong County Classification System

The desert classification system in Dangxiong County can be divided into two Type I desert, four Type II desert, sixty-one Type III desert and eighty-four Type IV desert (see Table 1).

Table 1: Desert classification system in Dangxiong County

Type I	Type II	Type III	Type IV
Arid deserts	Arid gravel desert	Arid river valley plain gravel desert	Arid river valley plains low vegetation cover gravelly deserts
			Gravelly desert vegetation cover in arid river valley plains
Alpine desert	Alpine gravel desert	Alpine moraine high terrace gravel desert	Alpine moraine high terraces low vegetation cover gravelly deserts
			Gravelly desert vegetation cover in alpine moraine high terraces
		Alpine moraine plain gravel desert	Low vegetation cover gravelly deserts on alpine moraine plains
			Gravelly desert vegetation cover in alpine moraine plains
		Alpine moraine	Low vegetation cover gravel deserts on alpine moraine terraces

		terrace gravel desert	Gravelly desert vegetation cover in alpine moraine terraces
		Alpine ice erosion on high terraced gravel deserts	Alpine ice erosion high terraces low vegetation cover gravelly deserts
			Gravelly desert vegetation cover in alpine ice erosion high terraces
		Alpine ice and water river valley plain gravel desert	Low vegetation cover gravelly deserts in alpine ice and water valley plains
			Gravelly desert vegetation cover in alpine ice-water valley plains
		Alpine ice and water plain gravel desert	Low vegetation cover gravelly deserts in alpine ice and water plains
			Gravelly desert vegetation cover in alpine ice and water plains
		Alpine ice margin denuded plain gravel desert	Low vegetation cover gravelly deserts on alpine ice margin denudation plains
			Gravelly desert vegetation cover in alpine ice margin denudation plains
		Alpine ice margined river plain gravel desert	Low vegetation cover gravelly deserts in alpine ice-marginal river valley plains
			Gravelly desert vegetation cover in alpine ice-marginal river valley plains
		High terrace gravel deserts with alpine ice margin action	High terrace low vegetation cover gravelly deserts with alpine ice margin action
			Gravelly desert vegetation cover in high terraces with alpine ice margin action
		Alpine alluvial flood plain gravel desert	Alpine alluvial floodplain low vegetation cover gravelly desert
			Gravelly desert vegetation cover in alpine alluvial flood plains
		Alpine alluvial lacustrine plain gravel desert	Alpine alluvial lacustrine plain low vegetation cover gravelly desert
			Gravelly desert vegetation cover in alpine alluvial lacustrine plains
		Alpine alluvial gravel desert	Low vegetation cover gravelly deserts in alpine alluvial plains
			Gravelly desert vegetation cover in alpine alluvial plains
		Alpine river valley gravel desert	Low vegetation cover gravel deserts in alpine river valleys
			Gravelly desert vegetation cover in alpine river valleys
		Alpine river valley plain gravel desert	Low vegetation cover gravelly deserts in alpine river valley plains
			Gravelly desert vegetation cover in alpine river valley plains
		Alpine floodplain high terrace gravel desert	Alpine floodplain high terrace low vegetation cover gravelly desert
			Gravelly desert vegetation cover in alpine floodplain high terraces
		Alpine flood plain gravel desert	Low vegetation cover gravelly deserts in alpine floodplains
			Gravelly desert vegetation cover in alpine flood plains
		Alpine lacustrine gravel desert	Low vegetation cover gravelly deserts in alpine lacustrine plains
			Gravelly desert vegetation cover in alpine lacustrine plains
		Alpine lakeshore gravel desert	Low vegetation cover gravel deserts on alpine lakeshores
			Gravelly desert vegetation cover in alpine lake flats
		Alpine moraine low terrace rock deserts	Alpine moraine low terrace low vegetation cover rocky deserts
		Alpine moraine high hilly rock desert	Alpine moraine high hills low vegetation cover rocky deserts
		Very high hilly rocky desert with alpine moraine	Alpine moraine very high hills low vegetation cover rocky deserts
		Alpine ice-marginal action of low hilly rock deserts	Alpine ice-marginal action of low hills and low vegetation cover rock deserts

		Alpine rock deserts with alpine ice margin action	Alpine ice-marginal action of high hills and low vegetation cover rock deserts
		Very high hilly rock deserts with alpine ice margin action	Very high hills and low vegetation cover rock deserts with alpine ice margin action
		Small undulating alpine rock deserts with alpine ice margin action	Small undulating alpine low vegetation cover rock deserts with alpine ice margin action
		Small undulating very high mountain rock deserts with alpine ice margin action	Small undulating very high mountain low vegetation cover rock deserts with alpine ice margin action
		Alpine Ice Marginal Actions of the Middle Undulating Alpine Rock Desert	Low vegetation cover rock deserts of medium rolling mountains with alpine ice margin action
		Alpine ice-marginal interaction of mid-relief very high mountain rock deserts	Alpine ice-marginal action of medium-relief very high mountain low-vegetation cover rock deserts
		Alpine ice-marginal action of medium-rise lava very high mountain rock deserts	Alpine ice-marginal role of medium-rise lava in very high mountain low-vegetation cover rock deserts
			Alpine ice-marginal action of mid-relief lava very high mountain mid-vegetation cover rock deserts
		Mesic undulating very high mountain rock deserts with alpine karst ice margin action	Low vegetation cover rock deserts of medium rolling very high mountains with alpine karst ice margin action
			Vegetation-covered rock deserts in mid-undulating very high mountains with alpine karst ice margin action
		Alpine erosion and denudation of large undulating alpine rock deserts	Alpine erosion and denudation of large undulating alpine low vegetation cover rock deserts
		Alpine erosion and denudation of low hilly rock deserts	Alpine erosion denudation low hills low vegetation cover rock deserts
			Alpine erosion denuding rocky deserts in low hills with vegetation cover
		Alpine erosion and denudation of high hilly rock deserts	Alpine erosion denudation of high hills and low vegetation cover rock deserts
		Alpine erosion and denudation of small undulating alpine rock deserts	alpine erosion denudation small undulating alpine low vegetation cover rock deserts

3.2 Results of Type I desert of Dangxiong County

The areas and proportions of arid desert and high desert types are shown in Table 3.2. From Table 2, it can be concluded that the area of high desert is the largest in the desert region, accounting for approximately 31.23% of the study area, while the area of arid desert is slightly lower, with an area proportion of approximately 3.21%.

Table 2: Table of data on Type I desert in Dangxiong County

Type I desert	Area/km^2	Percentage/%
Arid deserts	736.03	3.21
alpine desert	3171.17	31.23
Non-desert	6325.24	61.8
Total	10232.19	100

3.3 Results of Type II desert of Dangxiong County

The area and proportion of Type II desert are shown in Table 3. From Table 3, it can be concluded that the desert area of Dangxiong County is 6229.17 km^2. Among them, the proportion of alpine rock desert is the largest, accounting for about 58.78 % of the desert area; followed by alpine sandy desert, with an area proportion of about 21.66%; the area of arid gravel desert is less than 1 km^2.

Table 3: Table of data on Type II desert in Dangxiong County

Type II desert	Area/km^2	Percentage/%
Arid gravel desert	0.00	0.00
Alpine sandy desert	1218.51	19.56
Alpine gravel desert	1349.39	21.66
Alpine rock desert	3661.28	58.78
Total	6229.17	100.00

3.4 Results of Type III desert of Dangxiong County

There are 61 Type III desert in Dangxiong County: arid alluvial valley plain gravel desert, arid alluvial flood plain gravel desert, arid alluvial plain gravel desert, alpine alluvial valley plain gravel desert, alpine alluvial flood plain gravel desert, alpine erosion and denudation large undulating alpine sand and gravel desert, alpine erosion and denudation large undulating alpine rock desert, etc.

Table 4: Table of data on Type III desert in Dangxiong County

Type III desert	Area/km^2	Percentage/%	Type III desert	Area/km^2	Percentage/%
Arid river valley plain gravel desert	0.00	0.00	Very high hilly sand and gravel desert with alpine ice margin action	86.34	1.39
Small undulating alpine sand and gravel desert with alpine glacial ice margin action	76.78	1.23	Very high hilly rock deserts with alpine ice margin action	71.80	1.15
Small undulating alpine rock deserts with alpine glacial ice margin action	60.06	0.96	Small undulating alpine sand and gravel desert with alpine ice margin action	32.16	0.52
Small undulating very high alpine sand and gravel deserts with alpine glacial ice margin action	22.21	0.36	Small undulating alpine rock deserts with alpine ice margin action	34.32	0.55
Small undulating very high mountain rock deserts with	55.72	0.89	Small undulating very high mountain gravel desert	280.29	4.50

alpine glacial ice margin action			with alpine ice margin action		
A mid-undulating very high mountain gravel desert with alpine glacial ice margin action	230.26	3.70	Small undulating very high mountain rock deserts with alpine ice margin action	140.50	2.26
Mid-relief very high mountain rock deserts with alpine glacial ice margin action	1500.42	24.09	Mesic undulating alpine gravel desert with alpine ice margin action	43.13	0.69
Large undulating very high mountain gravel desert with alpine glacial action	61.03	0.98	Alpine Ice Marginal Actions of the Middle Undulating Alpine Rock Desert	43.61	0.70
Large undulating very high mountain rock deserts of alpine glacial action	1204.82	19.34	A mid-undulating very high mountain gravel desert with alpine ice margin action	229.32	3.68
Alpine glaciated medium-relief very high mountain gravel deserts	75.03	1.20	Alpine ice-marginal interaction of mid-relief very high mountain rock deserts	161.27	2.59
Alpine glaciated mid-relief very high mountain rock deserts	261.91	4.20	Alpine ice-marginal action of medium-rise lava very high mountain rock deserts	10.47	0.17
Alpine glacially-influenced mid-relief lava very high mountain rock deserts	30.85	0.50	Alpine alluvial flood plain gravel desert	101.16	1.62
Alpine moraine low terrace sand and gravel desert	25.96	0.42	Alpine alluvial lacustrine plain gravel desert	25.76	0.41
Alpine moraine low terrace rock deserts	14.78	0.24	Alpine alluvial gravel desert	198.30	3.18
Alpine moraine high hills sand and gravel desert	13.58	0.22	Alpine river valley gravel desert	2.47	0.04
Alpine moraine high hilly rock desert	6.93	0.11	Alpine river valley plain gravel desert	8.03	0.13
Alpine moraine high terrace gravel desert	86.48	1.39	Alpine floodplain high terrace gravel desert	20.11	0.32
Very high hilly gravel desert with alpine moraine	11.18	0.18	Alpine flood plain gravel desert	15.04	0.24
Very high hilly rocky desert with alpine moraine	1.46	0.02	Alpine lacustrine gravel desert	36.03	0.58
Alpine moraine plain gravel desert	52.22	0.84	Alpine Lakeshore Gravelly Desert	56.16	0.90
Alpine moraine terrace gravel desert	18.95	0.30	Mesic undulating very high mountain rock deserts with alpine karst ice margin action	3.25	0.05

3.5 Recommendations and measures

The development and construction of towns and industrial and mining sites in Dangxiong

County must be tailored to the local conditions. For highly suitable areas, effective and optimized development and construction should be carried out in a targeted manner, considering ecological and environmental protection.

For medium and low suitability areas, a reasonable layout should be made according to the nature of the construction land and the level of suitability required. We must ensure that urban, industrial, and mining land lay on their most suitable plots. In the case of problematic areas, all construction should be explicitly prohibited. In short, the development of towns and industrial and mining sites must be tailored to the local context.

In addition to adapting to local conditions, it is important to highlight the characteristics of Dangxiong County as a mountain town. The character of towns and industrial and mining sites is not limited to the character of the buildings. The characteristics of mountain towns should include the structural characteristics of the town, the architectural characteristics and, especially important, the characteristics of the mountains and rivers, the green features and the human characteristics. The layout of mountain towns should be in harmony with the surrounding natural environment and follow an urbanization path with Chengdu characteristics. In addition to considering the suitability of the layout of industrial and mining land, the location of land for construction in industrial and mining areas should be based on the leading local industries and the rich natural or mineral resources. The development and construction of towns and industrial and mining sites play a huge role in promoting the rapid development of the local economy. Therefore, it is necessary to follow the principle of moderate development, concentrated development and strict protection of the ecological environment. We need to take a new path of industrialization and urbanization in mountainous areas and give full play to the advantages of ecological culture. We will highlight the regional characteristics and create a harmonious and beautiful new mountainous region in an orderly manner.

4. Conclusion

Traditional desertification evaluation methods take a long time and involve much work. Remote sensing and GIS can combine the acquisition of ground information, numerical calculation and spatial analysis, providing a sub-decision, intuitive and comprehensive desertification evaluation method. In areas with vast territories and complex ecological conditions, remote sensing and GIS technology effectively analyze desertification dynamics. Through the improvement of technical means and the analysis of multi-source data sources, it provides decision support for the process, hazards and driving factors of the dynamics of urban desertification.

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