A GIS-based study of desert classification in Dangxiong County

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Keywords: Desertification; remote sensing; GIS; Dangxiong County

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 10,133.29m². 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
profundely 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).

| Type I  | Type II          | Type III                                      | Type IV                                      |
|--------|------------------|-----------------------------------------------|----------------------------------------------|
| Arid   | Arid gravel      | Arid river valley plain gravel desert         | Arid river valley plains low vegetation cover gravelly deserts |
| deserts| desert           |                                               | Gravelly desert vegetation cover in arid river valley plains |
| Alpine | Alpine moraine   | Alpine moraine high terraces low vegetation cover gravelly deserts | Gravelly desert vegetation cover in alpine moraine high terraces |
| desert | high terraces    |                                               |                                               |
|        | gravel desert    | Alpine moraine high terraces gravel desert    |                                               |
|        |                  | Alpine moraine low vegetation cover gravelly deserts | Low vegetation cover gravelly deserts on alpine moraine plains |
|        |                  | Alpine moraine gravel desert                  | Gravelly desert vegetation cover in alpine moraine plains |
|        |                  | Alpine moraine low vegetation cover           |                                               |
|        |                  | gravel desert                                 |                                               |
|        |                  | Low vegetation cover gravel deserts on alpine moraine terraces |                                               |
| **terraces 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 floodplain 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 gravelly 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 floodplains |
| 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 gravelly 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 |
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/km² | 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 km². 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 km².

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

| Type II desert          | Area/km² | 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/km² | Percentage/% | Type III desert | Area/km² | 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 |
|----------------------------------|-------------------------------|
| **Alpine Glacial Ice Margin Action** | **With Alpine Ice Margin Action** |
| A mid-undulating very high mountain gravel desert with alpine glacial ice margin action | Small undulating very high mountain rock deserts with alpine ice margin action |
| Mid-relief very high mountain rock deserts with alpine glacial ice margin action | Mesic undulating alpine gravel desert with alpine ice margin action |
| Large undulating very high mountain gravel desert with alpine glacial ice margin action | Alpine Ice Marginal Actions of the Middle Undulating Alpine Rock Desert |
| Large undulating very high mountain rock deserts of alpine glacial action | A mid-undulating very high mountain gravel desert with alpine ice margin action |
| Alpine glaciated medium-relief very high mountain gravel deserts | Alpine ice-marginal interaction of mid-relief very high mountain rock deserts |
| Alpine glaciated mid-relief very high mountain rock deserts | Alpine ice-marginal action of medium-rise lava very high mountain rock deserts |
| Alpine glacially-influenced mid-relief lava very high mountain rock deserts | Alpine alluvial flood plain gravel desert |
| Alpine moraine low terrace sand and gravel desert | Alpine alluvial lacustrine plain gravel desert |
| Alpine moraine low terrace rock deserts | Alpine alluvial gravel desert |
| Alpine moraine high hills sand and gravel desert | Alpine river valley gravel desert |
| Alpine moraine high hilly rock desert | Alpine river valley plain gravel desert |
| Alpine moraine high terrace gravel desert | Alpine floodplain high terrace gravel desert |
| Very high hilly gravel desert with alpine moraine | Alpine flood plain gravel desert |
| Very high hilly rocky desert with alpine moraine | Alpine lacustrine gravel desert |
| Alpine moraine plain gravel desert | Alpine Lakeshore Gravely Desert |
| Alpine moraine terrace gravel desert | Mesic undulating very high mountain rock deserts with alpine karst ice margin action |

**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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