Landscape-structural factors of the development of a mountainous region (on the example of the Chechen Republic)

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Abstract. The effective development of mountainous areas in the Chechen Republic lies in considering the complex natural environment in terms of its spatial and temporal structure and applying flexible rules of natural resource management capable of ensuring adaptation to changing natural and socio-political conditions and processes. Mountainous areas of the Chechen Republic have landscape-structural features expressed in altitude-zonal and geological-geomorphological differentiation of habitats (6 altitude zones, 11 subzones, 45 landscape groups and 34 landscape localities). The development of landscapes is extremely uneven. The most developed landscapes are mountain-steppe and mountain-meadow-steppe landscapes, confined to intermountain depressions. There is a degradation of the soil and vegetation cover, erosion, and increased mudflow and landslide activity.

1. Introduction

The development of an area and its resources often faces natural constraints that determine the nature of development, its heterogeneity in space and time. Mountain regions have a complex physical and geographical differentiation, dynamic spontaneous and destructive processes, fragmented land use, etc. [1, 2, 5]. Effective mountain region development is based on an in-depth study of landscape-structural factors. Environmental management in developed areas is ensured by aligning the scale of natural processes with the institutions responsible for managing human-environment interactions [4]. Landscape-structural factors include, above all, the complex of natural conditions and resources underlying the spatial organisation of the livelihoods of the mountain population. The main determinants are the boundaries of residence and land use (at different altitudes, slopes of different steepness and exposure), the fragmentation and dispersion of farming areas, accessibility and isolation, exposure to natural-destructive processes.

The main problem with the development of mountainous regions is the one-sided consideration of natural factors related to the influence of a specific component: climate, topography, soils, water availability, etc. The lack of a comprehensive analysis of natural components and the neglect of systemic relationships between them often fail to provide a complete picture of the cause-effect
relationships and effectively use natural feature studies in environmental management. When characterising development, it is necessary to consider the heterogeneity, or selectivity of the development of the landscape, given its intrinsic landscape-ecological structure. The diversity of natural conditions and the uneven natural potential of the different elements of the landscape's morphological structure determine the fundamental heterogeneity of development. As the initial motives for development tend to be economically based, development does not always match the natural capacity of the landscape systems. Consequently, some landscapes are over-utilised and others under-utilised.

**The purpose of the work** is a comprehensive analysis of natural differentiation in the framework of the landscape concept and the identification of the main landscape-structural factors of development in the mountainous areas of the Chechen Republic.

The middle and highlands of the Chechen Republic occupy about a quarter of its territory. However, this part of the republic is still undeveloped. The reasons for this are the expulsion of Chechens in 1944 and the ban on their return to mountainous settlements at the end of the 1950s. About 300 settlements in total remain abandoned. The changed socio-economic and natural-environmental conditions created the challenge of redeveloping the area. There is a need for new maps of the natural environment and land use, as well as justifications for the development of institutions to facilitate the efficient development of the mountainous regions of the republic.

2. **Materials and methods**

The main methods used in the fieldwork included landscape description, comprehensive physical-geographical profiling and landscape mapping. We also interviewed local people, drew maps of land use and assessed the current human pressure on the developed areas. The study included the development of a database of comprehensive landscape descriptions. To extrapolate the field data, the results of the interpretation and classification of the vegetation cover, using the Sentinel-2 series image from 15 August 2019, provided the most accurate picture. The classification made it possible to combine data from ground-based field surveys with the areas highlighted in the satellite image. We identified about 30 layers in the GIS environment and the possibility of superimposing different layers helped to reveal the links between the components and elements of the whole natural-economic geosystem.

3. **Results and discussion**

The authors produced a detailed landscape map of the mountainous part of the Chechen Republic as part of the North Caucasus comprehensive expedition [3]. Landscape-structural features of mountainous areas are expressed in altitude-zonal and geological-geomorphological differentiation of habitats (6 altitude zones, 11 subzones, 45 groups of landscapes and 34 landscape terrains). Landscape types (altitude zones) consist of nival-glacial landscapes (over 3000-3500 m above sea level); mountain-meadow landscapes (the lower boundary varies from 2000 to 2500 m, and the upper one coincides with the upper boundaries of nival-glacial landscapes, i.e. as 3000-3500 m above sea level); mountain-steppe (up to 2000 m above sea level in some parts of warm slopes forests reach up to 2600 m above sea level); mountain-steppe (up to 1800-2400 m above sea level). There are two separate types: mountain forest-steppe landscapes, which represent the anthropogenic transformation of the mountain forest zone (2000-2600), and mountain forest-steppe transition from mountain steppe to mountain forest (up to 1800-2400). There is absolutely no strict sequence of change of some landscape types with altitude by others, as the ratio of heat and moisture changes unevenly with altitude depending on the mesoclimatic conditions of the relief: in wide and narrow gorges, on different exposures, on slopes of different steepness.

The six landscape types are represented by eleven subtypes (subzones), differing in terms of heat and moisture relations. The nival-glacial landscape type is divided into glacial and nival-rock landscapes. Nival-rocky landscapes gradually change to subnival-alpine landscapes as altitude decreases. There is no clear boundary with the mountain-meadow belt. It can vary from year to year.
Mountain-meadow landscapes are divided into subnival-alpine, subalpine and subalpine steppe. Mountain forest landscapes are divided into small-leaved-coniferous highlands and broad-leaved-chalky highlands (up to 1600-1800 m altitude). Mountain forest-meadow landscapes feature the grassland subtype. Mountain-forest-steppe landscapes are cultivated subtypes of landscapes. Mountain-steppe landscapes include shrublands and domesticated mountain-steppe landscapes.

The leading factors in the differentiation of landscapes into groups are geological and geomorphological factors, primarily the geological structure and lithological composition of rocks, as well as the steepness and exposure of slopes. The landscape structure of Chechnya's mountains is made up of intermountain basins, which became centres of historical development and economic activities - the Galanchozhskaya, Itumkalinskaya, Sharo-Argunskaya and Makazhoyskaya. Table 1 shows the main limiting factors due to the landscape structure.

**Table 1. Landscape-structural factors in the development of mountainous areas of the Chechen Republic**

| The leading natural factor of differentiation | Landscape-structural elements in the studied area | Limitations of development |
|-----------------------------------------------|-----------------------------------------------|-----------------------------|
| Climate                                       | 6 zones, 11 subzones                          | Altitudinal boundaries of habitation and land use, differences in the bioproductivity of landscapes due to the ratio of heat and moisture |
| Geological and geomorphological conditions    | 45 landscape groups                           | Changes in living and land-use conditions and bioproductivity of landscapes, depending on steepness and exposition, and exposure to natural disruptive processes |
|                                               | 34 landscaped areas                           | Fragmentation and dispersion of habitats, accessibility and isolation |

The differentiation of landscapes at the level of types and subtypes (altitude zones and subzones) determines the altitudinal boundaries of habitation and land use, as well as differences in the bioproductivity of the landscapes. Habitats within zones and subzones are narrowed and fragmented as a result of differentiation into groups of landscapes. The steepness and exposure of slopes and the susceptibility of slope sections to spontaneous erosion processes play an important differentiating role. The most suitable for settlement and farming are the relatively gentle slopes of southern exposures within the 1200-1600 m altitude range, formed by loose deposits of mudstones and siltstones, with fertile soils forming on them. In terms of the degree of fragmentation and dissection of habitats, as well as accessibility and isolation, we identified 34 landscapes, which are relatively autonomous habitats of mountain community formation. These areas have different resource endowments. Most of them have a combination of arable land (mountain-steppe and mountain-meadow-steppe landscapes), hayfields (mountain-meadow-steppe and mountain-forest-steppe landscapes) and pastures (mountain-steppe, mountain-meadow-steppe landscapes). The limits to settlement growth have a close relationship to the availability of suitable arable land.

The high degree of development and the largest disturbances are associated with intermountain basins, mountain-steppe and mountain-meadow-steppe landscapes (Figure 1).
Figure 1. Anthropogenic degradation of landscapes in mountainous areas of the Chechen Republic (within the borders of the Argun Historical and Archaeological Museum-Reserve). The lines show the altitude contours of 1600 m: 1 - landscapes slightly affected by anthropogenic activity, 2 - landscapes with medium anthropogenic load and local soil and vegetation disturbance, 3 - landscapes with high anthropogenic load, local and area soil and vegetation disturbance, development of erosion processes.

The southern exposure slopes, composed of siltstones, are particularly deeply disturbed. There are large pockets of erosion and landslides. Mudflows are common in the south-eastern landscape areas where the local population is active in livestock farming. The neighbouring areas of the villages are virtually devoid of woody vegetation, with the mountain meadow-steppes and sub-alpine meadows being stratified. Medium degradation includes mid-mountain landscapes of post-forest meadows, mountain-forest-meadow and mountain-meadow belts. The main disturbances are caused by grazing. The middle and high mountain landscapes, which currently have restricted access for use due to the border regime, have the lowest changes. This zone also includes lowland forests with a restricted forest management regime. The development of mountainous areas is now on the rise. This involves developing landscapes that are confined to transport arteries and energy supply systems. There is a lack of landscape planning in the area.

4. Conclusion
Landscape-structural factors and boundaries between high-altitude zones, landscapes formed on different rocks and in different geomorphological conditions have significantly influenced the modern development of the mountainous territory of the Chechen Republic. The natural landscape constraints of development relate to climatic and geological-geomorphological conditions and processes that limit settlement and the conduct of natural resource use. Warm intermountain basins with the presence of a cover of loose sediments, conducive to the formation of fertile mountain-meadow-steppe soils, have become the most developed. However, it is the landscapes that experience the greatest anthropogenic pressure: there are erosion processes developing here. The prospects for development depend, on the one hand, on the regulation of anthropogenic pressures, which requires studying the dynamics of natural processes and structures and the development of adaptation mechanisms. On the other hand,
development should be considered in terms of stimulating new economic activities, such as tourism, which could provide an alternative to traditional extensive natural resource use and an additional source of income for the mountain dwellers. This research and the identification of patterns in landscape differentiation can form the basis for the creation of landscape planning maps to optimise nature management in the mountainous regions of the Chechen Republic.

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