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Relief assessment in the North Caucasian Federal District for agrarian purposes

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Abstract. North Caucasian Federal District is made up of seven constituent entities. In terms of physical and geographical conditions predominately differentiated by the topography of an area, the territory of the region is grouped around two large areas – plain and mountainous. Most of the territory of the District is characterized by slopes of up to 5°, which occupy an area of 114,101 km², or 66.9 %. The highlands of up to 500 m are most favorable for agricultural development in Stavropol Krai, Dagestan and Chechnya. The large low-plain areas with relatively high elevation points contribute to the formation of homogeneous microclimatic factors, and, consequently, agricultural methods.

1. Introduction

At present, one of the most effective agricultural and, in particular, crop production methods lies in the endeavors to adapt farming to local conditions related to a spatial pattern of natural landscapes. The latter is formed due to some zonal and azonal factors, among which relief and climate are the most crucial. According to N.A. Solntsev [1], relief, along with geology aspects and surface lithology, is one of the most “strong” factors to affect the formation and differentiation of natural-territorial habitats (NTH). Terrain mega-features are the basis for differentiating the territory into plain and mountainous parts. Further local differentiation relies on zonal-azonal conditions that create an environment for the development of local processes.

The North Caucasian Federal District was split from the Southern Federal District by the Decree #82 of the President of the Russian Federation of January 19, 2010. It is located in the south of the European part of Russia, in the central and eastern parts of the North Caucasus. The North Caucasian Federal District includes seven constituent entities of the Federation (Stavropol Krai, Karachay-Cherkess Republic – KCR, Kabardino-Balkarian Republic – KBR, Republic of North Ossetia-Alania – North Ossetia-A, Republic of Ingushetia – RI, Chechen Republic – CR, Republic Dagestan – RD) with an area of 170,440 km² (1 % of the territory of the Russian Federation) and a population of 9,928,721 people. (6.77 % of the population of the Russian Federation as of January 1, 2020).

In terms of physical and geographical conditions predominately differentiated by the topography of an area, the territory of the district is grouped around two large areas – plain and mountainous. The plain part is confined to the northern part of the district and is represented by different hypsometric areas with relatively slight elevations and angles of slopes within the Ciscaucasia. The mountainous



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part is located within the Greater Caucasus and is characterized by the highest elevation for the country. The border between the mountainous and lowland parts touches the foothills of the Greater Caucasus and is expressed both in terms of elevation points and the angle of the slopes [2–5].

2. Materials and methods

One of the ways towards boosting national agriculture is its optimal location in terms of geographical conditions. In practical terms, this means defining geographical areas and territories (with specific geosystems) for producing definite types of crops and animal breeds (products). Earlier, this task was solved through planning procedures that ended up with some progress. In recent decades, studies of this kind have been aimed at certain regions. However, they form the basis for forecasting and planning the structure and potential functioning of national agriculture. Another prerequisite for new methodological provisions to arise is the advent of some new sources of information and technical capabilities for information processing. Comprehensive environmental studies traditionally carried out under a landscape approach primarily rely on morphometric analysis of the relief, in which the main emphasis is on cartometric methods. The development of this approach was facilitated by the wide application of digital elevation models (DEM).

Currently, there are a number of DEMs to provide different resolution for a target area. ALOS Global Digital Surface Model “ALOS World 3D – 30 m (AW3D30)”, publicly available at <https://www.eorc.jaxa.jp/ALOS/en/aw3d30/> was used to compute the areas occupied by different heights and slopes. It is one of the latest in obtaining information, and its resolution is close to the maps with a scale of 1: 200000, thereby corresponding to the regional level of research. DEMs were processed based on the ArcGIS software package, in particular, a Spatial Analyst tool that systemizes DEMs and computes the area of objects.

In the context of elevation points, regions can fall within lowlands (up to 200 m), plains (200–500 m), uplands (500–700 m), plateaus, highlands, and mountains (above 1000 m). To distinguish the latter, besides the absolute height, the ruggedness of terrain is important, which is expressed in a significant difference in elevations within a relatively small area. The differences in elevation points are also combined with significant variations in the angle of slopes [5–6]

The cartometric activities encountered some challenges related to the border between the Chechen Republic and the Republic of Ingushetia. They were due to the fact that by the time the paper was initiated, the websites of both the North Caucasian Federal District and these entities had no comparable information on their areas. In this regard, information about the areas of the Republic of Ingushetia and the Chechen Republic was based on the Rosreestr data for 2019.

3. The effect of the relief on the spatial structure of agriculture in the North Caucasian Federal District

The North Caucasian Federal District features the relief that is most contrasting in the Russian Federation with elevation differences of up to 5,700 m, since it houses the highest point of the country (Elbrus, 5642 m) and the Caspian lowland located below sea level. However, regarding the elevation points, the territory under consideration is dominated by a level terrain with elevations of up to 500 m, which stretches over an area of 107,394 km² (63.0 %). In a 500 to 1000 m height range, the territory of the Ciscaucasia is represented by uplands (Stavropol, Siltanuk and others), foothill (forward) ranges (Tersky, Kabarino-Sunjensky, etc.) and individual massifs (laccolith mountains in Pyatigory). They account for 17,952 km² (10.5 %). Finally, regions with heights above 1,000 m are traditionally referred to as mountainous. Here, the altitude ranges up to 2,000 m are referred to as midlands, and above 2,000 m – high mountains. Subalpine and alpine landscapes routinely used in transhumance and pasture livestock breeding have become widespread in the midland and especially highland altitudinal zones, above the forest zone. In addition, gardening and horticulture are advanced in mountain basins and widened river valleys, especially in the Inner Mountain Dagestan. The areas located in uplands above 1,000 m in the North Caucasian Federal District constitute 45,094 km² (26.5 %) (Fig. 1, Table 1).

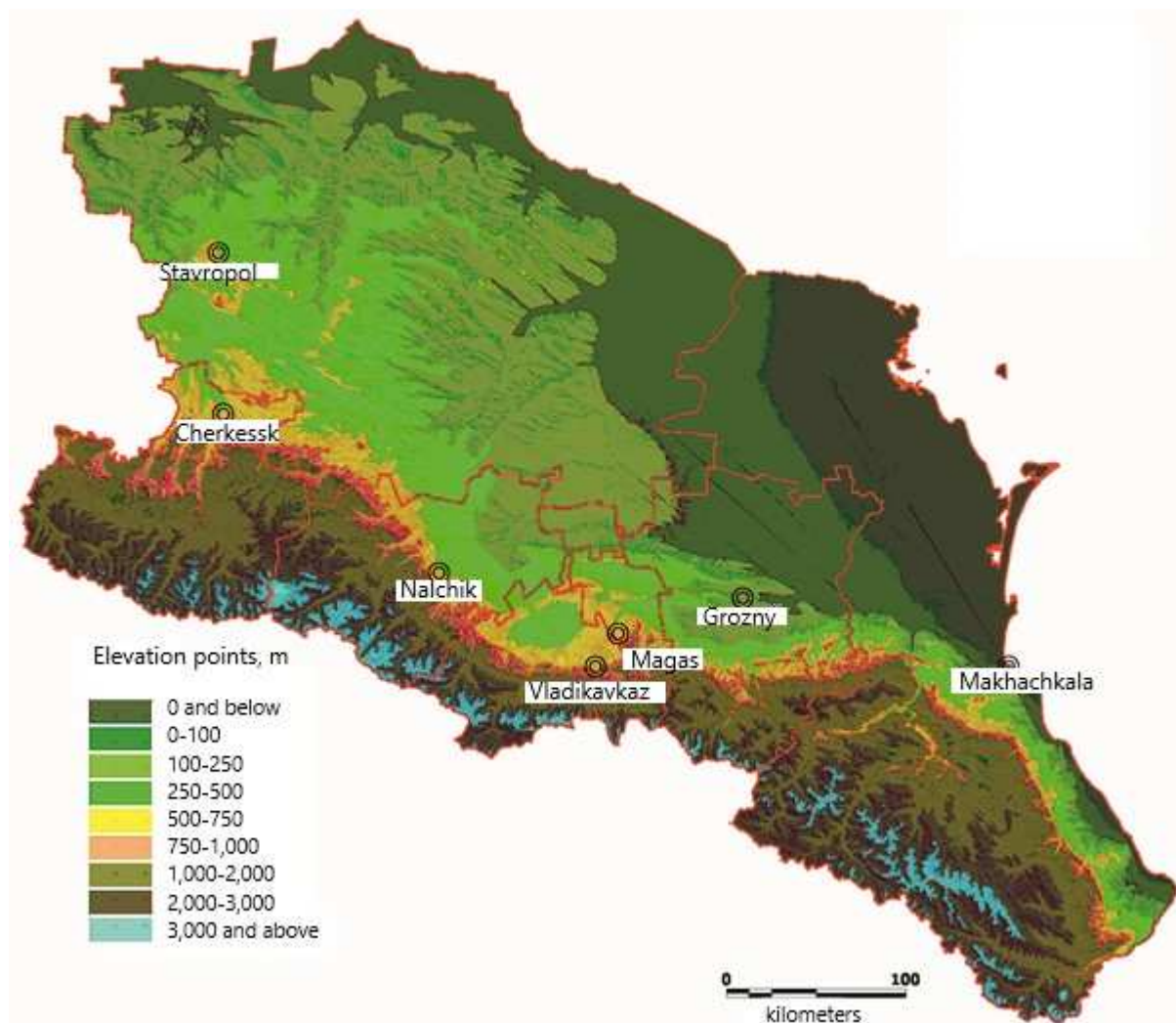


Figure 1. Differentiation of the NCFD territory by elevation points

The overall picture showing the distribution of absolute heights and their areas on the territory of the district is quite significantly different for its individual entities. Thus, lowlands and plains are most widely represented in Stavropol Krai, Chechnya and Dagestan, where the proportion of elevations up to 500 m is 93.9, 66.8 and 53.7 %, respectively. The plains are fairly represented in Karachay-Cherkessia, where they account for just over 2 % of the territory. In other entities, they make up from 26 % (North Ossetia-Alania) to 36.8 % (Ingushetia).

As for the foothills, they are the least widely represented in the topography of Stavropol (5.4 %), Dagestan (7.0 %) and Chechnya (11.8 %). In other entities they make up from 16.7 % in Kabardino-Balkaria to 35.7 % in Ingushetia. As for the mountains, they are under-represented in Stavropol Krai (0.6 %). The most mountainous relief is present in Karachay-Cherkessia, 75.2 % of the territory of which is accommodated in uplands above 1000 m, and Kabardino-Balkaria, where mountains occupy more than 50 %. In North Ossetia-Alania and Dagestan, they account for 44.3 and 39.3 % of the territory, respectively, and in Ingushetia and Chechnya – 27.5 and 21.4 %.

In general, elevation points are most favorable for the development of agriculture in Stavropol Krai, Dagestan and Chechnya, where regions with heights of up to 500 m occupy the vastest area, largely with uplands, low-mountain ranges, and actual foothills. The predominance of the territories with heights above 1,000 m in Karachay-Cherkessia and Kabardino-Balkaria, with the mountainous

terrain to be most characteristic, limits the usage of these territories for crop production, but contributes to the development of transhumance and pasture livestock breeding. The steepness of the slopes, along with their hypsometry, are one of the important morphometric parameters enabling to divide the territory into mountainous and plain parts, and to create farming conditions. The differentiation of the territory of the North Caucasian Federal District depending on the angle (steepness) of the slopes is illustrated in Fig. 2 and Table 2.

The data provided illustrate that the steeper the slopes the fewer the areas available. The angle of the slopes as such is associated with absolute heights, since a level terrain is characterized by relatively small excesses, and, accordingly, slopes. From this point of view, most of the territory of the North Caucasian Federal District is characterized by the slopes of up to 5°, which occupy an area of 114,101 km², or 66.9 %. Moreover, the main part of this gradation area is occupied by almost flat surfaces (0–1°), widely represented on the territory of the Caspian lowland and its parts, where the topography is complicated by aeolian features.

Table 1. Differentiation of the NCFD territory by elevation points

Elevations, m	Stavropol Krai	KCR	KBR	North Ossetia- A	RI	CR	RD	NCFD
< 0	0	0	0	0	0	483	15646	16129
	0.0	0.0	0.0	0.0	0.0	3.1	31.1	9.5
0–100	16340	0	0	0	0	5187	7318	28845
	24.7	0.0	0.0	0.0	0.0	33.2	14.6	16.9
100–250	29723	0	1622	928	123	2806	1543	36745
	44.9	0.0	13.0	11.6	3.4	17.9	3.1	21.6
250–500	16089	298	2462	1139	1213	1973	2502	25676
	24.3	2.1	19.7	14.3	33.4	12.6	5.0	15.1
500–750	3028	1639	1096	1541	993	1128	1971	11396
	4.6	11.5	8.8	19.3	27.4	7.2	3.9	6.7
750–1000	560	1607	985	841	302	721	1540	6556
	0.8	11.3	7.9	10.5	8.3	4.6	3.1	3.8
1000–2000	420	6252	2625	1461	599	2142	8957	22456
	0.6	43.8	21.1	18.3	16.5	13.7	17.8	13.2
2000–3000	0	3798	2315	1443	303	985	8580	17424
	0.0	26.6	18.6	18.1	8.4	6.3	17.1	10.2
> 3000	0	684	1364	634	95	222	2214	5213
	0.0	4.8	10.9	7.9	2.6	1.4	4.4	3.1
Total	66160	14278	12471	7988	3627	15647	50271	170440
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Note: the area is in km² in the numerator, in percent – in the denominator

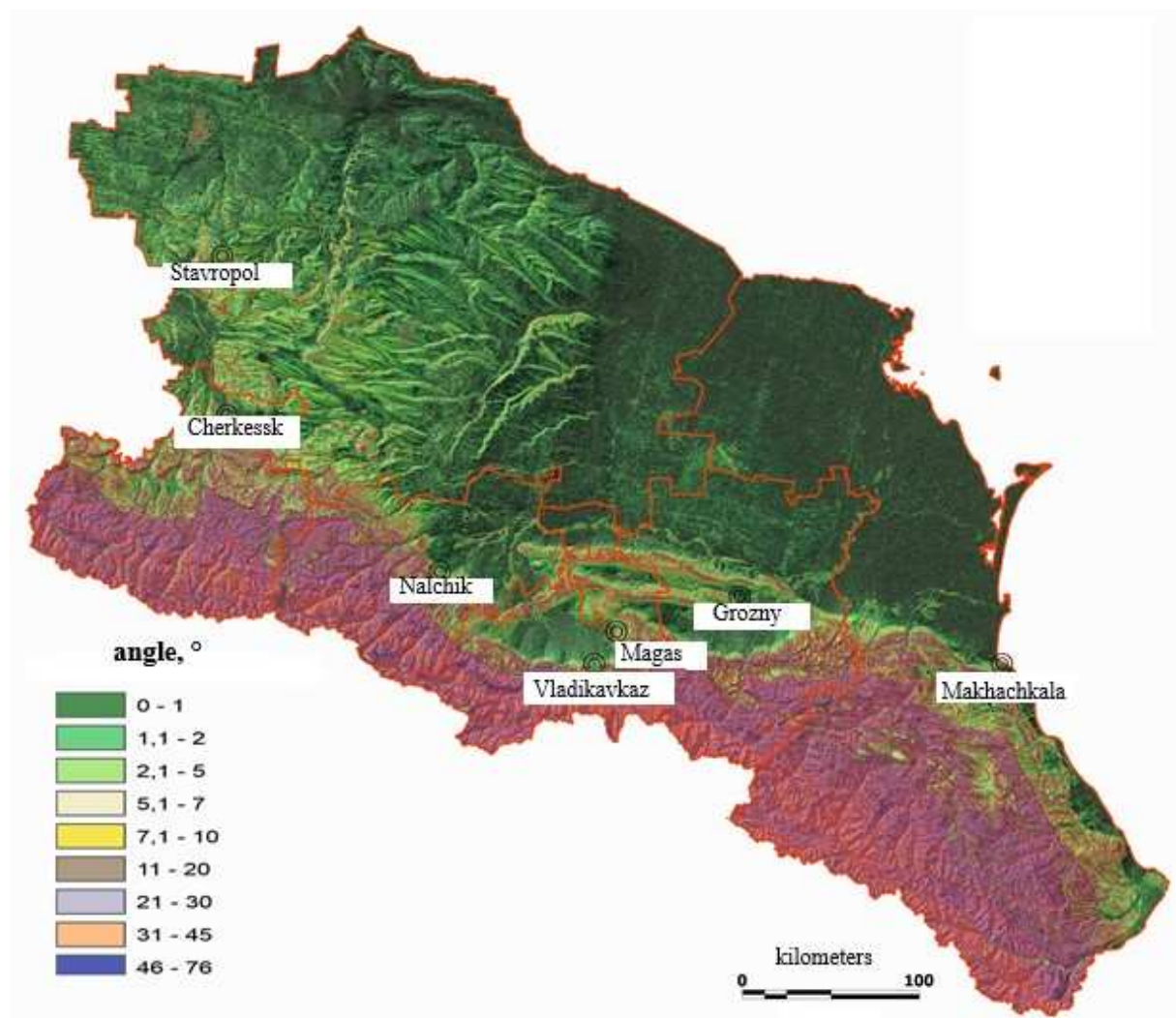


Figure 2. Differentiation of the NCFD territory by the angle of slopes

Similarly with absolute heights, the territories with minimal slopes in absolute and relative values are the most widely represented in Stavropol Krai (63,488 km² or 96.0 %), Dagestan (2,675 km² or 53.2 %) and Chechnya (9,810 km² or 62, 7 %). In Kabardino-Balkaria, North Ossetia-Alania and Ingushetia, slopes with an angle of up to 5° account for an average of 45 % of the territory. Finally, the smallest areas with a given gradation are present in Karachay-Cherkessia.

The slopes with an angle of 5–10° occupy 14,712 km² (8.6 %) in the territory of the North Caucasian Federal District. They are least represented in Stavropol Krai (3.4 %) and Dagestan (8.6 %), and as much as possible in Ingushetia (21.4 %). These slopes largely correspond to uplands and foothills. The slopes with an angle of more than 10 ° occupy an area of 41,677 km² (24.4 %). The largest share of steep slopes is typical of Karachay-Cherkessia (56.6 %), North Ossetia-Alania (44.2 %) and Kabardino-Balkaria (43.4 %). In Ingushetia and Dagestan, this category of slopes accounts for 30 to 40 % of the territory, and in Chechnya – less than 30 %. Finally, in Stavropol Krai, the regions with such an angle occupy less than 1 % of the territory.

Table 2. Differentiation of the NCFD territory by the angle of slopes

Angle, °	Stavropol Krai	KCR	KBR	North Ossetia-A	RI	CR	RD	NCFD
0–1	41525 62.8	816 5.7	3098 24.8	2170 27.2	381 10.5	7201 46.0	22401 44.6	77592 45.5
1–2	13756 20.8	755 5.3	950 7.6	650 8.1	409 11.3	1189 7.6	1478 2.9	19187 11.3
2–5	8207 12.4	1989 13.9	1354 10.9	740 9.3	766 21.1	1420 9.1	2846 5.7	17322 10.2
5–7	1350 2.0	1190 8.3	715 5.7	393 4.9	355 9.8	700 4.5	1909 3.8	6612 3.9
7–10	901 1.4	1453 10.2	944 7.6	501 6.3	421 11.6	1022 6.5	2859 5.7	8101 4.8
10–20	397 0.6	3638 25.5	2339 18.8	1221 15.3	604 16.7	2052 13.1	8251 16.4	18502 10.9
20–30	22 0.0	2736 19.2	1730 13.9	1198 15.0	342 9.4	1250 8.0	6653 13.2	13931 8.2
30–45	2 0.0	1643 11.5	1232 9.9	1051 13.2	332 9.2	797 5.1	3804 7.6	8861 5.2
45 and above	0 0.0	58 0.4	109 0.9	64 0.8	17 0.5	16 0.1	70 0.1	334 0.2
Total	66160 100.0	14278 100.0	12471 100.0	7988 100.0	3627 100.0	15647 100.0	50271 100.0	170440 100.0

Note: the area is in km² in the numerator, in percent – in the denominator

4. Conclusion

A comparison of regions with different absolute heights and angle of slopes shows that the lowest elevation points are typical of the lowlands that are widespread in the northern parts of Dagestan and Chechnya, as well as in the east of Stavropol. However, a limiting factor for crop production here is thought to be climate conditions rather than terrain. In this regard, transhumance and pasture livestock breeding has gained significant momentum in these regions.

The most favorable synergy of elevation points and angle of slopes is typical of Stavropol Krai, where a level relief with heights of up to 250 m (44.9 %) and slopes of up to 5° is widely represented. Similar conditions are available in the northern parts of Kabardino-Balkaria and North Ossetia-Alania, as well as in the central parts of Ingushetia and Chechnya, with piedmont sloping plains. As for the mountainous part, where the angle of the slopes increases as the absolute height rises, sheep breeding is mainly developed in the highlands of all the republics of the North Caucasian Federal District. Mountain agriculture is confined to the mildest areas in the wide river valleys and large mountain basins.

Thus, being the most important element of the natural environment, the relief has an impact on agricultural production. Large areas of low-plain relief with relatively high elevation points contribute to the formation of homogeneous microclimate factors, and, consequently, agricultural methods. A slight angle of slopes (up to 5°) make it possible to widely use mechanic means in the region. These factors encourage agricultural production, especially crop production [7–10].

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