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ASSESSING MOUNTAIN ECOSYSTEMS FOR AGRICULTURAL MANAGEMENT: CHECHEN REPUBLIC CASE STUDY

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Abstract

The aim of the research was to assess mountain ecosystems for agricultural management, with a focus on the Chechen Republic. The methodology involved a comprehensive analysis based on geographic information systems (GIS), remote sensing, and field studies. Data were collected using satellite imagery, cartographic information, and territorial investigations. One notable result of the study is the identification of vulnerabilities and potential within the mountain ecosystems of the Chechen Republic concerning agriculture. GIS analysis enabled the determination of optimal zones for agricultural activities, taking into account the features of the terrain, climate, and soil composition. The results also revealed the potential for implementing sustainable agricultural practices aimed at preserving mountain ecosystems. The conclusions of the study underscore the importance of considering ecological characteristics when developing agricultural strategies in mountainous regions. Recommendations for sustainable land use and agriculture in the Chechen Republic can serve as a basis for formulating policies that balance agricultural activities with nature conservation in mountainous areas.

Keywords: Agroclimatic assessment, ecological potential of phytocenosis productivity, ecosystem, heat and moisture supply, mountain landscapes, natural productivity of phytomass t/ha

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1. Introduction

Spatial and temporal changes in climatic conditions in small areas against the backdrop of global warming can affect various sectors of agar land use. Therefore, the study of the climatic features of individual territories for further forecasting is very relevant. The climate of any territory is formed due to the main factors: the latitude of the area, the total solar radiation, the circulation of atmospheric fronts and the underlying surface. In each territory, one of the above factors always comes first. For the territory of the Chechen Republic, we can confidently single out the dominant factor as the structure of the surface. The Caucasian ridge to some extent changed the latitude of the area, since the territory of the republic is located in the subtropical zone. The Caucasian watershed with lateral and rocky ridges strongly influenced the circulation of atmospheric fronts, in particular, precipitation and exposure of slopes to the incoming total solar radiation. The northern slopes of the front ranges: the black mountains experience high humidity and are therefore covered with dense forest. Higher, gradually, depending on the direction of the mountain ranges, heat and moisture supply and barometric pressure change. On the slopes located perpendicular to the prevailing winds, and in the intermountain valleys, more precipitation falls than on other forms of mountain relief (Ryzhikov, 1978). Naturally, orographic conditions form relatively humid weather during the warm period on the northern slopes of the mountain forest-meadow zone and in intermountain valleys.

In the mountainous regions of the Chechen Republic, there are no enterprises of the agro-industrial complex, the land is used as hay and pasture lands (Ryzhikov, 1978).

2. Problem Statement

The problem statement revolves around the impact of elevation on various meteorological parameters and climatic conditions, emphasizing the direct influence on agricultural activities. The identified changes with increasing height include temperature fluctuations, variations in illumination, precipitation patterns, humidity levels, air cleanliness, and the content of atmospheric particles. Higher elevations are characterized by a decrease in vegetation cover due to the altering atmospheric conditions. Additionally, the study acknowledges the agro-climatic significance of these variations in relation to agricultural crop growth and animal husbandry (Podkolzina & Belousov et al., 2021; Podkolzina & Taranova et al., 2021; Taranova & Podkolzina et al., 2021).

The diminishing warm period at higher elevations, resulting in a delayed spring and an earlier autumn, further highlights the climatic challenges that impact agricultural practices. Understanding these agro-climatic conditions is crucial for implementing effective strategies and interventions to optimize agricultural productivity in mountainous regions.

3. Research Methods

The research methods involve analyzing meteorological data to understand the temperature variations in different seasons at varying elevations in mountainous regions. The focus is on identifying patterns such as the warmer autumn compared to spring, the impact of snow and glacier melting on

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temperature, and the overall climatic conditions throughout the year (Elbuzdukaeva et al., 2019; Sugaipova & Gapurov, 2018).

Specifically, the study considers temperature differences in winter, autumn, spring, and summer, examining factors like snow and glacier melting, cloud cover, and seasonal variations. The concept of "lakes of cold" in mountain valleys and hollows is introduced, emphasizing the unique climatic characteristics of these areas. The research also delves into the timing of frosts at different altitudes, illustrating how elevation influences the onset and duration of cold weather.

By utilizing meteorological data and focusing on temperature patterns at various elevations, the research aims to provide insights into the agro-climatic conditions that affect agricultural practices in mountain ecosystems.

Table 1. Average annual temperatures in the mountainous regions of the Czech Republic from 2010-18

№	Weather stations / year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2010-2018
	Nojay Yurt		8,4	9,8	10,4	9,9	10,1	9,9	10,1	10,4	9,875
	Vedeno	10,5	7,6	8,9	9,3	9,0	7,0	8,9	9,1	9,7	8,89
	Shatoy	11	8,3	9,6	9,7	9,4	9,8	9,8	9,3	10,2	9,68
	Itum Kale			7,0	6,9	7,2	9,4	6,7	7,2	11,7	8,014

Source: according to weather data (temperature) of the Chechen Center for Hydrometeorology and Environmental Monitoring for 2010-18

In the mountains, climatic conditions largely depend on the forms of relief, exposure and steepness of the slopes in relation to the Sun, i.e. in winter, the eastern and northern slopes are a little colder by 2-3 °, the snow lasts longer, on the western and southern slopes with a steepness of 10 ° in spring, by 3-4 4-5° higher. The thermal regime in the mountains depends on the orographic indicators of the relief: the steepness of the slopes of exposures, and forms. For example, in winter on the southern and southwestern slopes, the snow melts earlier, and it can be several degrees warmer.

Table 2. Average annual rainfall in mm in the mountainous regions of the Czech Republic since 2010-18

№	weather stations / year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2010-2018
	Nojay Yurt	734,7	979,9	889,7	1197,8	864,7	959,3	1207,3	833	529,4	910,6
	Vedeno	675,9	643,2	715,8	895,6	856,1	695,3	1030,9	800,4	643,7	772,9
	Shatoy	699	890,7	687,2	808,1	620,9	649,3	888,2	579,4	503,7	702,9
	Itum Kale			638,7	338,8	598,9	791,8	868,9	589,8	481,2	615,5

Source: according to meteorological data (jcflrb) of the Chechen Center for Hydrometeorology and Environmentl Monitoring for 2010-18

4. Findings

The findings reveal that the agro-climatic conditions crucially depend on heat and moisture supply within the territory. These conditions, in turn, dictate the suitable locations for various agricultural activities at different elevations in the mountains. Soil temperature emerges as a key determinant in the selection and placement of agricultural crops in these mountainous regions (Klishina et al., 2017).

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Several factors significantly influence the temperature regime of soils, including terrain height, slope exposure, relief shape, soil humidity, soil color, vegetation cover color, density, and height. Notably, lighter-colored soils and underlying rocks, gleyed and moist soils, and dense and tall vegetation contribute to cooler soil temperatures. The interplay of these factors underscores the complexity of agro-climatic considerations in mountainous areas, highlighting the need for precise understanding and management of these conditions for successful agricultural practices (Figure 1).

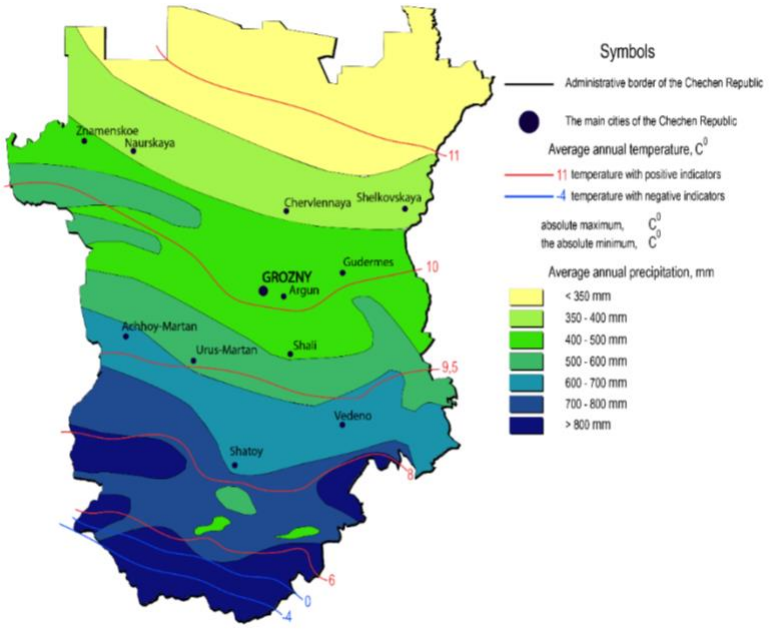

Figure 1. Climate map of the Chechen Republic (Matsaev, 2012)

Table 3. Heat supply of the growing season with an average daily air temperature above 10 ° C, at different altitudes and characteristics of the thermal period

Height above sea level, m	Places with difficult air flow (cold places)				Places with normal conditions (temperate places)				Places with good cold air flow (warm places)				Places with good air exchange (very warm places)			
	The beginning	The end	Duration of days	The sum of the duration of the	The beginning	The end	Duration of days	The sum of the duration of the	The beginning	The end	Duration of days	The sum of the duration of the	The beginning	The end	Duration of days	The sum of the duration of the
500	21 IV	13 X	175	2920	19 IV	14 X	178	3060	17 IV	16 X	182	3210	-	-	-	-
600	22 IV	11 X	172	2780	21 IV	13 X	175	2920	19 IV	15 X	179	3080	-	-	-	-
700	24 IV	8 X	167	2650	22 IV	11 X	172	2820	20 IV	13 X	176	2970	-	-	-	-
800	26 IV	5 X	162	2520	24 IV	9 X	168	2680	22 IV	12 X	173	2840	19IV	15 X	179	3080
1800	1 VI	9 IX	100	1260	27 V	13 IX	109	1400	22 V	18 IX	119	1570	14V	23IX	132	1820
2000	10	2	84	980	5	6	93	1140	20	10	103	1300	23V		116	1540

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	VI	IX		VI	IX		V	IX				16IX			
2200			710			880	8 VI	3 IX	87	1040	31V	10 IX	102	1280
2400			440			600				760	9VI	2 IX	85	1000
2600						320				500				740
2800						0				210				460

Source: Agroclimatic reference book of the Kabardino-Balkarian North Ossetian, Chechen-Ingush Autonomous Soviet Socialist Republics (Matsaev, 2012)

Of fundamental importance in the reproduction of plant mass is the humidity of atmospheric air, for this it is necessary to calculate the moisture coefficient according to the formula:

Ku = P / Σd

where Ku - coefficient of annual atmospheric moisture, equal to the ratio of precipitation to evaporation P is the amount of precipitation in mm per year;

Σd - the sum of the average daily values of the air humidity deficit (Ryzhikov, 1978; Shmatko et al., 2016).

To determine the productivity of ecosystems (phytomass per ton/ha), it is necessary to collect material on meteorological parameters for at least the last ten or twenty years. In calculating the natural productivity of phytocenoses t/ha (plant mass), soil and climatic conditions play an important role for the growing season and are calculated by the formula:

Epr = 0.000035*∑t>10°*Ku*Q, (1)

Epr - Natural productivity of phytomass) t/ha;

0.000035 - coefficient of dependence between phytocenosis and climate mountains. The temperature regime of soils is greatly influenced by: the height of the terrain, the exposure of the slopes, the shape of the relief, the humidity and color of the soil, the color, density and height of the vegetation cover. The soil is colder if it and its underlying rock are light in color, also if it is gleyed and moist and the vegetation is dense and tall (Matsaev, 2014).

Ku - moisture coefficient;

∑t>10°*° sum of active temperatures during the growing season;

Q is the number of days of the active vegetation period (Matsaev, 2014; Shashko, 2019; Vorontsova et al., 2019).

To accurately determine phytomass per hectare, the plant growth factor should be calculated using the following formula: As a result of the research, we have tracking indicators of the natural productivity of the phytomass of ecosystems in the mountain landscapes of the Chechen Republic. Using weather data from tabular materials (see Tables 1-3), we will carry out calculations on the natural productivity (reproduction of phytomass during the growing season) of ecosystems of mountain natural landscapes on the territory of the Chechen Republic. 1. Mountain forest zone at altitudes of 500-1200 meters above sea level. and with a moisture coefficient of 1.04, the sum of temperatures is -2990 and the number of days for the growing season is 176. According to the weather station Nozhai-Yurt-510m. n.s.l. Epr \u003d 0.000035 * 2920 * 1.04 * 178 \u003d 18.9 t / ha 2. Mountain forest-meadow zone at altitudes of 700-1700 meters above sea level. and with a moisture coefficient of 0.9-1.5, respectively, we calculate the average value equal to 1.3, the sum of temperatures is -2840 and the number of days for the growing

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season is equal to 176. According to the weather station Vedeno-715 a.s.l. Epr \u003d 0.000035 * 2800 * 1.3 * 170 \u003d 22 t / ha three. The Shatoi intermountain basin is located within the mountain forest-meadow natural zone at an altitude of 610 meters above sea level. According to the weather station Shatoy, Epr = 0.000035*2850*1.1*174=19.1 t/ha 4. The Itum-Kalinskaya intermountain valley is located in the upper reaches of the Chanty-Argun River at an altitude of 773 meters above sea level, according to the Itum-Kali weather station, Epr = 0.000035*2670*0.5*174=8.1 t /ha 5. Alpine meadows at altitudes above 2000 meters, according to V.V. Ryzhikova Nature and economy Chechen-Ingush ASSR Grozny, 1978. From: -11. Epr \u003d 0.000035 * 1260 * 0.6 * 130 \u003d 3.5 t / ha The conducted studies show the similarity and difference of some data on the ecological potential of the natural productivity of phytocenoses of mountain landscapes on the territory of the Chechen Republic. Heat and moisture supply are factors that form the natural appearance of a given territory, giving distinctive features by types of vegetation cover population, etc. (table 4).

Table 4. Ecological potential of natural productivity of phytocenoses in mountain landscapes Chechen Republic

Natural area (ecosystem)	**Weather stations**	**$\sum t>10°$* the sum of active temperatures during the growing season**	***Km* - moisture factor**	**Q - number of growing days above10^0**	***Ep* - Natural productivity of mountain landscapes (phytomass) t/ha**
Gornolesnaya	Nozhay-Yurt	2920	1,04	1789	18,9
Mountain forest meadow	Vedeno	2800	1,3	170	22
Intermountain basins	Shatoy	2850	1,1	174	19,1
Intermountain valleys	Itum-Kale	2670	0,5	171	8,1
Alpine meadows	(Ryzhikov, 1978)	1260	0,6	130	3,5

5. Conclusion

In conclusion, this study represents a pioneering effort in the Chechen Republic to apply methods for calculating and assessing the ecological potential of natural productivity in mountain landscapes. The focus is primarily on agro-climatic conditions, encompassing factors such as heat and moisture supply, and other meteorological parameters. The research incorporates comprehensive data, including dynamic trends analyzed over short-term periods from 2010 to 2018, complemented by historical data spanning 1960 to 1980 for long-term analysis.

This study lays the groundwork for future programming and strategic planning concerning the optimal utilization of mountainous territories for agricultural purposes. The findings contribute to the development of a robust forecast that can inform sustainable land use practices in these regions. Additionally, the study presents an updated climatic map of the Chechen Republic, providing a clear visual representation of average meteorological parameter values based on extensive long-term research.

Overall, the insights gained from this research are valuable for guiding ecological and agricultural initiatives in the Chechen Republic's mountainous landscapes.

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