Analysing the Impact of Climate Indicators on Agricultural Crops in the Specific Context of the Bakhmal District

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Abstract: In this article, based on the scientists who conducted research in the assessment of climate for agricultural crops and their work, criteria were developed in the conditions of the Bakhmal district. In the development of the criteria, the temperature, and humidity indicators of the climate, as well as the sum of effective temperatures, various "hydrothermal coefficients", and "humidity coefficients" were taken into account.

1 INTRODUCTION

The consideration of climate assessment for agriculture has been a focal point in the research of notable scientists, including G. T. Selyaninov, N. N. Ivanov, D. I. Shashko, P. I. Koloskov, L. N. Babushkin, and Sh. S. Zokirov. In the Bakhmal region, understanding the growth, development, and productivity of agricultural crops necessitates a comprehensive analysis of temperature and humidity indicators, along with factors such as the sum of effective temperatures, various hydrothermal coefficients, and humidity coefficients.

Moreover, the assessment must encompass potential adversities posed by climatic phenomena that could negatively impact agricultural crops. These encompass spring and autumn frosts, hail and sleet, sleet, strong winds, and dust. To enhance precision, adjustments to the primary assessment are made using specific coefficients.

This holistic approach to climate assessment acknowledges the multifaceted nature of environmental factors affecting agriculture in the Bakhmal region. It emphasizes the importance of considering not only favourable conditions but also potential challenges posed by various climatic elements, ensuring a more nuanced understanding for effective agricultural planning and management (Sharipov et. al., 2020).

1.1 The Main Part

For optimal crop growth, each crop type and variety necessitate a specific set of effective temperatures. The sum of effective temperatures is calculated based on the accumulation of average temperatures exceeding +10°C, a threshold at which the plant's physiological processes function normally. In assessing the sum of effective temperatures for winter and spring farming in the Bakhmal district, insights from experiments conducted by L.N. Babushkin (1964) and Sh.S. Zokirov (1972) are incorporated. A thermal resources evaluation system tailored to the conditions of the Bakhmal district can be formulated accordingly, as outlined in Table 1. This approach ensures a nuanced understanding of thermal dynamics crucial for agricultural planning, emphasizing the significance of specific temperature thresholds in optimizing crop cultivation.

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Table 1: Evaluation of thermal resources.

No	The sum of effective temperatures (+10˚C above)	Evaluation scores	Evaluation quality
1	More than 3800	100	the most convenient
2	2700-3800	80-100	comfortable
3	2100-2700	60-80	average
4	1600-2100	40-60	below average
5	1000-1600	20-40	uncomfortable
6	0-1000	0-20	Invalid

In the development of this evaluation system, the thermal properties of local agricultural crops, namely wheat, barley, peas, corn, beans, alfalfa, sugarcane and vegetable crops, grapes, and fruit trees were taken into account [11].

L.N.Babushkin (1964), and Sh.S.Zokirov (1972) based on the requirements of the cotton crop (latest ripening varieties, medium ripening varieties, fastest ripening varieties) in developing the provision of thermal resources for obikor farming and evaluated as follows develops a system.

Table 2: Estimating the sum of effective temperatures.

No	The sum of effective temperatures	Evaluation scores
1	2670	100
2	2250	85
3	2020	75
4	1500	60
5	1000	40

Changes were introduced to the assessment system developed by scientists due to the absence of cotton cultivation in the Bakhmal district. Landscapes with a sum of effective temperatures exceeding 3800°C are awarded a perfect score of 100 points, designating them as "most comfortable." This thermal zone is not only suitable for all crops in the region but also facilitates the full ripening of heat-loving crops such as cotton and grapes. The conducive thermal conditions even allow for a double harvest in organic farming. L.N. Babushkin (1964) delineated five thermal zones based on the sum of positive temperatures during the growing season, designating areas with 3800°C and above as the hot zone, suitable for growing medium and fast-ripening cotton varieties.

For sums of effective temperatures ranging between 2700°C and 3800°C, a rating of 80 to 100 points is assigned, indicating "favourable" conditions. Heat-loving grapes do not ripen in regions with a sum of effective temperatures below 2700°C. Landscapes with sums between 2100°C and 2700°C are rated between 60 and 80 points, labelled as "average." L.N. Babushkin (1964, 1985) terms this zone as the grain crops zone due to the optimal conditions for legumes, legumes, and vegetables. Sum of effective temperatures between 1600°C and 2100°C scores between 40 and 60, categorised as "below average," crucial for the ripening of specific barley varieties in spring landscapes. Landscapes with sums between 1000°C and 1600°C are deemed "unfavourable" and receive ratings from 20 to 40 points. Those with sums below 1000°C are considered "unsuitable" with a score of 0-20, corresponding to non-agricultural areas in the highlands. L.N. Babushkin (1964) notes this zone as unsuitable for agriculture due to the thermal resource. The growth, development, and yield of agricultural crops during spring farming hinge on soil moisture supplied by rainwater, assessed using the "hydrothermal coefficient" formula by G.T. Selyaninov (1).

$$\text{ГТК} = \Sigma \text{P}/(\Sigma \boldsymbol{t}: \mathbf{10}) \quad (1)$$

$\mathbf{\Sigma P}$ – average amount of precipitation during the growing season.

$\boldsymbol{\Sigma t}$ – the temperature sum of the period when the average daily temperature is above +10°.

This necessitates data on precipitation during the growing season and the sum of effective temperatures with average daily temperatures above 10°C. The vegetation period aligns with the initial development phases of plants [7;8], varying depending on plant types and yearly weather fluctuations. For barley and wheat, it's observed at 5°C, 10°C for cotton, 12°C for oats, and 15°C for rice and fruit trees [2; 354–357-p.]. Considering periods with average daily temperatures of +10°C and above, the vegetation period in the Bakhmal district commences in mid-March and concludes in early October. Precipitation during this timeframe ranges from 119 mm to 211 mm, corresponding to altitude changes from 800 m to 3000 m. The sum of temperatures with average daily temperature above +10°C decreases from 4160°C to 500°C concerning altitude (Table 3).

G.T. Selyaninov's formula determined the hydrothermal coefficient for each landscape morphological unit, exhibiting variations from 0.29 to 4.23 in the district. Based on this data, a hydrothermal coefficient less than 0.3 designates a dry zone (suitable only for irrigated farming), 0.3 to 0.5 indicates a drier zone (spring grain crops at 75-99% natural soil moisture), and a zone with a coefficient greater than 0.5 signifies a wet zone (natural moisture supply reaching 100% for spring grain crops) [1]. The dry zone, with a hydrothermal coefficient below 0.3, encompasses areas up to 850 m absolute altitude, while the drier zone (0.3 to 0.5) includes altitudes between 850 m and 1540 m. Areas above 1540 m in the Bakhmal district fall into the wet zone, possessing a hydrothermal coefficient greater than 0.5.

Hydrothermal coefficients are assessed using points and quality indicators, including the sum of effective temperatures. A result above 0.75 earns 100 points (most favourable), 0.50-0.75 corresponds to 80 to 100 points (favourable), 0.30-0.50 equates to 60 to 80 points (average), 0.20-0.30 warrants 40 to 60 points (below average), 0.11-0.20 merits 20 to 40 points (unfavourable), and less than 0.11 is categorised from 0 to 20 points (invalid).

Table 3: Evaluation of hydrothermal indicators.

No	Hydrothermal index	Evaluation scores	Evaluation quality
1	0.75	100	the most convenient
2	0.50-0.75	80-100	comfortable
3	0.30-0.50	60-80	average
4	0.20-0.30	40-60	below average
5	0.11-0.20	20-40	uncomfortable
6	0-0.11	0-20	invalid

The assessment of thermal resources for agricultural crops reveals a noteworthy contradiction when compared to the evaluation of hydrothermal resources. Areas deemed unusable and unfavourable in the thermal resource assessment paradoxically exhibit the most favourable and favourable qualities in the hydrothermal coefficient assessment. This incongruity is rooted in the well-established understanding that thermal resources diminish while precipitation increases with higher altitudes in mountainous regions.

Spring and autumn black frosts, naturally occurring meteorological phenomena, do not significantly impact agricultural assessments. The adjustments made involve modifying the main score using specific coefficients [3; 202–221-p.]. These black frosts, characterized by air temperature and soil surface dropping to 0°C or lower, are deemed harmful, with a notable prevalence in the Bekhmal district. Over the last 5 years in the town of Osmat and its surroundings, spring black frosts have caused considerable damage to various crops multiple times, underscoring their detrimental impact.

The timing of black frosts is influenced by geographical position, plant type, variety, agrotechnical conditions, and other factors. Different crops exhibit varying degrees of resistance to cold, with spring wheat, barley, and peas enduring temperatures from -7°C to -10°C, cabbage from -5°C to -7°C, soybeans and radish from -3°C to -4°C. Less cold-resistant crops, including corn, millet, potatoes, and tobacco, can withstand black frosts up to 0°C.

In our republic, the onset of the plant vegetation period experiences an average delay of 1.5-2.5 days for every 100 meters rise in altitude. In the moderately steep hills of the Bakhmal district, this delay extends to 3-4 days. For example, in 2020, the full flowering phase of apple trees occurred on April 10 in the town of Osmat at an altitude of 1000 m above sea level. In contrast, in the village of Zartepa, located 700 m above Osmat and 45 km away, the same phase was observed on May 10. This delayed onset of the spring period is associated with a reduction in the occurrence of spring frosts.

When determining the coefficient of spring and autumn cold shocks, the focus extends beyond the number of days after the start of the growing season to consider the frequency of occurrence. This approach has led to the development of specific criteria, as outlined in Table 4. The emphasis on frequency provides a more nuanced understanding of the impact of cold shocks on crops, offering a comprehensive assessment that goes beyond temporal considerations.

In conclusion, the intricacies of thermal and hydrothermal assessments, coupled with the impact of black frosts and the delayed onset of the spring period, underscore the multifaceted nature of agricultural conditions in the Bakhmal district. As agricultural planning necessitates a comprehensive understanding of these factors, the developed criteria for assessing cold shocks provide a valuable tool for farmers and researchers alike. The interplay of geographical, climatic, and crop-specific variables highlights the need for adaptive and region-specific agricultural practices to optimize productivity and resilience in the face of diverse meteorological challenges.

Table 4: Coefficients of spring and autumn frostbite.

No	Spring frost hit	Correction factor	Fall frost hit	Correction factor
1	During the growing season, spring black frosts do not occur at all	1.00	During the growing season, there are no autumn black frosts at all	1.00
2	During the growing season, spring black frosts occur less than 1 time in 10 years	0.98	During the growing season, autumn black frosts occur less than 1 time in 10 years	0.98
3	During the vegetation period, spring black frosts occur 1-2 times in 10 years	0.96	During the vegetation period, autumn black frosts occur 1-2 times in 10 years	0.96
4	During the growing season, spring black frosts occur 3-4 times in 10 years	0.94	During the growing season, autumn black frosts occur 3-4 times in 10 years	0.94
5	During the growing season, spring black frosts occur more than 4 times in 10 years	0.92	During the growing season, autumn black frosts occur more than 4 times in 10 years	0.92

In the Bakhmal district, the delicate balance of agricultural productivity faces formidable challenges, particularly in the context of frequent meteorological extremes that shape the fate of crops. These challenges manifest in distinct patterns depending on the season and geographical features of the region.

Spring frosts, a recurring adversary for farmers, find their stronghold in the spring landscapes situated at an average altitude of 900-1400 meters above sea level. These chilly intruders disrupt the early stages of plant development, posing a threat to crops at a critical juncture. On the flip side, autumn frosts, another facet of nature's unpredictability, exhibit a preference for regions engaged in irrigated agriculture, particularly those hovering at an average altitude of 800-900 meters above sea level.

The vulnerability of agricultural crops extends beyond the whims of temperature, as hazardous meteorological events wreak havoc during the crucial growing season. The foothills, often deemed idyllic for cultivation, become a battleground for crops contending with hail, storms, floods, and relentless winds. The repercussions of these events are far-reaching and multifaceted.

Wind-blown rains, a formidable force of nature, not only jeopardize the structural integrity of wheat and barley stems but also inflict damage on delicate vine branches. Simultaneously, the fertile top layer of the soil faces erosion, threatening the very foundation of agricultural productivity. The untimely influence of rain close to the ripening period of grapes introduces an additional layer of risk, causing grapes to burst and compromising both the quantity and quality of the harvest.

Hailstorms, a recurrent nemesis, unleash their fury primarily in the foothills of the district. Their unwelcome visitation, typically observed from April to May and sometimes extending into early June, coincides with critical phases in the growth of apple trees, the development of vine branches, and the rapid maturation of grain crops. Even brief spells of hail can dismantle the intricate structures of plants, stripping them of leaves, flowers, and fruits. The aftermath is a compromised yield and diminished quality, with the potential for a lasting impact on the harvest in the subsequent year.

The toll on farmers in the foothills, particularly those specializing in horticulture, is not just agrarian but economic. Hailstorms can inflict severe economic losses as apple fruits, a primary focus of horticultural endeavors, bear the brunt of these meteorological assaults. The night of May 23, 1998, stands as a poignant testament to the destructive potential of hailstorms, where hailstones the size of eggs and bowls, weighing between 100 and 150 grams (some reaching as much as 500-600 grams), prompted a state of emergency in the district. The town of Osmat and Aktash villages and their surroundings were severely impacted, with thousands of buildings rendered unusable and vast expanses of both dry and irrigated grain fields laid waste. Orchards and vineyards, once thriving, succumbed to the hail's onslaught, tallying material damages that amounted to a staggering 532 million soums at the prices of that era [6; 29–32-p.].

Adding to the litany of challenges, early spring floods in some years pose a lurking menace to crop fields. The potential destruction or submersion of fields in mud during these floods necessitates a thorough evaluation of their impact. In the assessment process, specific coefficients are applied to the main scores, providing a nuanced understanding of the challenges posed by these dangerous flood events. The authors, mindful of the complex interplay of meteorological variables, have meticulously outlined the criteria for calculating these coefficients, as presented in Table 5.

In conclusion, the agricultural landscape of the Bakhmal district is intricately woven with challenges imposed by nature's capricious elements. From the frosty embrace of spring to the tumultuous storms and hailstorms, farmers navigate a complex terrain where the resilience of crops is continually tested. The authors' comprehensive assessment, encapsulated in the presented criteria, serves not only as a diagnostic tool but also as a roadmap for devising strategies that mitigate the impact of these meteorological adversaries, fostering sustainable and adaptive agricultural practices.(Holbaev, 2017- Anorboev, 2000)

Table 5: Coefficients of Dangerous Meteorological Phenomena

No	Dangerous meteorological phenomena	Correction factor
1	During the growing season, dangerous meteorological events do not occur at all	1
2	During the growing season, dangerous meteorological events occur less than once in 10 years	0.98
3	During the growing season, dangerous meteorological events occur 1-2 times in 10 years	0.96
4	During the growing season, dangerous meteorological events occur 3-4 times in 10 years	0.94
5	During the growing season, dangerous meteorological events occur more than 4 times in 10 years	0.92

2 CONCLUSIONS

It is desirable to make a general assessment of the climate for agricultural crops through the following formula (developed by the author) (Formula 1).

$$\text{И}_{\text{б}} = \Sigma t_{\text{б}} \times \Sigma_{\text{гткб}} \times \Sigma_{\text{бсук}} \times \Sigma_{\text{ксук}} \times \Sigma_{\text{хмхк}} \times 0{,}01 \quad (1)$$

$\text{И}_{\text{б}}$ – climate assessment score for agricultural crops;

$\Sigma t_{\text{б}}$ – the sum of temperatures with the average daily temperature above +10° is the evaluation score;

$\Sigma_{\text{гткб}}$ – Hydrothermal coefficient score

$\Sigma_{\text{бсук}}$ – Coefficient of spring cold shock

$\Sigma_{\text{ксук}}$ – Autumn frost coefficient

$\Sigma_{\text{хмхк}}$ – Coefficient of dangerous meteorological phenomena

According to the results of climate assessment for agricultural crops in Bakhmal District, the parts of the region close to the Zarafshan Oasis were assessed as favorable, while the unfavorable conditions towards the Chumkor and Morguzar mountains increased.

As the climate of the district is dry and continental, most of the agricultural crops depend on rainfall. Wheat, barley, peas - these crops form the basis of dry farming.

The territory of the district is rich in biological and landscape diversity, but due to the aridity of the climate, it is extremely sensitive and fragile to external factors. If the types of use of nature are not regulated, and not planned purposefully, if the inconveniences of climate change are not taken into account, the system in nature will be destroyed, and it will lead to the reduction of natural resources and the loss of biodiversity. This causes the balance between nature and society to be disturbed and new problems to arise.

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