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ARTICLE

Climate Change and its Impact on Southern Fergana Landscapes

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Abstract

This study examines the impacts of climate change on the Southern Fergana landscapes, focusing on temperature trends, precipitation variability, and their implications for agricultural productivity in Uzbekistan. Utilizing meteorological data from the Kokand weather station (1930–2023), the research analyzes long-term shifts in seasonal temperatures, agroclimatic parameters, and extreme weather events. Key findings reveal a significant temperature increase, with winter temperatures rising by 0.8°C between 1960–1990 and summer anomalies becoming more frequent. Precipitation patterns show irregularity, with April experiencing excessive rainfall that disrupts crop sowing cycles. The study highlights the adverse effects of rising temperatures on staple crops such as cotton, wheat, and tomatoes, with yield reductions of 9–22% under prolonged heatwaves (>35°C). Conversely, elevated CO concentrations and traditional practices like winter irrigation ("chilla suvi") demonstrate partial mitigation benefits, improving soil moisture and reducing pest infestations. Regional disparities are evident: northern areas with shallow groundwater face challenges in fruit cultivation, while southern regions adapt through diversified horticulture. Projections indicate worsening conditions by 2070–2100, with intensified water scarcity threatening irrigated lands. The findings underscore the urgency for adaptive strategies, including optimized irrigation scheduling, heat-resistant crop varieties, and policy reforms to address food security. This research provides critical insights for sustainable agricultural planning in Central Asia's arid zones under evolving climatic stresses.

Keywords: climate change; Fergana Valley; agroclimatic trends; temperature anomalies; agricultural adaptation; water resources.

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1 Introduction

The global phenomenon of climate change has prompted significant international efforts, including the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement, to mitigate its adverse effects. In this context, the Southern Fergana landscapes of Uzbekistan have emerged as a critical area of study due to their vulnerability to climatic shifts and their profound implications for human health, agricultural productivity, and ecological sustainability. This research aims to investigate the impacts of climate change on the Southern Fergana region, employing a multidisciplinary approach that integrates field expeditions, remote sensing technologies, and Geographic Information Systems (GIS) to map and analyze ecological and sustainability potentials.

The study focuses on assessing the region's agroclimatic resources, identifying trends in temperature and precipitation, and evaluating their effects on crop yields. By leveraging advanced technologies such as remote sensing and GIS, the research seeks to provide a comprehensive understanding of the ecological dynamics and resilience of the Southern Fergana landscapes. Furthermore, the study emphasizes the importance of optimizing the use of climatic resources to enhance agricultural productivity, improve ecological conditions, and ensure sustainable development in the face of ongoing climate challenges.

This research is particularly significant as it addresses the urgent need for adaptive strategies in Central Asia's arid regions, where climate change poses a growing threat to food security and environmental stability. By combining traditional field methods with modern technological tools, the study aims to contribute valuable insights for policymakers, agricultural planners, and environmental scientists working toward sustainable solutions in the context of a changing climate.

2 Literature Review and Methodology

2.1 Literature Review

Climate change has been a focal point of scientific research globally, including in Uzbekistan, where numerous studies have addressed its impacts on ecosystems, agriculture, and socio-economic systems. Scholars such as Zubkova G.F., Ososkova T.A., Khikmatov F.Kh., and Chub V.E. have contributed significantly to understanding climate change dynamics, particularly in the context of Uzbekistan. Their work has explored the integration of climate change studies into higher education curricula, participation in international climate conferences, and the development of climate scenarios for Central Asia.

Global climate change has affected all regions, with the Earth's average temperature rising by 0.6°C in the second half of the 20th century, while Europe experienced a more pronounced increase of 1.2°C [1]. Concurrently, sea levels have risen by 10–20 cm, exacerbating coastal vulnerabilities. In Uzbekistan, the impacts of climate change are evident in the Southern Fergana region, where rising temperatures and shifting precipitation patterns have led to increased frequency of extreme weather events, such as anomalous cold spells in 2022 and prolonged heatwaves in 2023–2024. These changes have significant implications for agricultural productivity, water resources, and ecological stability.

2.2 Methodology

This study employs a multidisciplinary approach to analyze climate change impacts on the Southern Fergana landscapes. The methodology integrates the following components:

Data Collection: Meteorological data from the Kokand weather station (1930–2023) were used to analyze long-term trends in temperature and precipitation.

Satellite imagery and remote sensing data were utilized to assess land use changes, vegetation dynamics, and water resource availability.

Field Surveys: Field expeditions were conducted to collect ground-truth data, validate remote sensing findings, and assess the impacts of climate change on local ecosystems and agriculture.

Statistical Analysis: Time-series analysis was performed to identify trends in temperature and precipitation.

Correlation and regression analyses were used to evaluate the relationship between climatic variables and agricultural productivity.

Scenario Development: Climate scenarios were developed based on historical data and future projections to assess potential impacts on the Southern Fergana region.

Geospatial Analysis: Geographic Information Systems (GIS) were employed to map and visualize spatial patterns of climate change impacts, including temperature anomalies, precipitation variability, and land degradation.

By combining these methods, the study provides a comprehensive understanding of climate change impacts on the Southern Fergana landscapes, offering valuable insights for adaptive strategies and sustainable development.

3 Results

The data from the table (Tab 1) reveal a clear trend: starting from 1950, the January temperatures in Southern Fergana landscapes have been rising. During the winter season, the average temperature

Table 1. Monthly Temperature Sum from 1930 to 2023 in the Landscapes of Southern Fergana: (*Compiled by the author based on data from the Kokand city meteorological station.*)

Average Daily Temperature in Kokand (°C)												
Years	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**
1930	-7.1	-1.2	7.9	15.1	21.3	26	27.9	24.8	18	12	8.2	-2.6
1950	-2.3	-1.1	10.4	15	22.9	26.3	27.4	25.8	19.2	12.5	1.8	-4.4
1970	-0.2	5.9	8.2	17.9	22.2	25.2	25.8	25.5	19.5	13.3	7.1	0.3
1990	-0.2	4.4	9.4	16.3	23.2	28.4	27.9	28.4	23.3	13.9	9.6	1.9
2000	2.1	3.2	9.4	19.1	24.5	26.9	29.7	28.2	23	13.3	7.3	3.5
2010	4.0	3.4	12.0	18.7	21.4	26.1	27.9	27.2	21.7	16.5	7.8	2.1
2020	2.4	6.6	13.4	18	23.7	26.7	28.5	27.1	21.2	13.8	4.4	1.4
2023	4.2	5.4	10.2	21.1	22.4	27.3	30.3	27.4	23.1	14.9	7.5	-0.2

has not dropped below 0°C. From May onward, the region clearly experiences the onset of summer, as climate scientists define summer as beginning when temperatures exceed +20°C and lasting up to +30°C.

Furthermore, we observe that temperatures in the landscapes of Southern Fergana are also increasing in the autumn. The most significant temperature changes occur during the winter and spring, while in the central parts of the region, the greatest shifts happen during the summer and autumn. This has led to an increase in thermal resources in the region.

In terms of agro-climatic resources, the sum of useful temperatures above +10°C is most evident in the spring and autumn, with temperature transitions at 0°C, 5°C, 10°C, and 15°C, as well as the timing of early spring and late autumn frosts, showing a general trend and notable cyclic pattern.

Historically, the first frost in Southern Fergana landscapes was expected around early October. However, in recent years, the first frost has been recorded between October 12 and October 17.

To predict the changes in agro-meteorological parameters from 1930 to 2023, the values of regional variations were analyzed and compared with regional climate scenarios [1, 2].

From the data in the figure (Fig 1) above, it is evident that in the region, the average temperatures have increased from 13.4°C in 1960 to 14.2°C in 1990 [2] (Author's Abstract, O.M. Kuzibayeva). During this period, the temperature sum increased by 0.8°C.

From the analysis (Tab 2) of the data above, it is observed that in the landscapes of Southern Fergana, the highest amount of rainfall generally occurs in April. However, it would be more beneficial if the heaviest rainfall occurred in March. This is because, by the

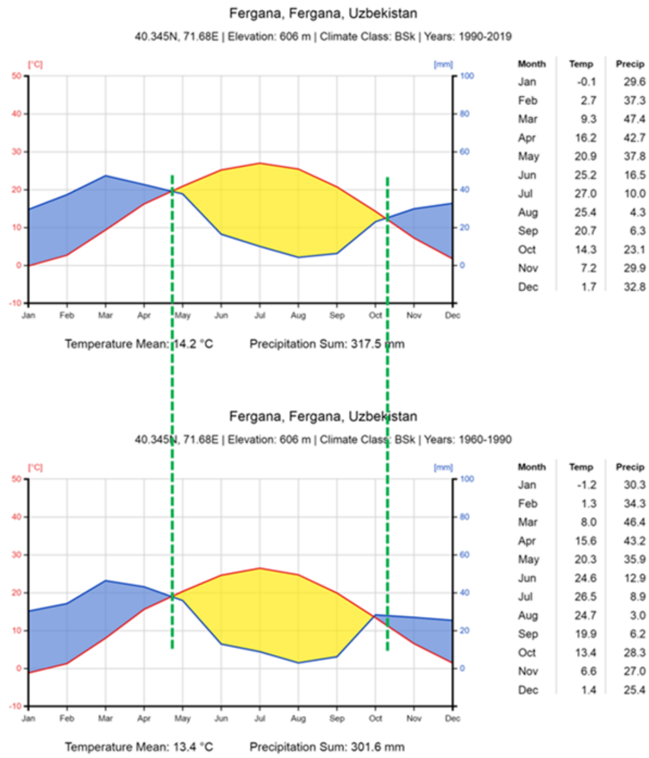

Figure 1. Section 7A. Geochemical spectrum of macroelements

end of March and the beginning of April, agricultural activities start in Southern Fergana landscapes, as in other regions. During this time, crops such as cotton, corn, beans, and peas are sown across the vast fields. Excessive rainfall in April, however, can cause significant damage to the seeds, as the seeds may become submerged or fail to sprout due to waterlogging.

4 Discussion

In our country, 85% of all irrigated lands are used for agricultural activities. As a result, climate change is increasingly tied to water resources and food security.

Table 2. Average Daily Precipitation in Kokand (mm) (*Compiled by the author based on data from the Kokand city meteorological station.*)

Year	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1936	0	5	7	10	12	2	18	21	1	10	1	6
1950	0	0.3	3	4	10	1	5	0.2	0	17	6	1
1970	1	3.5	11.4	19.8	4.2	0.4	5.9	1.9	0.6	2.6	1.4	22.5
1990	7.2	13.1	11.3	21	3.1	7.8	6.7	0	0.6	3.1	0	14.4
2000	13.7	0	2	16.9	3	2.4	5.8	9.1	2	23.8	11.3	20.8
2023	3.2	0.3	5	13.4	5.6	8.3	3.2	6.3	1.2	4.2	5.8	12.3

Rising annual average temperatures lead to issues such as drought and water shortages, which in turn impact agricultural output and quality. Some researchers predict a decline in the yields of crops such as cotton, wheat, apples, tomatoes, and potatoes by 2050, while others foresee an increase in crop yields from irrigated lands. [2, 4, 10]

Under the conditions of climate change, an increase in rainfall will enhance the potential for crop yields from irrigated lands. According to American scientists' studies, "wheat experiences stress during flowering at higher than usual temperatures, resulting in poor pollination and a reduction in yield." [2, 4, 9] This indicates that temperatures above the optimal level directly negatively impact crop yields. The reduction in crop yields further exacerbates food security concerns.

Rainfall levels—whether high or low—are highly dependent on the geographical location of each region. In recent years, extreme weather phenomena such as floods, droughts, and unusual snowfall in hot seasons have been observed globally. In Uzbekistan's Bukhara, Khorezm, and Karakalpakstan regions, there has been a noticeable lack of moisture. This leads to an increased demand for labor and expertise in agriculture. Sustainable practices, efficient management, and necessary knowledge and skills are required for effective farming. [2]

During periods of high temperatures, an increase in carbon dioxide concentration in the atmosphere can also influence crop yields positively under certain adverse climate conditions, such as moisture scarcity. During the vegetative growth period, favorable conditions coupled with increased atmospheric carbon dioxide result in a yield increase of 5% to 10% for crops such as corn, cotton, rice, vegetables, and grains. [6]

Historically, farmers in Southern Fergana landscapes were cautious about planting a second crop after the first harvest. Today, however, they comfortably cultivate a second crop and achieve high yields. An increase in atmospheric carbon dioxide concentration means that agricultural crops now require more nutrient-rich soil and more water for irrigation. Overall, crop yields in Southern Fergana landscapes have increased by 20-40%, with the requirement for phosphorus and potassium in the soil. Therefore, it is recommended to use winter "sleeping" water for irrigation in Southern Fergana. Our ancestors used to irrigate the land with "winter" water during the cold season. In experimental plots, we compared the results of using "winter" water with areas where it was not applied. The application of "winter water" led to the suppression of various pests and insects in the soil, which is crucial for plant development during the hot summer months. [2]

In conclusion, applying "winter water" in Southern Fergana landscapes reduces soil salinity and the prevalence of harmful insects. However, the impacts of climate change, such as increased temperatures, may hinder plant growth and development, especially during the summer "sleeping" period. For instance, higher temperatures (above 30-35°C) in May negatively affect wheat yields. The elevated temperatures cause the wheat grains to over-ripen and lose moisture, making them weaker compared to grains from countries like Kazakhstan, Russia, Ukraine, and Canada.

The future of agriculture in Uzbekistan will be influenced by water availability. For example, wheat requires 2000-4000 m^3/ton of water in Uzbekistan, while wheat in northern Kazakhstan is successfully cultivated with only 1400 m^3/ton of rainwater. Thus, it is recommended to focus on planting more climate-resistant varieties of wheat. [7]

Climate change is expected to exacerbate issues related to agriculture and food security. In Central Asia, temperature changes could have a positive effect on some mountainous regions, while excessive rainfall in others may lead to wheat diseases. According to some researchers, crop yields in our country will increase from 2010-2040, with positive trends in temperature and rainfall. However, between 2070-2100, we will face significant temperature increases and water shortages, which will lead to reduced yields from irrigated lands. [6]

An increase in temperature by 3.2°C could reduce crop yields by 25% and increase water demand in irrigated lands by 15%. In some regions, higher rainfall may benefit rice farming, which could positively impact countries in Southeast and East Asia. However, the depletion of water resources will lead to the degradation of irrigated lands, salinization, and a decline in soil fertility.

Table 3. Average number of days per year when the air temperature exceeds the optimal range. (*Compiled by the author based on data from the Kokand city meteorological station.*)

Districts of the Kokand region	The number of days with high temperatures		
	25 °C	35 – 40 °C	> 40 °C
Urban areas of the region	56-63	40-45	7-8
The center of the region	80-98	30-60	10-17
Sariqorgon (Sukh)	45-74	25-57	0-3
Lower part of the region	94-103	68-77	14-30

Table 4. Useful Temperature Sum for the Growth and Development of Crops (According to A.G. Goltsberg's data).

Optimal and Maximum Temperatures for Crops		
Crop Name	**Optimal Temperature (°C)**	**Maximum Temperature (°C)**
Cotton	25-30	35-37
Wheat, Barley, Rye	20-25	30-35
Maize	25-30	35-40

The number of days with temperatures above 25°C, increasing from 10-30 days to over 50-70 days, reduces cabbage yields by 10-55%. This situation also affects potato yields. When the number of days with temperatures above 35-40°C increases to 50-80 days, tomato yields decrease by 10-50%, sometimes even causing total crop failure. Similarly, the increase in temperature during the summer period is also affecting the yields of vegetables and cotton. When the number of days with temperatures above 30°C increases from 15 to 30 days, cotton yields decrease by 9-22%, and in the southern parts of the region, this decrease is between 0-8%. This is because high temperatures affect cotton blossoms, preventing them from pollinating.

Currently, the Kokand region's agricultural lands are primarily focused on growing cotton, followed by cereal crops, barley, potatoes, and legumes. The southern parts of the Kokand region, including the Uzbek, Beshariq, and Uchkuprik districts, particularly in the southern part of Sariqqorgon village, are known for their intensive orchards, specializing in growing a variety of fruits such as peaches, cherries, apricots, and strawberries. The distinct feature of these regions is that the fruits become sweet, and even after long storage, they remain durable. This is due to the fact that underground water levels are considerably low in these areas, such as in Sariqqorgon, Uqchi, Nursukh, and Beshariq districts, where the water is located at least 100-150 meters underground. As a result, these fruits grow sweet and can be stored for a long time without being affected by underground water.

5 Conclusion

The northern parts of the Kokand region, due to the proximity of underground water to the surface, are not suitable for growing fruit crops. The reason for this is that the underground water levels are close to the surface, allowing all trees, including fruit trees, to access these waters. As a result, these trees tend to have thick trunks, tall heights, and large leaves, with their primary energy directed toward transpiring underground water through their leaves. Consequently, the fruit yield of these trees is low, and their fruits tend to be large but prone to rotting if stored for long periods. Therefore, these areas have primarily adopted a practice of growing mung beans as a second crop after wheat, as mung beans efficiently utilize underground water. It has been established that mung beans can produce a good harvest even if they are watered once or not at all. Today, the northern parts of the Danjara, Furqat, Bogdod, Buvayda, and Uchkuprik districts are mostly engaged in planting mung beans as a second crop.

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