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## PROCESSES OF SALINATION AND SOIL METAMORPHISM IN THE FERGANA VALLEY UNDER CLIMATE CHANGE: ECOLOGICAL ANALYSIS

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### Abstract

This article ecologically analyzes the natural-geographic, climatic, and anthropogenic factors affecting the processes of soil salinization and metamorphism in the Fergana Valley under climate change. The study was conducted based on meteorological data for 2016–2025. Based on meteorological data, the dynamics of temperature, precipitation, wind speed, and soil surface heat balance were studied. The results of the study showed that the desertification process is intensifying and the risk of soil degradation is increasing against the backdrop of global warming. The results showed that the average annual temperature in the region increased by 0.4–0.8 °C, the maximum temperature increased by 1.7 °C, and precipitation decreased by 14–44 mm. The soil surface temperature increased by 1.9–2.7 °C, accelerating evaporation processes. This led to increased salinization, groundwater mineralization, and soil metamorphism.

**Keywords:** Climate change, soil degradation, salinization, metamorphism, desertification, hydrological factors, heat balance, land reclamation.



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### **Introduction**

The Fergana Valley is one of the most important agro-ecological regions of Central Asia, characterized by a high level of agricultural activity and complex soil-reclamation conditions. The region's mountainous terrain, continental climate, and uneven distribution of water resources directly affect soil formation and transformation processes. Its geological structure, climatic conditions, orography and the level of anthropogenic pressure directly determine the evolution of soils in this area, including the processes of salinization and metamorphism. In recent decades, as a result of increased global warming, imbalanced irrigation systems and disruption of the natural water cycle, saline and structurally altered soils have appeared in some parts of the valley, especially in the districts of Yozyavon, Buvayda, Oltiariq and Ulug'nor.

In recent years, global climate change has led to increased temperatures, decreased precipitation, and increased anthropogenic load, accelerating soil degradation processes in the Fergana Valley, especially salinization and metamorphism.

Soil salinization is one of the main environmental problems that reduces agricultural productivity. Soil metamorphism is characterized by changes in the structural, morphological, and chemical properties of soil.

The purpose of this study is to identify factors affecting soil salinization and metamorphism processes in the Fergana Valley under climate change and to assess their ecological consequences.

### **Research area and natural and geographical location**

The Fergana Valley is a large tectonic depression surrounded by the Chatkal and Kurama mountains to the north, the Turkestan mountains to the south, and the Fergana mountains to the east. The region is approximately 300 km long and 150–160 km wide.

The central part of the valley is home to the Syrdarya terraces and desert landscapes, where arid climatic conditions prevail. The study paid particular attention to the areas around Yazyavan, Buvayda, Oltiariq, and Kokand. Due to



limited water resources and high evaporation rates, salinization processes are actively occurring in these areas.

The Yazyavan district is located in the western part of the Fergana region, on an area of 41 thousand km<sup>2</sup>, and has a population of 71.6 thousand. The arid climate of the region, the speed of winds, and the limited water resources have a significant impact on soil salinity.

### Results Air temperature dynamics

The analysis revealed an increasing trend in temperature at all observation points. In Fergana, the average temperature increased from 15.4 °C to 15.8 °C (+0.4 °C), in Kokand from 15.6 °C to 16.4 °C (+0.8 °C), and in Quva from 14.7 °C to 15.3 °C (+0.6 °C).

The maximum temperature in Fergana increased by 1.7 °C, while the minimum temperature decreased by 2.3–4.7 °C. This indicates an increase in temperature amplitude and a worsening climate.

**Table 1** Air temperature and wind speed, dynamics in Fergana region

Meteorological stations	Indicator types	Years												The difference
		2016	2017	2018	2019	2020	Five-year average	2021	2022	2023	2024	2025	Five-year average	
Fergana	Average air temperature, °C.	15.7	15.0	14.8	15.4	15.9	15.4	14.8	15.4	16.0	16.3	16.6	15.8	0.4
Kokand		15.9	15.8	15.5	15.8	14.9	15.6	16.0	16.2	16.4	16.6	16.9	16.4	0.8
Kuva		15.3	14.6	14.5	14.7	14.4	14.7	14.4	15.4	15.4	15.6	15.8	15.3	0.6
Fergana	Maximum air temperature (°C)	40.1	40.6	40.5	40.5	39.0	40.1	40.8	41.2	41.9	42.3	42.7	41.8	1.7
Kokand		40.0	42.0	40.8	41.0	49.0	42.6	40.8	42.0	41.0	41.5	42.0	41.5	-1.1
Kuva		39.2	40.0	39.8	39.0	36.7	38.9	39.7	40.0	39.4	39.7	40.0	39.8	0.9
Fergana	Minimum air temperature (°C)	-9.3	-6.3	-10.5	-6.1	-6.7	-7.8	-9.9	-6.6	-14.6	-15.5	-16.0	-12.5	-4.7
Kokand		-9.0	-6.0	-9.5	-5.4	-7.2	-7.4	-9.6	-5.0	-14.0	-14.5	-15.0	-11.6	-4.2
Kuva		-13.1	-7.0	-9.9	-6.9	-8.8	-9.1	-6.9	-6.3	-17.4	-18.0	-18.5	-11.4	-2.3
Fergana	Strongest wind observed (m/s)	25	27	18	15	20	21	22	17	18	19	20	19.2	-1.8
Kokand		27	25	26	20	27	25	30	25	22	23	24	24.8	-0.2
Kuva		22	23	22	20	20	21.4	24	24	18	19	20	21.0	0.4

*(Scientific and Practical Reference on Climate 2016 - 2025)*



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### **Soil surface temperature and precipitation**

The maximum soil surface temperature increased by 1.9 °C in Fergana and by 2.7 °C in Kokand. This increases the intensity of evaporation and causes salts to reach the soil surface.

Precipitation decreased by 30.6 mm in Fergana, by 14.3 mm in Kokand, and by 44 mm in Kuva. This situation slows down the natural leaching process of the soil and increases salinity. — this indicates an increase in desertification. (Table 2) presents the ten-year dynamics of soil surface temperature and precipitation.

#### **Wind speed**

Although there has been no significant change in wind speed, some areas have seen increases and decreases. This factor indirectly affects evaporation and soil surface processes.

The main factors in the formation of salinity and soil metamorphism are:

**Climate factor:**As a result of increasing temperatures and decreasing precipitation, evaporation intensity is increasing, and salts are emerging on the surface.

**Hydrological factor:**Obsolete irrigation systems and imbalances in water distribution raise groundwater levels and increase soil salinity through capillary rise.

**Anthropogenic factors:**Intensive irrigation, excessive use of chemical fertilizers and pesticides in agriculture change the physicochemical properties of the soil.

**Geomorphological factor:**Due to the valley's location in a tectonic depression, the inadequate drainage system does not slow down the salinization process, but rather intensifies it.

**Ecological degradation:**Along with desertification, vegetation cover is thinning and landscape blocks are being degraded



**Table 2 Soil temperature and precipitation amount and dynamics in Fergana region**

Meteorological stations	Indicator types	Years												The differen
		2016	2017	2018	2019	2020	Five-year average	2021	2022	2023	2024	2025	Five-year average	
Fergana	Maximum soil surface temperature (°C)	68.6	70.6	67.1	70.0	71.1	<b>69.5</b>	69.5	68.5	72.3	73	73.5	<b>71.4</b>	<b>1.9</b>
Kokand		69.0	72.0	75.0	75.0	75.0	<b>73.2</b>	76.0	75.0	76.0	76.5	76	<b>75.9</b>	<b>2.7</b>
Kuva		60.2	63.6	65.2	66.2	67.0	<b>64.4</b>	61.6	65.2	65.2	65.5	66	<b>64.7</b>	<b>0.3</b>
Fergana	Minimum soil surface air temperature (°C)	-14.3	-7.4	-12.7	-7.5	-11.0	<b>-10.6</b>	-13.3	-9.2	-13.5	-14.0	-14.2	<b>-12.8</b>	<b>-2.2</b>
Kokand		-11.0	-13.0	-14.0	-8.0	-10.0	<b>-11.2</b>	-11.0	-5.5	-13.2	-13.5	-13.8	<b>-11.4</b>	<b>-0.2</b>
Kuva		-19.5	-10.2	-10.0	-7.5	-11.1	<b>-11.7</b>	-12.2	-11.0	-20.8	-21.0	-21.3	<b>-17.3</b>	<b>-5.6</b>
Fergana	Precipitation amount (mm)	224.9	170.6	185.1	124.2	115.6	<b>164.1</b>	104.1	156.2	127.9	137.	142	<b>133.5</b>	<b>-30.6</b>
Kokand		136.2	134.8	149.9	129.6	113.7	<b>132.8</b>	66.0	190.1	108.9	117	110.5	<b>118.5</b>	<b>-14.3</b>
Kuva		265.8	229.2	221.5	114.7	180.4	<b>202.3</b>	66.5	215.2	161.5	176	172.5	<b>158.5</b>	<b>-44.0</b>

*(Scientific and practical reference book on climate. 2016 - 2025)*

### Analysis results and discussion

According to an analysis of climate data for 2016–2025:

1. In the desert regions of the Fergana Valley, air temperatures increased by 0.6–2.2 °C
2. The minimum temperature decreased by 2–4 °C;
3. The temperature of the soil surface has increased by 5–6 °C;
4. The amount of precipitation decreased by 10-15 mm.

These changes are causing an increase in the valley's salinity, mineralization of groundwater, and changes in soil morphology.

As a result, the process of soil metamorphism (i.e., changes in structure, color, layering, and chemical composition) is intensifying. These processes are having a significant impact on the ecological balance, especially in the districts of Yozyavon and the Kokand group.

### Conclusion

The area of saline and metamorphosed soils in the Fergana Valley is expanding due to climate warming, imbalances in water distribution, and anthropogenic load.

The research results show the following:



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1. In desert regions, increasing temperatures and decreasing precipitation have exacerbated desertification;
  2. The heat balance of the soil surface has been disrupted and biological activity has decreased;
  3. Landscape degradation is observed.

Therefore, regular environmental monitoring, land reclamation measures, modernization of salt-washing systems, and biological reclamation (planting salt-tolerant plants) are necessary in these areas.

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