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IMPACT OF CLIMATE CHANGE ON AGRICULTURE IN UZBEKISTAN: CHALLENGES AND ADAPTATION STRATEGIES

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Abstract
This study analyzes the impact of climate change on Uzbekistan's agriculture, using observational data (1960–2023) and modeled projections. Uzbekistan has experienced a mean temperature increase of +1.2 °C since 1991, with declining precipitation and higher drought frequency Under scenarios, crop yields could decline by 25–63% by the 2050s. Findings highlight significant risks to cotton, wheat, and horticulture, especially in water-stressed regions like Karakalpakstan and Khorezm. Key adaptation strategies include water-saving irrigation, climate-resilient crops, and digital monitoring. Policy engagement and institutional support will be critical for sustainable agriculture and food security.

Keywords: Climate change, Uzbekistan, Agriculture, Crop yield, Food Security, Adaptation, Water management.

Introduction

Today, the growing anthropogenic impact on the environment and natural resources, unsustainable agricultural practices, food waste, the widening food balance gap between developed and developing countries, global warming, water scarcity, biodiversity loss, declining soil fertility, and land degradation are leading to a series of negative consequences.

In its address at the UN Climate Change Conference (COP28), the President of the Republic of Uzbekistan, Shavkat Mirziyoyev, emphasized:"Climate issues have already become the main threat to sustainable development. These risks are even influencing the global geopolitical architecture. The negative consequences of climate change are particularly acute in Central Asia due to the Aral Sea disaster" [1].

Severe climate changes trigger serious threats such as the reduction of water resources, an increase in natural disasters, and declining agricultural productivity, ultimately hindering the sustainable development of our region. These consequences primarily affect vulnerable segments of the population.

Climate change is intensifying in Central Asia, with Uzbekistan experiencing rising temperatures, reduced precipitation, and increased drought frequency. Agriculture employs 23% of the labor force and contributes roughly 20% to GDP [2]., making it vital for rural livelihoods and economy.

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This study aims to quantify climate trends, assess their impact on crop yields, and propose adaptation pathways.

Literature Review

Temperatures in Uzbekistan have risen by ~2.4 °C between 1880–2020 [3]. Temperature: +1.2 °C average rise from 1991–2023 (~0.4 °C/decade); central regions up to +0.52 °C/decade. Precipitation trends are variable, with farmers observing declines since 2008. [4]. Regional studies show irrigated agriculture is especially vulnerable. These studies provide a basis for our analysis.

Methodology

During the research, theoretical methods such as induction, deduction, generalization, and comparison were used, as well as typological analysis and synthesis of statistical data.

Data Sources:

Climate: Uzbekistan Hydromet (1960–2023), World Bank Climate.
Agriculture: FAO, stat.uz

Results and Discussion

It is known that about one-third of the population of Uzbekistan lives in areas prone to natural hydrometeorological disasters (droughts, floods, landslides, avalanches, frosts, and dust storms). Naturally, if precipitation increases or extreme cold and heat events occur, the situation may worsen.

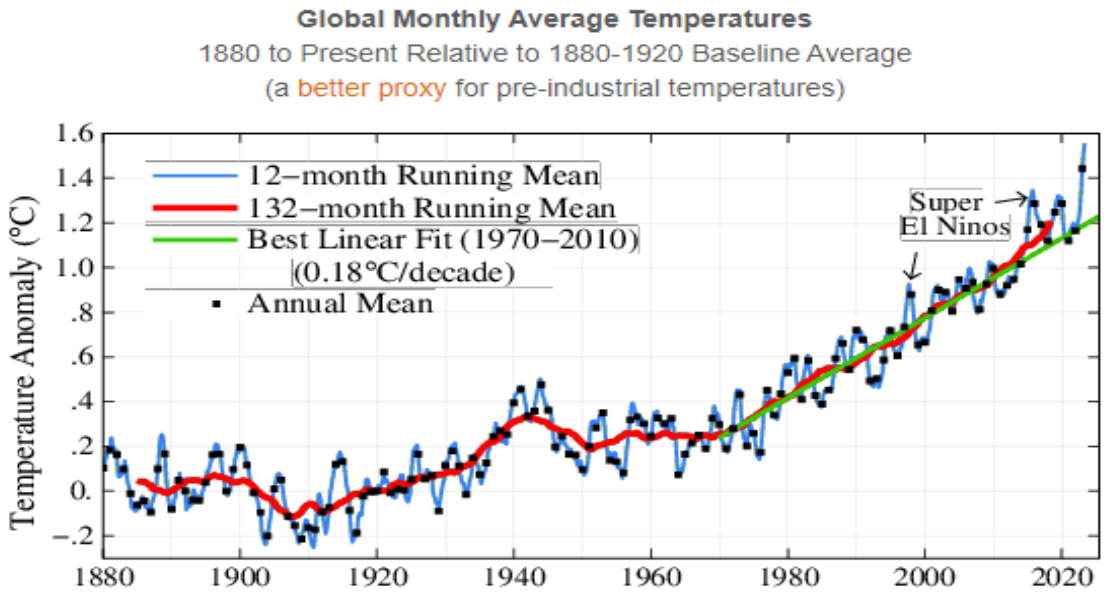

Figure 1. Change in Average Annual Temperature in Uzbekistan (1880–2020) [4].

Uzbekistan is among the countries with a high risk of climate change. Since 1880, the average annual temperature in the country has increased by 1.6°C (from 13.2°C to 14.8°C) (Figure 1). Projections suggest that by 2030–2050, the air temperature in Central Asia will rise by an

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additional 1.5–3°C, with the most significant warming expected in the Aral Sea region due to local climate shifts caused by the sea's desiccation.

Temperature: +1.2 °C average rise from 1991–2023 (~0.4 °C/decade); central regions up to +0.52 °C/decade (Figure 2).

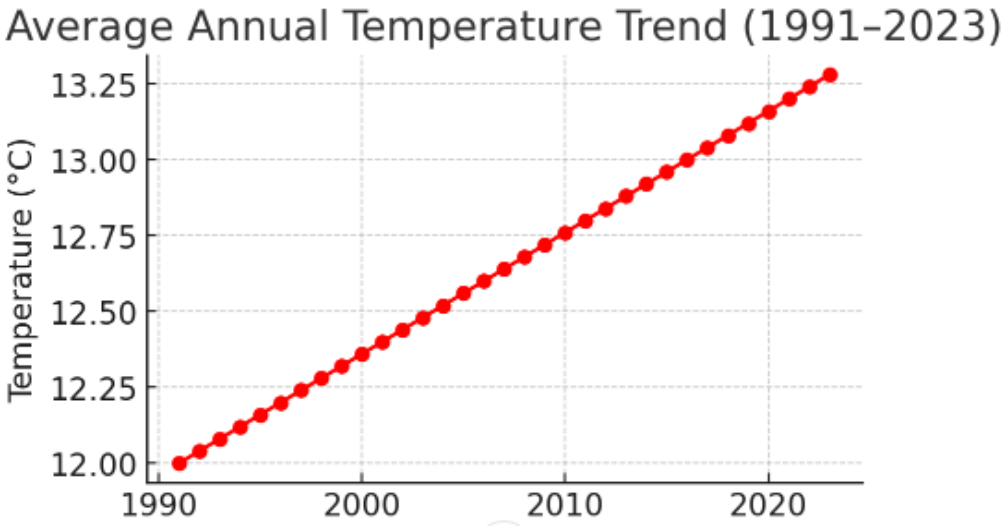

Figure 2. Average Annual Temperature Trend (1991-2023) [5].

Projections suggest that by 2030–2050, the air temperature in Central Asia will rise by an additional 1.5–3°C, with the most significant warming expected in the Aral Sea region due to local climate shifts caused by the sea's desiccation.

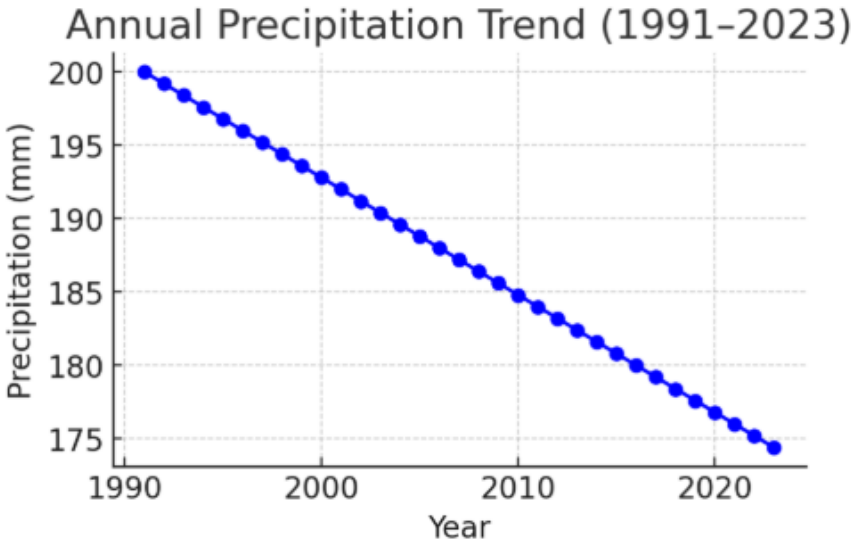

Figure 3. Annual Temperature Trend (1991-2023) [6].

The consequences of climate change will have varying impacts on the well-being of Uzbekistan's population. By 2030, at least 8 million people across urban and rural areas are expected to live in zones with a very high climate risk. If adaptation measures are not implemented, by 2050 the national economy could be 10% smaller than in a no-climate-change scenario, leading to a sharp decline in employment and household incomes.

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Agricultural Impacts

Cotton yields (~2.2–3.0 t/ha) are sensitive to heat and water stress.

Regression shows a 10 mm decrease in rainfall → 0.05 t/ha yield loss for cotton/wheat.

Projected yield decline: 25–63% reduction by 2050.

Regions like Karakalpakstan, Khorezm, and Kashkadarya—reliant on Amu/Syr Darya—face elevated risk due to reduced river flows and glacier melt. The Aral Sea drying exacerbates soil salinity and dust storms.

The convergence of hotter, drier conditions and inefficient irrigation amplifies agriculture vulnerability. Projected dire yield declines highlight urgent need for adaptation and policy realignment.

Challenges and Risks

- Food Security: Yield losses threaten national supply.
- Water Scarcity: Inefficient canal systems lose 30–75% of water.
- Environmental Degradation: Increasing salinization and desertification .

According to the World Resources Institute (WRI), water scarcity currently affects 400 regions worldwide, and Uzbekistan is expected to become one of the most water-stressed countries in the next 20–25 years. Turkmenistan is already the most water-scarce country in Central Asia, followed by Uzbekistan. If current trends continue, Uzbekistan could face extreme water stress globally by 2040.

By 2060, plans for decarbonizing the economy require special attention to the energy sector, which accounts for almost 75% of Uzbekistan's greenhouse gas (GHG) emissions. Improving energy efficiency and expanding the use of renewable energy sources will help reduce dependence on diminishing natural gas reserves and strengthen energy security. Reliance on fossil fuels also contributes to air pollution, which is among the top 10 causes of premature mortality and disease in the country.

Uzbekistan officially signed the Paris Agreement on April 19, 2017, and ratified it in November 2018, committing to keep the global average temperature increase well below 2°C.

The Nationally Determined Contribution (NDC) of Uzbekistan sets the target to reduce GHG emissions per unit of GDP by 35% by 2030 compared to 2010 levels, as well as to mitigate climate impacts and strengthen adaptive capacity. Key strategies include:

- Uzbekistan’s Environmental Protection Concept
- Water Management Development Concept (2020–2030)
- Strategy for Transition to a Green Economy (2019–2030)
- Municipal Solid Waste Management Strategy (2019–2028) [7].

Currently, about 3 million hectares of pasture and cropland are degraded, with nearly 2 million hectares affected by salinization. Foreign experts predict that by 2030, water resources in the region could decrease by 6% due to climate change.

To address these challenges, Uzbekistan developed a National Program of 52 measures to adapt agriculture to climate change and mitigate its negative effects, attracting over USD 294 million in grant funding. Measures include restoring 1 million hectares of agroecological landscapes and degraded pastures in the Aral Sea region, creating shelterbelts in Karakalpakstan, Khorezm, Bukhara, and Kashkadarya, and promoting cultivation of crops like licorice, rosehip, sesame, and

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Artemia in water-scarce areas.

Additionally, a climate forecasting and analysis center will be established, along with five agrometeorological stations. With Italy's cooperation, an International Center for Intensive Seed and Seedling Production will be created, and seed farms for salt- and drought-resistant crops will be organized.

Water and Agriculture Initiatives

Efficient water use is crucial, especially in the lower Amu Darya basin. For this reason, a government program introduces subsidies for laser land leveling in Karakalpakstan. Farmers growing cotton, cereals, and rice will receive state budget subsidies covering up to 100% of fuel and lubricant costs for each hectare leveled using laser technology. In the first phase, this will be implemented in Turtkul, Beruni, and Amudarya districts. These measures are expected to increase yields by 5–7 centners per hectare and reduce water consumption by 15–20%.

Modernization plans also include energy-efficient pumping units and transformers to improve irrigation at research stations, such as the Bandikhon and Navoiy experimental stations, which will implement advanced water-saving technologies and establish vineyards with export-oriented varieties imported from France and other countries.

Greenhouse farming plays a special role in ensuring year-round agricultural production. In recent years, greenhouse area has increased 2.6 times, and production volume has grown more than threefold, employing 80,000 permanent and 70,000 seasonal workers. To increase efficiency, 50% of the cost of hiring foreign specialists (agronomists, entomologists, laboratory experts) and up to 20% of coal boiler costs will be covered by state support [8].

Key Adaptation Measures

In agriculture and land management:

- Strengthen mechanisms guaranteeing land users' rights (including local farmers) to attract investment in climate-resilient agriculture.
- Improve soil conservation practices.
- Scale up climate-smart agriculture and develop a clear roadmap with an investment plan.

At the economy-wide level:

- Accelerate structural reforms to create a favorable business and investment climate, promoting private sector development in the green economy.
- Develop monitoring, reporting, and impact assessment systems for climate and green projects.
- Introduce market-based incentives to reduce emissions, including a carbon tax.

In water resources and irrigation:

- Expand the introduction of water-saving technologies.
- Implement agricultural policies promoting efficient water use.
- Transfer irrigation system management to the private sector.
- Modernize irrigation and drainage infrastructure and water accounting systems.

Addressing food security requires the widespread adoption of moisture-saving technologies.

Human capital development: Strengthen social protection for vulnerable groups exposed to climate risks, and enhance education and retraining systems to equip citizens with skills for green economy jobs.

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Investment Needs and Expected Benefits

Uzbekistan will require large-scale investments for decarbonization and climate adaptation. Approximately USD 60 billion is needed to mitigate climate impacts on productivity, roads, bridges, livestock, and irrigation sectors, and an additional USD 340 billion to replace outdated energy infrastructure and decarbonize the energy sector by 2060. Most of these investments can come from the private sector.

Expected Benefits:

- Integrated landscape management and climate-smart agricultural technologies can increase crop production by USD 4.6 billion within 10 years and save over 1.8 billion m^3 of water annually.
- Between 2023 and 2060, infrastructure-related measures alone can generate benefits worth USD 178 billion, including avoiding USD 122 billion in damages from environmental pollution and accidents, and saving USD 66 billion in fossil fuel imports.
- Decarbonization measures could reduce deaths from air pollution-related diseases by nearly 90% and create significant employment opportunities in the energy and other sectors.

Adaptation Strategies

1. Efficient Irrigation: Drip systems to reduce losses and optimize water use.
2. Climate-Resilient Crops: Develop drought-tolerant and heat-resilient varieties.
3. Digital Agriculture: Implement real-time monitoring via IoT and GIS.
4. Policy & Investment: Increase R&D investment, irrigation infrastructure, and tailored subsidies.
5. Landscape Restoration: Reforestation and salt-tolerant vegetation to reduce degradation.

Conclusion

Climate change poses severe threats to Uzbekistan's agriculture with substantial yield reductions predicted. Through integrated adaptation—technological, institutional, and policy-driven—Uzbekistan can mitigate risks and secure future food and economic stability. Further research should focus on cost-benefit analyses and pilot programs to guide nationwide scaling.

Measures in the field of climate change and decarbonization in Uzbekistan will:

1.Enhance food security and improve natural landscapes.

2.Prevent negative consequences such as land degradation.

3.Reduce GHG emissions, resulting in positive environmental outcomes.

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