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GLOBAL AND REGIONAL ASPECTS OF CLIMATE CHANGE: THE CASE OF CENTRAL ASIA AND UZBEKISTAN

Nazarbaev Orynbay
Candidate of Economic Sciences,
Professor Karakalpak State University
E-mail: onazarbaev@mail.ru

Abstract
Climate change has become one of the central challenges of contemporary science and policy. In 2024, the global average temperature rose to +1.55°C above pre-industrial levels, setting a new record (WMO, 2025; NASA GISS, 2025). Atmospheric CO_2 concentrations have also reached historical maximums: in July 2025, the monthly average recorded at the Mauna Loa Observatory stood at approximately 427.9 ppm (NOAA, 2025). These figures confirm that greenhouse gas emissions remain at high levels and that their impact on the climate system continues to intensify.

Introduction

In regions highly vulnerable to climate change, such as Central Asia, these trends are particularly acute. Glacier retreat, water scarcity, and the increasing frequency of dust storms originating from the degraded Aral Sea basin pose direct threats to the region's sustainable development. The aim of this article is to systematically analyse the state, dynamics, and consequences of climate change at both global and regional scales, and to propose practical strategies for addressing these challenges.

2. Methodology

This study employs a systematic narrative review approach, synthesising data from authoritative institutional sources and peer-reviewed publications. Sources were selected on three criteria: (1) direct relevance to climate change in Central Asia and

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Uzbekistan, (2) institutional credibility or peer-reviewed status, and (3) recency, with priority given to publications from 2021 to 2025 and landmark foundational works included where appropriate.

Global physical science data are drawn from IPCC AR6 Working Group I (2021), WMO State of the Global Climate (2025), and NASA/NOAA monitoring datasets. Regional impact analysis draws on IPCC AR6 Working Group II (2022), the World Bank Uzbekistan Country Climate and Development Report (2022), and CMIP6 model scenario outputs (SSP2-4.5 and SSP5-8.5). Policy analysis covers the UNFCCC Paris Agreement framework, Uzbekistan's Updated NDC (2021), and national legislation.

The paper is structured thematically: global physical trends, regional impacts disaggregated by sector, international and national policy frameworks, and integrated solution pathways. This structure reflects the analytical progression from problem diagnosis to policy response. Limitations include reliance on secondary sources and the absence of primary field data; governmental self-reported statistics (e.g., renewable energy capacity) have not been independently verified.

3. Physical Foundations of Climate Change and Global Trends

The climate system comprises the interrelated components of the atmosphere, hydrosphere, cryosphere, lithosphere, and biosphere, which interact through the exchange of energy and matter. The greenhouse effect is a natural phenomenon that maintains temperatures conducive to life on Earth. However, human activity has increased atmospheric concentrations of CO_2, CH_4, N_2O, and other greenhouse gases, generating additional warming. According to the IPCC Sixth Assessment Report (IPCC AR6 WG I, 2021; IPCC AR6 Synthesis Report, 2023), global average temperatures in 2011–2020 were approximately 1.1°C above pre-industrial levels, and human influence on warming has been established as "unequivocal."

Sea level rise is also accelerating. Since 1993, the global mean sea level has risen by approximately 10 cm, with the annual rate of increase reaching around 4.5

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mm/year in the most recent decade. The primary drivers include thermal expansion and the loss of mass from glaciers and ice sheets. The Greenland and Antarctic ice sheets contributed 21.0 ± 1.9 mm to global sea level rise between 1992 and 2020 (IMBIE, 2023). Arctic sea ice extent reached a minimum of 4.28 million km² in 2024, a record low (NSIDC, 2024).

The increasing frequency and intensity of extreme weather events also warrants attention. Heat waves, heavy precipitation, droughts, and tropical cyclones are all intensifying. IPCC AR6 assesses it as "virtually certain" that heat waves will become more frequent and severe (IPCC AR6 WG I, 2021). These phenomena exert significant pressure on agriculture, water resources, energy systems, and public health.

4. Impacts of Climate Change on Central Asia and Uzbekistan

Central Asia is among the regions most vulnerable to climate change. Temperature increases in the region exceed the global average, with heat waves intensifying sharply, particularly during summer months. While precipitation patterns show regional and seasonal variation, the overall trend points toward heightened drought risk. Rapid melting of Tian Shan and Pamir-Alay glaciers is reducing the volume of these natural reservoirs, which serve as the primary water buffer for the region (Farinotti et al., 2020).

In Uzbekistan, long-term temperature trends show consistent warming: since 1951, the average air temperature has risen at a rate of approximately 0.29°C per decade, roughly twice the global average warming rate (UNFCCC NDC Registry, 2021). Based on CMIP6 projections (IPCC AR6 WG I, 2021), the SSP2-4.5 scenario anticipates temperature increases of 1.3–2.1°C by 2030–2050, while the SSP5-8.5 scenario projects increases of 1.6–3.0°C. By 2100, under the most severe scenario, warming could exceed 5°C.

Water resources represent the most critical and vulnerable sector in the region. The flow of the Amu Darya and Syr Darya rivers depends substantially on snowmelt and glacier melt; climate warming is shifting the seasonal distribution of this flow. Against a backdrop of rising irrigation demand, this change is deepening water

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scarcity. The desiccation of the Aral Sea is the most visible example: the reduction in river inflow caused by the expansion of irrigated agriculture since the mid-twentieth century has produced an ecological catastrophe affecting not only the water balance but also soil salinisation, dust storm frequency, and public health (World Bank, 2022). This origin in Soviet-era irrigation expansion, rather than climate change itself, means the Aral Sea crisis is best understood as a pre-existing land-and-water-management problem that climate warming is now compounding rather than causing.

Agriculture is among the sectors most severely affected by climate change (IPCC AR6 WG II, 2022). Heat waves, drought, and water scarcity increase the risk of declining crop yields. Improving irrigation efficiency (drip irrigation, sprinkler systems), introducing drought-resistant varieties, and modernising agrotechnologies are essential responses to these risks.

In the health sector, the primary threats are heat waves, deteriorating air quality (PM2.5, dust) (WHO, 2021), and the geographic expansion of infectious diseases. Heat stress and reduced labour productivity (particularly for outdoor workers) present a serious challenge to the workforce and the broader economy.

5. Climate Policy: International and National Frameworks

International cooperation plays a central role in the response to climate change. While the Kyoto Protocol (UNFCCC, 1997) established binding reduction targets for industrialised countries, the Paris Agreement (UNFCCC, 2015) operates through Nationally Determined Contributions (NDCs) submitted by all signatory countries. The Paris Agreement's primary objective is to limit global warming to well below 2°C above pre-industrial levels and to pursue efforts to limit it to 1.5°C. The Agreement includes an Enhanced Transparency Framework (ETF), a Global Stocktake every five years, and mechanisms for progressively raising ambition.

Central Asian countries have all acceded to the Paris Agreement. Their NDCs include commitments to improve energy efficiency, develop renewable energy sources, and introduce adaptation measures in the water and agricultural sectors (UNFCCC NDC Registry, 2021). Uzbekistan has adopted the Green Economy

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Transition Strategy 2019–2030 (Republic of Uzbekistan, 2019) and the Law on Renewable Energy Sources (Republic of Uzbekistan, 2019). Installed solar capacity has grown from negligible levels in 2016 to 5,934 MW by the end of 2025, and wind capacity has reached 1,652 MW over the same period; renewables now account for 36.1% of total installed electricity capacity, up from 13.3% in 2016 (IRENA, 2023). However, further work is needed to strengthen MRV (measurement, reporting, and verification) systems, build institutional capacity, and engage the private sector, the gaps that §6's recommendations on green finance and capacity building are designed to close.

6. Solutions and Recommendations

Mitigation and adaptation strategies are complementary components of a comprehensive response to climate change.

In the area of mitigation, key measures include improving energy efficiency, expanding the share of renewable energy (solar, wind, hydropower) (IRENA, 2023), electrifying the economy, developing carbon capture and storage (CCUS) technologies, and expanding forest cover (IPCC AR6 WG III, 2022; IEA, 2023). Priority areas specific to Central Asia include reducing methane losses from gas infrastructure, phasing out coal, and introducing resource-efficient technologies in agriculture.

Adaptation strategies focus on reducing risk, managing exposure, and decreasing vulnerability. Integrated Water Resources Management (IWRM), drip irrigation technologies, early warning systems (UNDRR, 2015), heat-health action plans, and urban green infrastructure represent effective measures in this domain. "No-regret" measures (actions that yield benefits under any climate scenario) deserve particular attention.

Green economy and innovation are important accelerators of both mitigation and adaptation. Key instruments in this area include green finance (green bonds, blended finance), carbon pricing (emissions trading systems and carbon taxes), technological innovation (energy storage, green hydrogen, circular economy), and the active participation of civil society.

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7. Conclusions

Climate change is generating serious ecological, economic, and social risks at both global and regional scales. Central Asia, and Uzbekistan in particular, faces a range of interconnected challenges: water scarcity, the Aral Sea crisis, threats to agriculture, and impacts on public health.

Notwithstanding the severity of these challenges, the scientific, technological, and policy tools available today offer meaningful potential to reduce their consequences. Comprehensive mitigation and adaptation measures, the transition to a green economy, international cooperation, and the active engagement of civil society are the principal factors on this path. Timely, scientifically grounded, and inclusive decision-making is essential for a sustainable future.

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