



CLIMATE-RELATED RISKS AND MACROECONOMIC STABILITY: INTERNATIONAL EVIDENCE AND IMPLICATIONS FOR UZBEKISTAN

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Abstract: *Climate change affects macroeconomic stability through agricultural output, food prices, productivity, infrastructure damage, public finances and financial-sector balance sheets. This article assesses these transmission channels with a focus on Uzbekistan, drawing on international research, official macroeconomic reports and climate-development scenario analysis. The method is a structured literature synthesis and descriptive comparison of published statistics and projections rather than a causal econometric model. The World Bank estimates that without adaptation Uzbekistan's economy could be 10% smaller by 2050 relative to a counterfactual without climate impacts. Irrigation accounts for substantial water and electricity demand, while exposure to water scarcity and extreme heat creates risks to food production and real incomes. The study separates historical macroeconomic observations from conditional long-run climate scenarios and identifies potential fiscal, inflationary and banking-sector spillovers. The results support integrated climate-macroeconomic monitoring, water-efficient infrastructure, renewable energy, targeted social protection and climate stress testing. The article concludes that adaptation and orderly transition policies can strengthen economic security, but estimates should not be mistaken for realized losses or precise crisis forecasts.*

Keywords: *climate risk; macroeconomic stability; Uzbekistan; physical risk; transition risk; water scarcity; inflation; economic security.*



Аннотация: Ushbu maqolada iqlim o'zgarishi bilan bog'liq xavflarning makroiqtisodiy barqarorlikka ta'siri O'zbekiston misolida o'rganiladi. Tadqiqot xalqaro ilmiy adabiyotlar, Jahon banki, Xalqaro valyuta jamg'armasi va markaziy banklar hisobotlariga asoslanadi. Qurg'oqchilik, suv tanqisligi, ekstremal issiqlik, energetika tizimidagi o'zgarishlar va ularning ishlab chiqarish, inflyatsiya, davlat moliyasi hamda bank tizimiga ta'sir kanallari tahlil qilinadi. Jahon bankining moslashuv choralari bo'lmagan ssenariysiga ko'ra, 2050-yilda O'zbekiston iqtisodiyoti iqlim ta'siri bo'lmagan holatga nisbatan 10 foiz kichikroq bo'lishi mumkin. Ushbu ko'rsatkich prognoz bo'lib, kuzatilgan zarar emas. Natijalar suv tejovchi texnologiyalar, yashil energetika, ijtimoiy himoya va iqlim stress-testlari makroiqtisodiy xavflarni kamaytirishda muhimligini ko'rsatadi.

Калит so'zlar: iqlim xavflari; makroiqtisodiy barqarorlik; O'zbekiston; suv tanqisligi; inflyatsiya; iqtisodiy xavfsizlik; yashil o'tish.

Аннотация: В статье исследуется влияние климатических рисков на макроэкономическую стабильность с особым вниманием к Узбекистану. Исследование основано на международной научной литературе и официальных материалах Всемирного банка, Международного валютного фонда и центральных банков. Рассматриваются каналы воздействия засух, дефицита воды, экстремальной жары и энергетического перехода на производство, инфляцию, государственные финансы и банковский сектор. Согласно условному сценарию Всемирного банка, без мер адаптации экономика Узбекистана к 2050 году может быть на 10% меньше, чем в сценарии без климатических воздействий. Это прогнозная оценка, а не уже понесенные потери. Сделан вывод о необходимости водосберегающих технологий, развития возобновляемой энергетики, адресной социальной защиты и климатического стресс-тестирования.

Ключевые слова: климатические риски; макроэкономическая стабильность; Узбекистан; дефицит воды; инфляция; экономическая безопасность; зеленый переход.



Introduction

Climate change is no longer only an environmental concern. Physical hazards can disrupt production, raise prices, weaken public budgets and increase credit losses. Climate mitigation and adaptation policies also reshape relative prices and investment needs. Consequently, central banks and finance ministries increasingly treat climate as a macroeconomic and financial stability issue (NGFS, 2020; ECB, 2026).

For Uzbekistan, climate exposure intersects with structural characteristics of the economy. Irrigated agriculture depends on scarce water resources; power generation and irrigation are linked through energy-intensive pumping; and households may be vulnerable to food and utility price changes. The Aral Sea disaster illustrates the long-term economic consequences of environmental degradation (World Bank, 2023).

Climate risks are often classified into physical risks and transition risks. Physical risks include acute events such as floods and droughts, and chronic shifts such as rising temperatures and declining water availability. Transition risks arise from changes in energy policy, technology, market demand and the repricing of carbon-intensive assets. Both categories can affect inflation, output, external accounts and financial institutions, but their timing and policy responses differ.

The research question is how climate-related risks can influence macroeconomic stability in Uzbekistan and which preventive policies are supported by available evidence. The article aims to identify transmission mechanisms, evaluate selected official scenario estimates and develop an integrated monitoring framework. It does not attempt to predict the date of a crisis or calculate new country-level damage coefficients.

This topic is important for economic security because stable economic growth requires reliable food, water, energy and financial systems. Climate adaptation can protect productive capacity and social welfare, while an orderly energy transition may reduce vulnerability to resource constraints and price shocks.



Yet adaptation and transition also require financing, administrative capacity and careful sequencing.

Unlike studies that estimate a global average effect, the present paper organizes published evidence around Uzbekistan-specific vulnerabilities. Its contribution is a transparent synthesis that distinguishes observed conditions, official projections and proposed policy indicators.

Literature Review

NGFS (2020) identifies major research priorities concerning macroeconomic transmission, monetary policy, financial stability and scenario design. It stresses that climate risks are nonlinear, long-horizon and difficult to capture using historical relationships alone. These characteristics complicate traditional macroeconomic forecasting and supervisory risk assessment.

Batten, Sowerbutts and Tanaka (2016) review channels through which climate change can affect central-bank objectives. Weather shocks can impair supply, alter prices and affect financial stability, while policy responses may change energy costs and investment. Their conceptual framework helps distinguish temporary relative-price changes from persistent macroeconomic instability.

Dell, Jones and Olken (2012) examine temperature shocks and economic growth across countries and show that climate-related changes can affect aggregate output, particularly in poorer economies. Their cross-country findings motivate attention to productivity but should not be treated as direct estimates for Uzbekistan.

Burke, Hsiang and Miguel (2015) investigate nonlinear relationships between temperature and economic production. The central lesson is that economic damage can vary with baseline climate and warming intensity. Such evidence supports scenario-based assessment rather than a single fixed cost per degree for every country.

Kahn et al. (2021) study the long-term macroeconomic effects of climate change using cross-country data. Their results indicate that persistent deviations in temperature from historical norms may reduce output growth. The empirical strategy



and international coverage provide useful context, although local water institutions and adaptation policies remain decisive.

The World Bank (2023) Country Climate and Development Report for Uzbekistan links climate exposure to economic development, water management, agriculture, energy and poverty. It projects that without adaptation the economy could be 10% smaller by 2050 relative to a no-climate-impact counterfactual. This conditional comparison should not be interpreted as a 10% decline from today's GDP.

The IMF (2024) explicitly discusses Uzbekistan's exposure to drought, heat, rainfall volatility, dust storms and the Aral Sea legacy. Its 2026 debt sustainability analysis again notes water scarcity, rising temperatures and land degradation as macroeconomic risks, while acknowledging that its baseline macroeconomic framework does not explicitly quantify long-run climate effects.

The ECB (2026) highlights climate and nature degradation as relevant to resilience, competitiveness and financial-sector risk. The speech is a policy perspective, not a peer-reviewed estimate of Uzbekistan's losses. Similarly, the NGFS technical document is used here for methodological framing, not as a source of newly estimated Uzbek coefficients.

The literature leaves a country-specific evidence gap: robust causal estimates linking climate events to Uzbekistan's inflation, bank loan quality and public debt remain limited. An appropriate initial contribution is therefore to map plausible channels and identify data that would permit stronger future testing.

Materials and Methods

The research applies a structured documentary review, descriptive statistical comparison and scenario interpretation. Source selection prioritizes peer-reviewed research, international financial institutions, the World Bank's Uzbekistan Country Climate and Development Report, and official NGFS and ECB materials. The analysis considers the mechanisms connecting climate events to output, prices, fiscal balances, external stability and bank soundness.



Quantitative values are taken directly from the cited sources. They are not pooled into a new econometric dataset because their units, reference periods and scenario assumptions differ. The central long-run estimate is a World Bank counterfactual for 2050; the irrigation and energy figures refer to current or historical sector conditions reported in 2025; and the GDP and inflation values describe the 2025 macroeconomic outcome reported by the IMF in 2026.

Three original charts visualize selected published figures. The first compares the no-climate-impact counterfactual index with the World Bank's no-adaptation 2050 projection. The second reports irrigation pumping exposure and associated energy use as separate physical quantities. The third displays 2025 GDP growth and end-year inflation, not as causal estimates of climate impacts but as background indicators of macroeconomic conditions.

The paper defines physical climate risk as the possibility of losses due to weather and longer-term climate shifts, and transition risk as losses associated with policy, technological and market adjustment toward a lower-emissions economy. Macrofinancial transmission is evaluated through a qualitative risk matrix, which distinguishes direct shocks from secondary effects.

The analytical method is intentionally non-causal. It does not estimate the marginal effect of temperature on GDP, run regressions, establish climate-attributable inflation, or calculate probabilities of bank distress. Forecasts are labeled explicitly and no confidence intervals are fabricated. This design supports traceability but limits claims about magnitude and causality.

For interpretation, the study evaluates each risk using four questions: what is the physical or transition trigger; which economic sector is initially affected; how could the shock propagate into macroeconomic indicators; and what policy tool could reduce the exposure? This framework can guide future quantitative stress tests.

Risk classification and transmission mechanisms

Climate risk	First-round effect	Macroeconomic channel
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Drought and water scarcity	Lower irrigation water availability	Crop output, food prices, rural income
Extreme heat	Labor and equipment productivity loss	GDP, wages, electricity demand
Floods and storms	Damage to infrastructure and assets	Public expenditure, bank collateral
Carbon/energy policy change	Higher short-run adjustment costs	Inflation, investment, fiscal transfers
Stranded carbon-intensive assets	Asset repricing and loan losses	Bank capital, credit conditions

Table 1. Author synthesis based on NGFS (2020), IMF (2024) and World Bank (2023).

Results

Long-term macroeconomic exposure

The World Bank (2023) estimates that, without adaptation, Uzbekistan's economy could be 10% smaller in 2050 than under a hypothetical scenario without climate impacts. Figure 1 expresses the counterfactual as an index of 100 and the climate-affected scenario as 90. This is a difference between future scenarios, not an observed contraction of GDP or a prediction of negative annual growth.

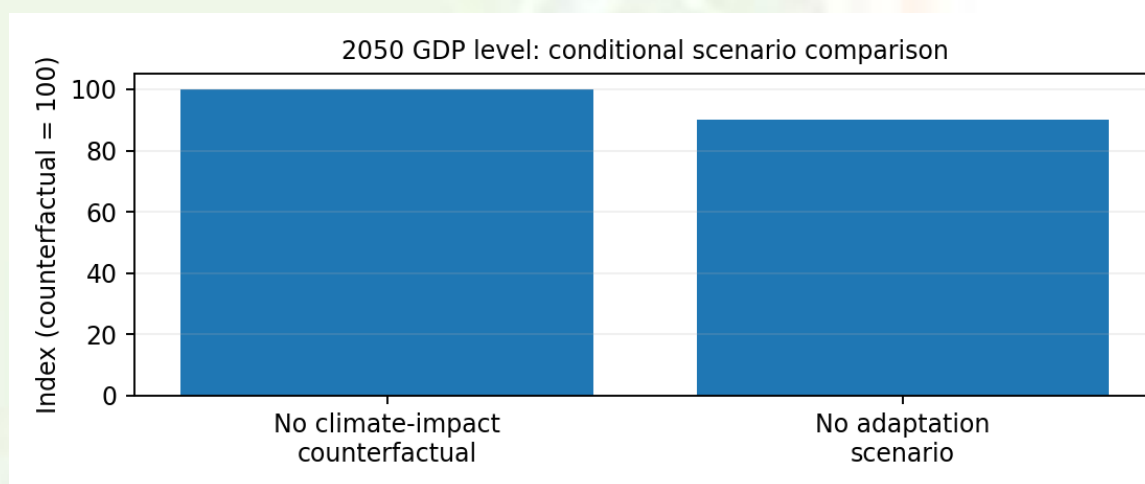


Figure 1. Author visualization of World Bank (2023) CCDR scenario estimate; the index is illustrative and does not represent observed GDP.



Water, agriculture and energy linkages

Water scarcity is a central transmission channel. The World Bank (2025) reports that approximately 2.4 million hectares of irrigated agricultural land, about 56% of the total irrigated area, depend on pumps. Around 1,700 pumping stations use approximately 7.2 billion kWh of electricity annually, equivalent to about 16% of national electricity use according to that source. These figures illustrate the coupling of water availability, agricultural productivity and energy demand.

Published measure	Reported value	Source
Irrigated land dependent on pumping	2.4 million hectares	World Bank (2025)
Share of irrigated land dependent on pumping	56%	World Bank (2025)
Irrigation pumping stations	1,700	World Bank (2025)
Annual pumping electricity use	7.2 billion kWh	World Bank (2025)
Pumping share of national electricity use	16%	World Bank (2025)

Table 2. Selected water-energy nexus indicators. These are reported sector statistics, not estimates produced by this study.

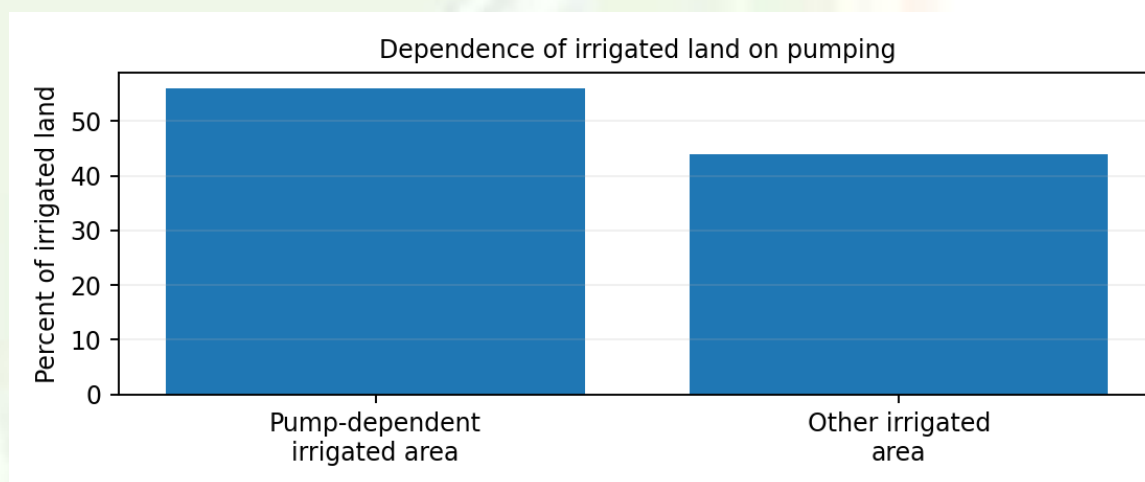


Figure 2. Share of irrigated land dependent on pumping (56%) and remaining share (44%), calculated as a complement. Source: World Bank (2025).

The World Bank (2025) also warns that future water availability may decline by 30-40% and irrigation demand may rise by 25% under the cited outlook. These are forward-looking risk estimates rather than changes already measured. Their precise interpretation depends on underlying scenario assumptions and planning horizons.

Recent macroeconomic context

The IMF (2026) reports real GDP growth of 7.7% in 2025 and end-year consumer inflation of 7.3%. These observations describe the broader macroeconomic environment; they cannot identify the contribution of climate events to inflation or output. Nonetheless, stable prices and growth are relevant outcomes that could be affected by future food supply or energy shocks.

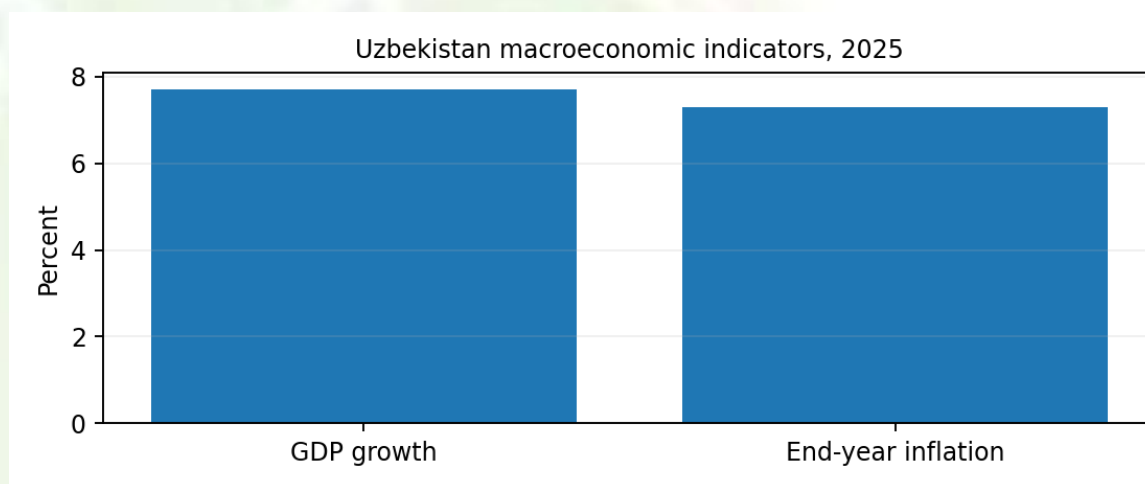


Figure 3. Real GDP growth and end-year CPI inflation for 2025. Source: IMF (2026 Article IV mission). Different indicator definitions; chart does not imply causal climate effects.

Financial-system exposure and policy response

A World Bank 2025 financial-sector assessment reports that up to 42% of bank lending in 2022 financed emissions-intensive activities. This exposure is a potential transition-risk indicator, not an estimate that 42% of loans will become impaired. The same assessment notes the Central Bank of Uzbekistan's 2025-2027



climate-related financial-risk strategy and the inclusion of a climate dashboard in financial stability reporting.

Indicator or institutional action	Evidence	Interpretation
Bank lending to emissions-intensive activities	Up to 42% (2022)	Exposure, not realized losses
CBU climate financial-risk strategy	2025–2027	Supervisory capacity-building
Climate Change Dashboard	Included in CBU financial stability reporting	Monitoring and transparency
Long-run no-adaptation GDP scenario	10% below counterfactual by 2050	Conditional macroeconomic risk

Table 3. Climate-related exposures and monitoring initiatives. Sources: World Bank (2023; 2025 financial-sector assessment).

Integrated monitoring framework

Monitoring pillar	Suggested indicators	Policy relevance
Physical hazard	Drought index, heat days, water availability	Adaptation planning and contingency budgets
Real economy	Crop yields, food CPI, electricity interruptions	Inflation and growth assessment
External sector	Energy imports, export crop volatility	Balance-of-payments resilience
Financial stability	Climate-exposed credit, NPLs, insurance	Supervisory stress testing
Transition	Energy mix, carbon intensity, investment	Orderly decarbonization and competitiveness



Table 4. Proposed monitoring dashboard developed by the author; these are indicators for future evaluation, not estimated crisis thresholds.

Discussion

The evidence indicates that climate-related macroeconomic risk in Uzbekistan is best understood as a system of connected shocks. Water scarcity can lower agricultural output, raise food prices and reduce rural income. The same event can increase demand for pumping electricity and place pressure on energy supply and public spending. Household repayment capacity and agricultural borrowers' balance sheets may then deteriorate, creating a financial transmission channel.

This chain is economically plausible but not mechanically inevitable. Irrigation efficiency, crop selection, storage, insurance and social protection can alter the size of the shock. A national projection should therefore be interpreted as conditional on adaptation, technology and policy assumptions. The World Bank's 10% 2050 scenario difference is particularly important for long-term planning, but it cannot be converted into a fixed annual loss rate.

Climate change can also affect inflation in different ways. A drought may raise food prices temporarily, while repeated supply disruptions can create persistent pressures. Higher energy costs during transition may influence the consumer price index, but investment in efficiency and renewable generation can reduce exposure to fossil-fuel price volatility over time. Monetary policy alone cannot restore lost water supplies or damaged infrastructure; coordination with structural and fiscal policies is essential.

Fiscal stability is exposed through disaster relief, reconstruction, infrastructure upgrades and potential support for vulnerable households. However, public adaptation spending may reduce future losses and yield broader development benefits. The optimal fiscal choice therefore depends on the expected avoided damage, financing terms and institutional capacity, not merely the immediate budgetary cost.



Financial-sector stability adds another layer. Physical risks can damage collateral, disrupt cash flows and increase credit losses. Transition risks can change profitability in emissions-intensive industries. The reported 42% emissions-intensive lending exposure should be read as a screening measure: actual loss depends on loan maturity, sector resilience, borrower adaptation and bank capitalization.

International lessons are useful but require adaptation to local institutions. NGFS scenario methods can help frame stress tests, while the ECB emphasizes the links between climate resilience and economic competitiveness. Uzbekistan's priorities are likely to differ from those of advanced economies because water-dependent agriculture and the energy-water nexus play unusually important roles.

Practical measures include modernizing irrigation networks, improving water accounting, scaling energy efficiency, developing reliable renewable power, strengthening climate-related disclosures and conducting bank stress tests. Transparent and targeted support can reduce the regressive effects of tariff or carbon-pricing reforms on low-income households.

The analysis has limitations. It combines documents published in different years, and the measures are not harmonized into one causal dataset. Future climate scenarios are sensitive to assumptions about emissions, adaptation and growth. Sector exposures do not equal realized losses, and annual macroeconomic indicators cannot isolate climate-attributable effects. These limitations are important for academic transparency.

Further research should build a quarterly or annual Uzbekistan dataset combining meteorological measures, regional crop yields, food inflation, energy outages, bank credit exposures and fiscal spending. Econometric models could test lagged effects and regional heterogeneity; scenario exercises could then quantify plausible macroeconomic impacts under alternative adaptation pathways.

Ultimately, climate policy is not separate from macroeconomic policy. Well-designed adaptation protects the supply side of the economy, and credible transition planning can reduce uncertainty for investors and lenders. Yet the timing of



investments, financing constraints and distributional effects must be incorporated into economic security planning.

Conclusion

Climate-related risks can affect macroeconomic stability through production, inflation, public finances, external accounts and the banking system. In Uzbekistan, water scarcity, heat, agricultural dependence and energy-intensive irrigation make these interactions especially important. The available evidence supports preventive monitoring and adaptation rather than a claim that a specific crisis is imminent.

The World Bank's conditional estimate of a 10% smaller economy by 2050 without adaptation underscores the potential scale of long-run exposure. Official data on pumping-dependent irrigation and electricity consumption demonstrate the practical links between climate resilience, agricultural output and energy security. Recent macroeconomic performance provides context but does not quantify climate causality.

The recommended policy approach combines investment in water efficiency and energy resilience, fiscal planning, targeted social protection and climate-sensitive banking supervision. Future research should test these channels using harmonized high-frequency data and clearly documented scenarios. Strengthening resilience can protect macroeconomic stability and support sustainable economic development.

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Data and transparency note. Figures are author-created visualizations of cited public statistics and scenarios. No climate-attributable regression coefficients, loss probabilities, or observed 2050 outcomes are claimed. The ResearchGate item and malformed combined ScienceDirect/NGFS link supplied by the requester were not used as evidentiary sources because their bibliographic details could not be independently verified.