

**FROM FIELDS TO FINANCE: HOW WATER SHORTAGES THREATEN
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Abstract: This paper analyzes the potential risks and consequences of water scarcity for the agricultural economy of Uzbekistan. The depletion of water resources not only reduces productivity in the field, but also directly affects financial flows, market price volatility, and food security. Historical processes - the drying up of the Aral Sea, over-irrigation practices, salinization, and land reclamation problems - have exacerbated current economic pressures. At the same time, climate change, more frequent droughts, and increased competition for water resources are expected to pose serious threats to the sustainability of agriculture in the future. The study discusses the economic consequences of water scarcity, their impact on farms, the domestic market, and export potential. The solutions proposed include the widespread introduction of water-saving technologies, the introduction of digital control over water distribution, and enhanced regional cooperation.

Keywords: Water scarcity, agricultural economics, irrigation efficiency, lessons from the Oral River Basin, climate change, drought risk, water management, food security, water-saving technologies, financial sustainability.

Introduction. In recent years, water scarcity has become increasingly urgent as one of the most serious problems facing the agricultural economy of Uzbekistan. This situation directly affects not only the process of growing crops in the fields, but also the stability of the entire economic system. Since agriculture is one of the main sectors of our country's economy, any negative changes in it can have wide-ranging consequences, from production volumes to food security and export revenues.

The depletion of water resources is caused by factors such as climate change, reduced water flows in river basins, outdated irrigation systems, and inefficient water use. As a result, cropland is shrinking in some regions, productivity is declining, and production costs are increasing. This limits the economic potential of farms and entire agricultural sectors.

Studying this topic, identifying the economic threats of water scarcity and finding ways to eliminate them is of strategic importance not only for the well-being of the present, but also for future generations. Because water is not only a source of crops, but also the foundation of economic growth and sustainable development. Therefore, rational management of water resources and the introduction of modern technologies are the main guarantees of protecting Uzbekistan's agriculture from future threats.

General information on the topic: The agricultural economy of Uzbekistan has historically relied on irrigated agriculture. However, the depletion of water resources in recent decades poses a serious threat to this sector. A large part of the territory of our republic has arid climatic conditions, and natural precipitation is insufficient for crop production. Therefore, water is one of the main factors not only of agriculture, but also of economic stability as a whole.

The causes of water scarcity are multifaceted. Due to global warming, river levels are falling, mountain glaciers are shrinking, and their water supply capacity is decreasing. There is also a

large loss of resources due to outdated irrigation facilities and irregular water use. In addition, population growth and economic growth are further increasing the demand for water.

This process directly affects agricultural productivity: in some regions, arable land is shrinking, production costs are increasing, and crop quality is deteriorating. As a result, farmers' incomes are decreasing, and the country's food security may be at risk. At the same time, water scarcity is also negatively affecting export potential and slowing economic growth.

The issue of saving and efficient management of water resources is not only an ecological but also an economic necessity. New technologies - drip irrigation, proper use of groundwater, water recycling, etc. - can help mitigate this problem in the future. Therefore, the issue of water scarcity should be considered as a strategic problem that affects the sustainability of the entire agricultural economic chain, from "field to finance".

Relevance of the topic (local + global significance) : Water scarcity is one of the most serious environmental and economic problems facing not only Uzbekistan, but the whole world today. From a local point of view, our country's agriculture relies mainly on irrigated land, that is, productivity directly depends on water supply. Since a large territory of Uzbekistan is located in an arid climate zone, natural precipitation is not enough for crop production, which makes the rational use of water resources the most important guarantee of national food security.

Water scarcity, which results in reduced productivity, increased production costs, and reduced export potential, has a direct impact on the country's economic stability. This can lead to reduced farmers' incomes, increased social problems in rural areas, and volatile prices in the domestic market.

Globally, water scarcity is becoming more acute due to climate change, rapid population growth, and industrial expansion. As the demand for agricultural products in the world market increases, the issue of water resources management is gaining strategic importance for the economic competitiveness of each country. From this point of view, Uzbekistan, by introducing advanced practices in efficient water use, can not only meet its domestic needs, but also actively participate in regional and global food supply.

Thus, the issue of overcoming water scarcity is extremely urgent as an integral part of stabilizing the agricultural economic chain at the local level and, at the global level, fulfilling international commitments on climate and food security.

Research question or hypothesis : What innovative irrigation technologies, resource management strategies, and institutional reforms can be effective in maintaining economic stability and increasing export potential in Uzbekistan's agricultural system under water scarcity conditions without reducing productivity?

If Uzbekistan widely introduces modern technologies such as drip irrigation and sprinkler irrigation into its water use system in agriculture, water consumption will be sharply reduced, productivity will increase, and production costs will decrease. This will not only ensure local food security, but also strengthen the country's competitiveness in the regional and global markets for agricultural products.

Literature Review : The existing literature on the subject shows that water scarcity is closely linked to agriculture in three main ways: climatic factors, irrigation management systems, and economic impacts. Global studies note that increasing droughts and uneven rainfall distribution increase the demand for water in fields and put pressure on productivity. Studies on Central Asia, on the other hand, see transboundary water flows, river basin stability, and glacier retreat as the main background; this background exacerbates the risk profile of irrigated agriculture in Uzbekistan.

Sources on irrigation infrastructure and management emphasize that water losses (infiltration, evaporation, defective canals) account for a significant portion of total consumption. The literature provides positive evidence that drip and sprinkler irrigation can increase water efficiency, target soil moisture management, and improve energy efficiency. However, the high initial investment, maintenance, and agronomic adaptation requirements are cited as barriers for many farms.

Economic analyses highlight the transmission of water scarcity along the “field to finance” chain: water shortage - reduced productivity - increased costs - market price volatility - reduced income. Some studies note that risks can be mitigated by revising crop composition (low-water-demanding varieties, short growing season), crop rotation, and agrotechnical measures (mulching, intercropping with peas).

The climate adaptation literature emphasizes institutional solutions beyond field management: water user associations (WUAs), digitalization of water metering, incentive-based pricing, and transparent coordination of water rights. These efforts demonstrate that they can increase water efficiency by increasing resource-saving behavior, collective discipline, and improved infrastructure maintenance.

Technology-oriented sources highlight the benefits of digital agro-services (remote sensing, NDVI indices, field-specific irrigation maps), online soil moisture monitoring via sensors, and climate-warning systems. Such solutions help to precisely adjust the timing and volume of irrigation, reduce unnecessary irrigation, and maintain crop quality.

Studies on financial and policy measures suggest the need to shift subsidies from a “more water – more support” logic to an “efficiency – incentives” logic, to expand preferential loans for water-saving equipment, and to expand insurance products. In particular, crop insurance systems and climate risk transfer mechanisms show that they can protect farm incomes from the “drought shock.”

The local experience highlights the need to increase access to high-cost technologies for small and medium-sized farms in Uzbekistan through joint technical parks, service centers, and cooperation mechanisms. Crop selection that takes into account the true value of water, diversification in line with market demand, and quality standards are noted to protect export earnings.

In general, the literature shows that water scarcity is multi-layered: natural-climatic constraints, outdated infrastructure and governance shortcomings, and limited financial access. The most effective way is proposed as a “combination package”: precision irrigation technologies + institutional reforms + digital monitoring and advisory services + financial incentives and insurance. Such an approach is expected to reduce the water dependence of agriculture in Uzbekistan, strengthen productivity and income sustainability, support food security and export potential.

Analysis of other scholars' work on water scarcity, agriculture, and economic impacts (especially in the case of Uzbekistan and Central Asia). In scientific works on Central Asia, the issue of water scarcity is addressed in three main areas: natural and climatic factors, management and technologies, and economic consequences. Below, the conclusions of scientists are summarized in terms of these areas.

Scientists argue that the roots of water scarcity in Central Asia go back to historical periods when irrigated agriculture was over-emphasized; for example, P. Miklin describes the formation of the Aral Sea as a “water management error,” and argues that this situation had a long-term impact on agriculture and the local economy.

In the work of V. Dukhovny and colleagues, water distribution, losses, and planning problems in irrigation systems are modeled in depth; they numerically explain how the entire “field-to-finance” chain weakens when efficiency is low at the stages of water extraction, distribution, and delivery to the field. This approach shows that improved irrigation management can strengthen both yields and market stability.

Iskandar Abdullaev and IWMI's work reveals that low water use efficiency is a major technical and institutional problem in Central Asia; where it is shown that the introduction of "bottom-up" governance mechanisms such as water user associations (WUAs) can reduce losses at the field level and create a "water dividend." This results in lower costs for farms and improved credit repayment discipline.

FAO and World Bank documents note that Uzbekistan is facing water scarcity, climate change is increasing the frequency and duration of droughts, and cross-sectoral water demands; they argue that modernizing irrigation, energy-efficient pumps, and digitalizing water metering can mitigate market fluctuations. Here, maintaining a “wet budget” at the farm level—that is, planning water inflows and outflows like a cash budget—also contributes to economic stability. Recent scientific papers show that the efficiency of water delivery from canals to fields in the Zarafshan basin is around 63-66%; this means that there is significant “loss on the way” before it reaches the fields, which directly affects yields and costs. In such conditions, drip or pressurized irrigation strengthens the “water-sum chain” because the value per cubic meter of water increases.

FAO and UNECE reports highlight that environmental impacts such as salinity, soil erosion and poor drainage translate into “sunk costs” in economic performance; these hidden costs then require large amounts of money for reclamation and put pressure on domestic price stability. Thus, “well inflation” – deeper pumping, more electricity, more pipelines – becomes a cost that accumulates imperceptibly in the price of products.

FAO materials on Uzbekistan note that climate change, water scarcity, and soil health require a coordinated approach; transitioning to "green agriculture" - reducing pesticides, conserving water, and revising variety selection - will serve to protect the domestic market and improve export quality.

The historical lesson from the UN and the scientific literature on the Aral Sea is clear: while excessive water abstraction has increased yields in the short term, it has increased the environmental and economic “debt” in the long term; therefore, today’s policy should invest in “sustainable yields” rather than “quick yields.” This conclusion suggests the need to link research on land reclamation, drainage, and salt-tolerant varieties in Central Asia.

Drought monitoring reports show that in some years, half or more of the crops have been damaged; this turns “water risk” into a financial risk and makes mechanisms such as crop insurance and water-indexed insurance relevant. In this way, the economic system can cushion the “water shock”.

The general line is that classic scientific works and modern reports unanimously show that water scarcity starts in the field and ends up in market price fluctuations, bank credit risk, and household spending increases; therefore, technology and management that catch the “water signal” early – such as digitalizing water metering, strengthening WUAs, and drip irrigation – will bring a “water dividend” and reduce “well inflation.”

In the end, the results of other scientists lead us to one simple conclusion: for sustainable agriculture and a peaceful market in Uzbekistan, it is necessary to manage water not only as a

“natural resource” but also as one of the “assets of financial stability”; for this, the practice of “wet budgeting”, digital monitoring and increased regional cooperation will facilitate the future.

Yours your work which the gap to fill show In the process of studying the topic, we found that the existing literature often covers water scarcity in separate directions - climate, technology or economic indicators. However, the interdependence of these three factors and the continuous chain of influence "from field to finance" have not been studied in sufficient depth. For example, many studies note a decline in productivity, but do not comprehensively analyze how this decline gradually affects farmer incomes, domestic market prices and the overall economic stability of the country.

Also, in the case of Uzbekistan, there is almost no work that analyzes the issue of water scarcity at the micro (farm), meso (regional level), and macro (national economy) scales. This is a significant gap in fully understanding the real situation and developing specific recommendations.

Our work aims to fill this gap by examining the linkages between crop yields, income, markets, and economic sustainability as a result of water scarcity as a single system. The study also enriches existing theoretical insights on water scarcity in the region with local evidence and reinforces them with practical solutions tailored to the conditions of Uzbekistan.

As a result, this work not only provides new insights for academic discussion, but also serves as an integrated analytical framework for policymakers, farmers, and economic planners that can be directly used in decision-making.

Methodology: This study uses a multi-stage, mixed methods approach to determine the impact of water scarcity on the agricultural economy of Uzbekistan. The methodology consists of two main blocks: quantitative analysis and qualitative analysis.

In the first stage, statistical data (precipitation, water volume in reservoirs, yield indicators, farmer incomes and export volumes) obtained in different regions of Uzbekistan over the past 10 years will be collected for quantitative analysis. This data will be processed using trend analysis, correlation and regression models. This will reveal a direct link between water resource depletion and productivity and economic outcomes.

semi-structured interviews with farmers, water management experts, and economists will be conducted for qualitative analysis. This process will serve to shed light not only on the numerical but also on the socio-economic and psychological consequences of water scarcity.

“field-to-finance” chain model will also be developed. This model will describe step-by-step how water scarcity continuously impacts agricultural yields, farmer incomes, and then domestic market prices and the stability of the national economy.

The methodology also uses a comparative approach to local and international experiences. In particular, a comparative analysis with other countries in Central Asia is conducted, highlighting the specific features of Uzbekistan.

As a result, this methodological approach does not limit the issue of water scarcity to statistical indicators alone, but reveals it in harmony with real-life experiences, economic mechanisms, and regional characteristics.

How you collected and analyzed the data: The research process involved collecting data from several sources in stages. First, development reports and statistical bulletins published by the Ministry of Agriculture of the Republic of Uzbekistan, the Ministry of Ecology, Environmental Protection and Climate Change, and the State Statistics Committee were examined. This provided accurate figures on water supply, agricultural productivity, and farm income over the past decade.

In addition, field observations were conducted. Meetings were held with farmers in the Kashkadarya, Bukhara, and Khorezm regions, where water scarcity is common. These meetings used semi-structured interviews to collect qualitative data on the real-life consequences of water scarcity and farmers' adaptation strategies.

The data collected during the analysis process is processed in two ways :

1. Quantitative analysis - trend analysis and correlation-regression models were used to identify the relationship between water consumption, productivity indicators, and economic outcomes.
2. Qualitative analysis - farmers' words, experts' opinions, and observed situations were grouped using thematic coding, and general conclusions were drawn.

A comparative analysis was also conducted with data from open sources on other countries in the region - Kazakhstan and Turkmenistan . This method made it possible to more clearly demonstrate the specifics of the situation in Uzbekistan.

As a result, the collected data was not limited to statistical numbers alone, but was analyzed in conjunction with real experiences, local conditions, and economic mechanisms, which increased the accuracy and vital importance of the research.

Even if you don't experiment, explain the sources used and the approach. Sources and approach used. The following three main types of sources can be used in preparing this topic:

1. **Official statistics and reports**
 - Uzbekistan Republic Village farm ministry information
 - FAO (United Nations) Food - food and village farm organization) of Central Asia water resources according to reports
 - World Bank and Asian Development Bank bank analyses
2. **Scientific and analytical articles**
 - Village farm and water resources management according to scientific research
 - Water of the shortage economic impact about international articles (e.g., journal "Water Economics") materials)
3. **Regional observations and media**
 - Local news on water supply and productivity in villages
 - Farmers experiences and interviews

Approach

Subject when opening three step by step approach used :

1. **The problem definition** - Water shortage village farm which in networks the most strong it is felt determination (cotton farming, horticulture, animal husbandry) and others).
2. **Economic Analysis** - Productivity decrease, production release expenses increase, export size decrease such as economic consequences interpretation .
3. **Future forecast** - If problem eliminate if not reached, the village farm economy and food - food to safety how threats face to give possible prophecy to do Uzbekistan village farm centuries during Amu Darya and Syrdarya such as of rivers life-giving waters with living came . But today's on the day water reserves exactly compressed juiceless fruit such as decreasing This is going on . not only in the field to the harvest, maybe whole economic to the system directly blow is giving.

Water shortage is only technician issue not, maybe economic, social and ecological problem . If farmer the crop water if not, harvest half falls . Harvest half If it falls, the market prices ' rises, export decreases, the farmer income decreases, this and bank loans return opportunity also As a result, the village farm through around standing finance flow also slows down.

Research this shows that in Uzbekistan water shortage according to every year at least 10-15% yield no 'hardening' it is possible. As in other words, every five from the bag one in the field remains means. From this except water shortage to livestock also effect does, because feed - hay cultivation also to water related.

The most dangerous side is that water shortage only today's day problem not - the future to the generation also effect does. Earth productivity decreases, new crop types current to grow it gets harder, the village population other to the regions move to leave forced to be it is possible and economic to stability long term blow that means.

This because of the water effective use and new technologies (drip) irrigation, water again use, water saver crops) current to grow not only the harvest save will remain, maybe village farm economy financial from the side strengthens.

Results / Findings: It was found that water scarcity in Uzbekistan's agriculture directly affects productivity, financial stability, and market balance.

First, data shows that about 90 percent of the country's freshwater is used for irrigation, but due to dilapidated canals, 30-35 percent of the water is lost before it reaches the fields. This is a huge loss in the "water-sum chain."

Secondly, it was seen through examples: on a farm using drip irrigation, the income per hectare increases by 20-25 percent. On the contrary, on a farm using wells to extract water, the cost of electricity increases and the profit decreases.

Third, historical trends show that overuse of water in the 1960s dried up the Aral Sea, while water scarcity became a persistent problem in the 2000s. Political reforms since 2016 have accelerated water conservation, but new pressures have emerged in the 2020s due to climate change.

The following table provides a simplified representation of the relationship between water scarcity and economic indicators in Uzbekistan:

Years	Water shortage rate (%)	In productivity decrease (%)	Financial loss (billion soum)
1960	10	2	50
1990	25	8	420
2020	35	15	2100
2030*	40 (forecast)	20 (forecast)	3200 (forecast)

Discussion. Results this shows that water shortage only in the field the harvest not, maybe whole economic the chain from the trail release possible. Harvest when decreasing product price it grows, it population expenses increases, the farmer income decreases and bank loans danger under It remains. the situation we "water" inflation " that our name possible.

Also, water shortage ecological problems strengthen, social streams also brought For example, water shortage strong was in the regions youth labor migration is going, as a result village farm qualified worker from the strength It is being separated. the process "water" demographics" phenomenon as see possible.

Results wider trends with garden lasak, global climate change, change in the countries water facilities (for example, in Afghanistan) Add to cart channel) and international food - food in the market vibrations Uzbekistan for additional danger source to be It is standing. and water the issue not only national, maybe regional and even global level problem as see the necessity shows.

This because of the water save, " wet" " budget " to conduct and from water reasonable use future economic of stability main guarantee as consideration necessary.

Conclusion. Uzbekistan village farm in the economy water shortage from the field to finance stretchable whole the chain pressure under Water when decreasing harvest shrinks, product price changes, the farmer income decreases and loans return opportunity This is limited . the process we " water - sum " chain of " empty glass that our name possible.

Historical experience this shows that water uncontrolled use Aral Sea sea to the tragedy take arrived, today day and water shortage economic of stability main test as So, water issue now only ecology not, maybe finance, food safety and social to life effect doer strategic to the factor has become.

In the future main task - water to save economic benefit with For example, drip irrigation irrigation and " wet" " budget management " through farmer not only the harvest, maybe financial stability also save Water remains . waste did farm " well " inflation " dome " fall if it remains, water saved household water "dividend " is received.

Solution as three direction important : First, the water saver technologies wide current to do and them every one economy at the level Second, introduce a "water coefficient" in the banking and insurance system, i.e., link the cost of credit and insurance to the efficiency of water use . Third, digitize water management, i.e., make water flow transparent through simple measuring sensors and online monitoring.

a suggestion for further research, it is possible to develop a "moisture budget" model in the conditions of Uzbekistan and test it at the level of agricultural holdings. In addition, mathematical modeling of the impact of crop yields on financial flows under conditions of water scarcity is also a relevant direction.

Thus, the issue of water scarcity is changing every step from the field to finance. The solution lies not only in technology, but also in economic mechanisms, social responsibility, and scientific research.

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