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The Dialectical Relationship Between the Decline in Agricultural Production and The Water Crisis in Iraq (An Analytical Perspective)

Rashid B Shannan
Imam Al-Sadiq University, Dhi Qar Branch, Al-Rifai Site, Iraq

* Corresponding Author: **Rashid B Shannan**

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Abstract
It has been proven through available data from extrapolating reality and from specialized international organizations, some of which are affiliated with the United Nations, that humanity today faces an acute water shortage crisis, supported by the phenomenon of drought and the frequent increases in population. This crisis threatens the existence of humanity in its social, economic and cultural aspects, and threatens global food security. The water crisis also creates a suitable ground for conflicts and wars that threaten global and regional peace, which requires joint efforts to develop legal and logical solutions to this major problem. Hence, and due to its importance, the topic of the water crisis and drought and their direct impact on food security was a strong incentive to address this problem, and because of its relation to the reality of the contemporary world, to Iraq and to the model we chose in the research.

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Introduction

With the rapid increase in the global population since the mid-20th century, numerous and pressing demands have arisen, particularly regarding support for urban expansion and essential infrastructure. This includes both social structures and the requirements for implementing economic development programs in industry, agriculture, and national development. These developments necessitate an abundance of water to accommodate this significant population growth and economic development. However, reality has revealed a water crisis and a shortage of water resources. These resources are insufficient to meet the rapidly growing needs and the ever-increasing demand for water from limited sources with fixed reserves. The water crisis has had serious repercussions on the global agricultural landscape, and particularly in Iraq, leading to migration and the abandonment of vast areas of farmland. This is accompanied by adverse climate changes and severe drought, which have exacerbated desertification, soil erosion, and environmental degradation. Furthermore, it has contributed to widespread hunger and poverty due to reduced agricultural imports. Consequently, the water crisis has become a source of local, regional, and global conflict, as it has begun to affect national and food security. This is not unrelated to the influence of political factors and the exploitation of vulnerable nations. Iraq has not been immune to the problems of water scarcity and environmental drought. In fact, it is among the countries suffering from a water crisis, as its water originates outside its borders. This is compounded by the drought and desertification that are devastating the land and agricultural production, threatening food security in Iraq at a time when the country is experiencing rapid population growth and political and social instability. The research comprised four sections. The first section addressed the global water crisis and its direct negative impact. The second section examined the water crisis in the Arab world. The third section explored the problems facing Iraq and other countries that rely on water sources outside their national borders for their funding, the fourth section examined the impact of water scarcity on agriculture in Iraq.

Research Problem

This research addresses a real problem facing the world today: the water crisis and drought, and the impact of this crisis on the agricultural sector in general, and specifically on Iraq, the subject of this research. It examines the effect of fluctuations in water allocations and drought on the volume of agricultural production and food security in Iraq over successive seasons.

Research Hypothesis

There is a statistically significant inverse correlation between the decline in available water resources and growth rates in the agricultural production sector in Iraq. The continued water deficit leads to a reduction in cultivated areas, which threatens national food security.

Research Significance

The importance of this research is underscored by the solutions it proposes to ensure access to sufficient water quantities from upstream countries. This can be achieved through new, binding agreements and understandings, the full utilization of abandoned agricultural lands, the rehabilitation of damaged lands, and improved water conservation in agriculture. Furthermore, it aims to ensure food security for citizens at a time when the world is experiencing serious security, food, and political instability that threatens the lives of entire populations. Research Objective:

The study aims to identify the laws and agreements that control water flows, the policies and conditions that govern upstream and downstream countries, and to study the factors that created the water crisis, which ultimately led to the abandonment of large areas of agricultural land and the decline in agricultural production, as is the case with regard to irrigation methods, water policies, agricultural plans, and sustainable development, and the need to work on developing appropriate and necessary plans to address these obstacles and problems and ensure food security.

Research methodology

It relies on the descriptive method and the quantitative method for standard analysis.

Section One

Water plays a vital role in human life, essential for survival, continuity, and the advancement of civilization. This importance is underscored, and its challenges intensify, with human development and migration over time, as well as the demands of population growth. This growth inevitably necessitates increased water consumption, whether for biological needs such as personal and domestic use, or as a fundamental requirement for construction and development.

The massive global population growth and the accompanying unprecedented development have created a pressing need for water. However, the inability to meet this population and developmental demand, due to natural, environmental, political, and climatic conditions, has created a significant gap and a severe shortage between the actual water requirements and the available supply. This gap has provided fertile ground for numerous local and regional crises, foreshadowing further conflicts and wars.

The Global Water Crisis and its Impact on Populations

There is a close relationship between human well-being, which includes meeting daily and essential needs such as health and food security, and access to water, which is fundamental to the functioning and facilitation of economic and social life.

The water crisis is a global crisis. To ensure water availability, robust infrastructure is essential to guarantee water conservation and prevent waste, especially during floods and the rainy season. This infrastructure is crucial for supplying vital economic sectors such as agriculture and industry. Furthermore, activating sectors related to water supply services, whether expanding irrigation and water distribution networks or revitalizing the sanitation sector, will create job opportunities for many unemployed individuals, thereby supporting and expanding economic and social activity(1) .

The agricultural sector and agricultural production are among the economic activities most affected by water availability and the development of irrigation projects. The importance of water availability is evident in its ability to revitalize the agricultural sector, increase agricultural production, and employ a large segment of the workforce. Conversely, the danger of insufficient water supply lies in its negative impact on the decline of agriculture and agricultural production, the creation of a large segment of the unemployed, and the potential for famine and food insecurity, thus threatening national food security.

Therefore, given the critical nature of the situation and the need to ensure food security, relevant authorities must enact laws guaranteeing the agricultural sector's right to water supplies and ensuring their delivery to farmers under legal protection and oversight.

Agriculture's Share of Total Global Water Consumption

Official global data indicates that agriculture consumes approximately 70% of freshwater, followed by the industrial sector at less than 20%, and domestic use at around 12%. These figures vary according to a country's development and economic status. Industrialized countries have a higher percentage of water used in the industrial sector, unlike poorer countries that rely on agriculture, where the percentage of water used in agriculture can reach up to 90%.

Due to highly volatile environmental and climatic changes occurring in many countries, adverse weather phenomena such as drought and low rainfall are leading to desertification, soil erosion, and rising temperatures. This translates to water scarcity, discouraging agriculture and potentially leading to famine, disease outbreaks, land abandonment, and population migration. Data indicates that half the world currently suffers from severe water shortages for at least some period of the year. Other regions experience water scarcity for several months, while still others suffer from severe shortages year-round. Conversely, some areas are subjected to devastating floods that damage crops and destroy homes, pushing populations into dire economic and social conditions, driving them towards poverty and migration.

In the period 2021-2022, floods caused the deaths of approximately 100,000 people, with an additional 8,000 deaths in 2022. These floods affected 1.6 billion people. Both situations necessitate the development of international and local laws and the adoption of decisions that address and mitigate the potential impacts of these climatic and natural changes on humanity *(2)* **.**

A report issued by UNESCO, the United Nations Educational, Scientific and Cultural Organization, on water development on March 27, 2024, addresses the potential for conflicts between many countries due to water scarcity. It emphasizes the need for international cooperation, the search for appropriate solutions, and efforts to establish peace before such conflicts erupt**.**

In a statement, Audrey Azoulay, Director-General of UNESCO, said that with the worsening water scarcity, the risks of local or regional conflicts increase, and the importance of the declaration for maintaining peace is evident. Alvaro Larraío, President of the International Fund for Agricultural Development (IFAD), added that water, if used correctly, equitably, and sustainably, can contribute to strengthening peace and economic and social prosperity for millions of people. He pointed out that 2.2 billion people do not meet their water needs safely and 3.5 billion people lack sanitation services, and that the desired solutions by 2030 seem difficult to implement. Droughts between 2002 and 2021 affected 1.4 billion people. In 2022, half the world's population experienced severe water shortages for some period of the year, and a quarter faced critical needs and severe shortages, consuming more than 80% of their annual freshwater supply. Water scarcity is projected to worsen, with serious economic, social, and political repercussions. (3) It can be noted that water insecurity can be a cause of population migration, thereby creating conflicts and social tensions. Studies on Somalia have indicated that the rate of violence and social conflicts has doubled due to the influx of displaced persons, reaching 200%**.**

Control of water resources by upstream countries and its role in conflicts with downstream countries

Section Two

The Water Crisis in the Arab World

The countries of the Middle East in general, and the Arab states in particular, face the problem of water scarcity, low rainfall, and insufficient groundwater. This is due to the fact that most of these countries are located in arid or semi-arid regions. The need is exacerbated by the development of construction and infrastructure, and the increasing population growth, which necessitates more water to meet the growing needs resulting from population increases and the rising demands of construction and development**.**

The water problem is not limited to the scarcity of available water and the increasing need for it, but also includes the deterioration of the quality of incoming water, characterized by high salinity levels and pollution. Furthermore, much of this water originates from sources outside the country's borders, which contributes to the crisis, as upstream countries control the amount of water entering the country from abroad**.**

Egypt and Sudan

The Nile River in Egypt is the longest and most abundant river in the Arab world. It is the sole source of water for both Egypt and Sudan. It originates from several tributaries, most notably the Equatorial Lakes region, a group of tributaries that flow into Lake Victoria, the Alberta Group, and the Ethiopian Highlands and its tributaries, including the Atbara River, the Sobat River, and the Blue Nile. Lake Victoria is the largest freshwater lake in East Africa, bordering Tanzania, Uganda, and Kenya**.**

The Nile water dispute between Egypt and Ethiopia dates back to 1956 when Ethiopia declared its right to full control over the Nile waters within its territory, which constitutes 86% of the river's total flow. (7) With Egypt's population projected at approximately 86 million by 2025, and its water allocation remaining at 74.5 billion cubic meters (based on 2000 estimates), this allocation is insufficient to cover the increasing deficit caused by economic development and population growth. The estimated need is 103.25 billion cubic meters, resulting in an actual deficit of 28.75 billion cubic meters. The problem worsens when the projected future population reaches 120 million, while the water flow to Egypt remains the same, resulting in a deficit of 69.5 billion cubic meters. This highlights the severity of this deficit for Egypt's national water and food security**.**

Sudan's population was 25 million in 1990. Assuming a constant water allocation from the Nile of 18.5 billion cubic meters, supplemented by additional water from other sources such as rainfall and rivers, bringing the total to 22.3 billion cubic meters (with the possibility of future increases), the estimated population of Sudan will reach 55 million by 2025. The actual water demand is estimated at 34.04 billion cubic meters, resulting in a water deficit of 9.47 billion cubic meters**.**

Yemen and Saudi Arabia

Yemen, with a population of 11 million in 1990 and total water resources of 5.2 billion cubic meters, which covered its agricultural and other needs, will see its water requirements rise to approximately 17.49 billion cubic meters by 2025, resulting in a deficit of about 12.29 billion cubic meters, or approximately 70%. (8) In Saudi Arabia, the projected population is 89 million by 2051, and water resources are expected to face a deficit of 6.48 billion cubic meters**.**

Oman and the rest of the Gulf Cooperation Council (GCC) countries

Kuwait, Qatar, and Bahrain have no natural water resources other than a very small amount of groundwater, supplemented by limited rainfall. Consequently, they rely primarily on seawater desalination plants.

The UAE and Oman, however, depend mainly on springs and groundwater. This situation presents all Arab countries with a serious water and food security threat commensurate with population growth and economic and urban development**.**

In Syria, it is estimated that the deficit will become apparent when the projected population reaches 66 million in 2048 *(9)* **.**

In Iraq, according to estimates from the 1990s, surface water quantities were 106 billion cubic meters annually, of which 80 billion cubic meters came from the Tigris and Euphrates rivers. Groundwater is concentrated in five areas or formations: the Bakhtiari Formation, the Euphrates Limestone Formation, the Umm al-Radhuma Formation, the Upper Fars Formation, and the Dammam Formation. The total amount of surface water utilized in Iraq is 42.56 billion cubic meters. With the increasing population, this amount will be insufficient to meet local needs *(10)* **.**

In a report dated July 28, 2025, the Iraqi Ministry of Water Resources warned of a severe drought crisis accompanied by record-breaking temperatures, as seen in southern Iraqi cities, the likes of which Iraq has not witnessed in over 90 years. The report stated that 2025 would be the driest year since

1933, and that the water flow from the Tigris and Euphrates rivers constituted only 27% of the 2024 flow, with water levels in dams and reservoirs dropping to 8% of their capacity. The report highlighted the serious repercussions on the environmental, social, and economic situation and stressed the urgent need to find solutions. The droughts have had a devastating impact on the agricultural sector. According to estimates by the Ministry of Agriculture, arable land has shrunk by 50% in recent years. Data indicates that total water resources have decreased from approximately 70 billion cubic meters to 40 billion cubic meters, and that the per capita share, according to the World Health Organization standard of 1,700 cubic meters annually, is projected to drop to 479 cubic meters by 2030. On April 4, 2025, the Iraqi Ministry of Water Resources announced that Iraq is facing a genuine water crisis requiring swift government action and effective practical steps. This crisis is attributed to Turkey's stance, climate change, and rising temperatures. The Ministry stated that Iraq is among the five countries globally most affected by drought and global warming. It also announced that it has taken practical steps, including dialogue with the three water-related countries—Turkey, Iran, and Syria—to secure a fair share of water, and coordination with the United Nations and international organizations to assert Iraq's water rights.

Section Three

Problems of Water Sources from Outside Iraq

The Problem of Turkish Dams and Their Role in Water Control

The Euphrates River, which originates in the mountains of eastern Turkey at the confluence of the Murat and Karasu rivers at the Keban Reservoir north of the Atatürk Dam, then continues until it enters Syria and flows towards Iraq. The primary source of these rivers is snowmelt.

The Euphrates River constitutes a vital tributary in Iraq, eventually emptying into the Arabian Gulf via the Shatt al-Arab. The Euphrates River is of strategic importance, controlling the fate of the economy, agriculture, and the lives of millions of Iraqis. Turkey has constructed numerous dams on it to control the amount of water flowing into Iraq, negatively impacting the agricultural, economic, and demographic realities of the country. Among these dams are the Keban Dam, completed in 1974, and the Karaaya Dam, completed in 1986. The Atatürk Dam, the fourth largest dam in the world, is considered one of the largest and most dangerous dams for Iraq, located on the Euphrates River, with a storage capacity of. 48.7 billion cubic meters.

The Tigris River originates in the Anatolian Plateau of southeastern Turkey, flows a short distance through the Syrian border, and then enters Iraq. Among the tributaries that feed into the Tigris are those originating from the Taurus and Zagros Mountains of Iran. Iran, along its 1,200 km mountainous border with Iraq, feeds the Tigris through 42 tributaries.

A report issued by the Iraqi Ministry of Water Resources on June 22, 2025, confirms a 75% decrease in water levels at the Dokan Dam, located in northern Iraq, for the year 2025. This decrease is attributed to low rainfall, drought, and Iran's construction of several dams on the Little Zab River on the Iranian side. This has exacerbated the drought already plaguing Iraqi farmers. The Dokan Dam has a storage capacity of 7 billion cubic meters of water, while its current storage is approximately 1.6 billion cubic meters, or about 24% of its total capacity. It can be noted that at the end of May 2025, Iraq faced its lowest water levels in 80 years. This was attributed, as previously explained, to the negative role of neighboring countries in constructing dams, as well as the scarcity of rainfall and the phenomenon of drought.

Turkish Control over Reducing Iraq's Water Shares

In recent years, Iraq has faced its worst water shortages compared to previous decades. Water levels in the Tigris and Euphrates rivers have decreased by 27%. The situation has been exacerbated by drought, deteriorating climate conditions, and an unstable political and social environment, which has negatively impacted the strength and position of the negotiating committees with Turkey, the upstream country of the Tigris and Euphrates rivers. Given the negative impacts of water scarcity and its clear effect on the environment and agriculture, the Iraqi authorities took a misguided step on March 31, 2024, when the government, despite opposition from experts, closed key waterways feeding the Hawizeh Marshes. These marshes are of vital economic, environmental, and cultural importance to the local population. The new situation has driven many residents into unregulated migration, creating demographic chaos due to the lack of plans to address the resulting social, economic, and environmental disruption. The marshes have long been known for their economic significance and their high-quality local production of livestock such as buffalo, cattle, poultry, and fish.

Weak Government Policies Towards Turkey, the Upstream Country

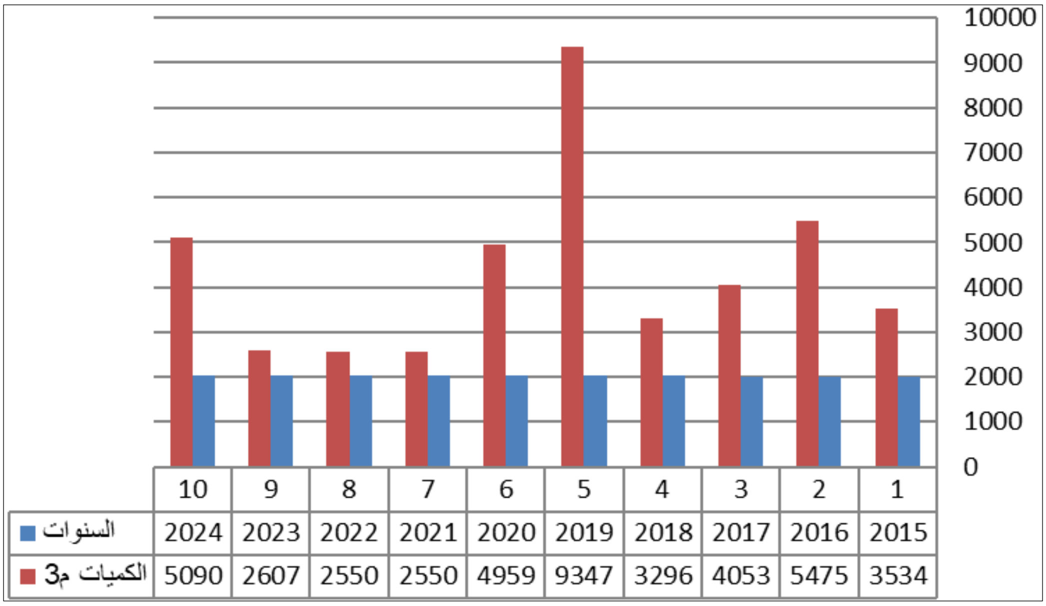
The shortcomings of successive governments were evident in their failure to develop sound economic development plans. This led to the country's dependence on the oil sector, with oil exports constituting over 99% and approximately 85% of the state budget and 42% of the GDP. Furthermore, granting three oil concessions to foreign companies in the Hawizeh, Halfaya, and Majnoon regions reduced the amount of water available for agriculture and contributed to the decline in agricultural production and environmental balance. This was achieved through the construction of six pumping stations on the Tigris River, diverting approximately 60,000 cubic meters of fresh water daily to the PetroChina group of companies to support and enhance oil extraction operations in the region.

According to the report dated September 30, 2025, UNESCO, as part of a program to help resolve the water crisis in Iraq, sought to collaborate with the Iraqi government by establishing several projects to support and encourage initiatives. This included reinforcing memoranda of understanding to regulate cooperation between countries sharing transboundary waters, particularly with Turkey regarding the Tigris and Euphrates rivers. The program also addressed the need to manage potential floods and mitigate drought to ensure equitable water use, develop technical capacities and personnel, and provide technologies to formulate optimal plans for managing surface and groundwater and addressing its scarcity using sound scientific methods(11) .

The Advanced Survey of Hydrogeological Resources in Iraq is considered one of the important projects in this field. The Advanced Survey of Hydrogeological Resources in Iraq (ASHRI1-2)

In a United Nations report issued on July 14, 2024, with the aim of prosperity and stability in Iraq, and through cooperation with local partners and achieving an equitable distribution of transboundary waters, which aims to achieve multiple Sustainable Development Goals, UNESCO partnered with the Food and Agriculture Organization of the United Nations (FAO) to develop water management, improve water use efficiency, and develop and make agricultural work more sustainable. The UNICEF project initiative for water desalination in Sinjar/Nineveh is considered beneficial and positive for improving the social, health, and economic conditions of the region's inhabitants. (12) Given the importance of water management and achieving sustainable development within the framework of the United Nations Sustainable Development Cooperation (SDGCC) roadmap for the period (2025-2029), this can be worked on with the Iraqi government to achieve sustainable development. The program began in July 2024 through public awareness campaigns in the area.

Water quantities for Iraq (2015-2024): 10 million cubic meters



Source: Republic of Iraq/Ministry of Planning/Central Statistical Organization/Water 2024

Fig 1:

The largest quantity of Turkey's water is found in the Tigris and Euphrates basins in eastern Turkey, which constitute 30.4% of Turkey's total surface water. In Iraq, surface water constitutes the largest percentage of the country's water, estimated at 80%, and this water originates from the same surface water in Turkey.

The total amount of water needed to meet Iraq's needs is estimated at 42.56 billion cubic meters annually. The majority of this amount is surface water from rivers, totaling 41.35 billion cubic meters, which is barely sufficient to meet local needs and portends a certain shortage as the population grows in the future. Complicating matters further is Turkey's attempt to reduce the amount of water flowing into Iraq by constructing more dams on the Tigris and Euphrates, which will inevitably lead to real crises between the two countries.

In 1974, Turkey began constructing the Keban Dam on the Euphrates River, part of a larger project known as the Southeastern Anatolia Project (GAP). This project comprises 22 dams: 17 on the Euphrates and 5 on the Tigris. Following this, the Karakaya Dam was built in 1986, and the Atatürk Dam in 1990. With a storage capacity of approximately 48 billion cubic meters, the Atatürk Dam diverts and controls roughly one-third of the Euphrates' water flow. Subsequently, the Birecik and Karakamış Dams were constructed, giving Turkey near-complete control over the Euphrates River's water. As for the Tigris River, Turkey completed in 1997 the Kiral Kizi Dam and the Tigris Dam on the river's tributaries, and the Ilisu Dam, which is one of the large dams on the Tigris River, as it works to reduce the percentage of water flowing towards Iraq to 60%. the amount of water from 20.93 billion cubic meters to 9.7 billion cubic meters annually, and the amount of the Euphrates River was reduced from 29 billion cubic meters to 4.4 billion cubic meters(18) .

Section Four

Agricultural GDP: Iraq's agricultural GDP during the period (2003-2024) witnessed sharp fluctuations in its relative contribution to the Gross Domestic Product (GDP), affected by security shocks, climate change, and excessive reliance on oil revenues. The agricultural sector's contribution reached its relative peak in the period (2003-2004) at nearly 20% of the GDP, followed by a period of decline and oil dominance (2005-2019). The relative importance of agriculture gradually decreased as a result of increased oil revenues, recording 12.6% in 2006, then dropping to 7.1% in 2009. The period (2020-2021) witnessed a remarkable increase in the contribution, reaching 19.9%, compared to 17.8% in the previous year, driven by the economic lockdown conditions and increased interest in local production. The current period (2022-2024) recorded its lowest levels in 2022 at 2.06% as a result of severe drought, and by 2024, the contribution rate reached approximately 3.39%.

Table 1: Time series of wheat and barley production and acreage(2024 - 2003)

Year	Wheat acreage (million dunams)	Wheat production (million tons)	Barley acreage (million dunams)	Barley production (million tons)	Average annual releases (billion m³)	Agricultural GDP (billion dollars)
2003	2.50	0.80	1.85	0.65	65	2.10
2005	4.20	2.10	2.10	0.70	73	2.80
2010	4.90	2.70	2.50	0.82	45 - 55	4.10
2015	5.30	2.65	2.40	0.60	35 - 45	5.40
2019	6.55	4.70	3.50	1.50	93	8.20
2020	9.50	6.23	4.10	1.80	50 - 60	9.10
2021	7.80	4.23	2.80	0.75	30 - 35	7.60
2022	4.50	3.02	1.20	0.25	18 - 20	8.10
2023	6.80	4.24	2.34	0.11	15 - 18	8.35
2024	8.50-9.0	5.23 - 6.0	2.50	1.40	10 - 15	9.49

Source: Ministry of Planning, various annual publication

The table above illustrates fundamental shifts in the Iraqi agricultural sector. This data can be analyzed as follows**:**
Productivity and Area Analysis (Wheat and Barley): Wheat production reached a historic peak in 2020 (6.23 million tons) across 9.50 million dunams. This is attributed to abundant water resources and direct government support**.**
In contrast, barley production declined sharply in 2023, reaching only 0.11 million tons, despite the cultivated area being similar to previous years. This decline is attributed to land-use changes resulting from severe drought. The recovery of wheat production to high levels (reaching 6 million tons) indicates the effectiveness of modern irrigation techniques in addressing water scarcity**.**
Productivity and Area Analysis (Wheat and Barley): 2020 saw a significant decrease in wheat production (6 million tons), reflecting the effectiveness of modern irrigation technologies in mitigating water scarcity. 2. Water Releases: There is a close relationship between water releases and the size of cultivated areas. The drought was clearly evident in 2022, when releases decreased to 18-20 billion m³, leading to a reduction in wheat acreage to 4.5 million dunams. Despite the continued decline in water releases to historically low levels (10-15 billion m³), production maintained its growth. This suggests a shift towards groundwater and increased reliance on artesian wells**.**
Practical Analysis of the Agricultural Production Function under Water Supply Shock:
AGDP: Agricultural GDP
AWATER: Average annual water releases
AREA: Total cultivated area (wheat + barley)

Table 2: Results of the stability (stationarity) test of variables at level I(0) and the first difference I(1) using the ADF test

Test	Transformation	Deterministic Component	AWATER (t / Prob)	AREA (t / Prob)	AGDP (t / Prob)	Significance
PP	Level	Constant	-1.933 / 0.315	-2.411 / 0.145	0.155 / 0.966	n.s., n.s., n.s.
	Level	Constant & Trend	-2.661 / 0.257	-3.140 / 0.110	-3.218 / 0.095	n.s., n.s., *
	Level	None	-1.253 / 0.190	-0.044 / 0.662	2.986 / 0.999	n.s., n.s., n.s.
	First Diff	Constant	-6.549 / 0.000	-6.388 / 0.000	-7.643 / 0.000	***, ***, ***
	First Diff	Constant & Trend	-6.596 / 0.000	-6.311 / 0.000	-7.610 / 0.000	***, ***, ***
	First Diff	None	-6.517 / 0.000	-6.403 / 0.000	-6.403 / 0.000	***, ***, ***
ADF	Level	Constant	-1.933 / 0.315	-1.435 / 0.555	-0.281 / 0.919	n.s., n.s., n.s.
	Level	Constant & Trend	-2.661 / 0.257	-2.616 / 0.276	-3.154 / 0.107	n.s., n.s., n.s.
	Level	None	-1.276 / 0.183	0.381 / 0.789	1.882 / 0.984	n.s., n.s., n.s.
	First Diff	Constant	-6.390 / 0.000	-6.890 / 0.000	-7.109 / 0.000	***, ***, ***
	First Diff	Constant & Trend	-6.331 / 0.000	-6.784 / 0.000	-7.053 / 0.000	***, ***, ***
	First Diff	None	-6.403 / 0.000	-6.906 / 0.000	-6.403 / 0.000	***, ***, ***

*** Significant at 1%
** Significant at 5%
Significant at 10%
n.s. = Not significant
Based on the Unit Root Test (ADF) and PP methods, here is a brief interpretation of the results:

1. At Level
Results: All variables (AWATER, AREA, AGDP) showed probability values greater than 0.05 in most cases (with a constant, and with a constant and a trend). We reject the null hypothesis, meaning that all time series are non-stationary at their original level, they contain a unit root**.**

2. At First Difference
After taking the first difference for the variables, all probability values became 0.000 (less than 1% and 5%). This means we reject the null hypothesis and accept the alternative hypothesis, indicating that the series became stationary after the first difference**.**
All variables (AWATER, AREA, AGDP) are first-order integral variables. Since all variables are stable at the same degree, this means it is possible to perform cointegration to verify the existence of a long-term relationship**.**

Table 3: Estimating the relationship between variables using ARDL

Variable	Coefficient	Std. Error	t-Statistic	Prob.
AGDP(-1)	0.272	0.115	2.366	0.025
AGDP(-2)	0.039	0.139	0.279	0.782
AGDP(-3)	0.070	0.135	0.516	0.610
AGDP(-4)	0.588	0.116	5.087	0.000
AREA	0.194	0.038	5.058	0.000
AREA(-1)	-0.074	0.041	-1.789	0.084
AWATER	0.014	0.005	3.053	0.005
AWATER(-1)	0.000	0.006	-0.058	0.954
AWATER(-2)	0.007	0.005	1.290	0.208
AWATER(-3)	-0.001	0.005	-0.139	0.891
AWATER(-4)	-0.026	0.005	-5.622	0.000
C	0.123	0.250	0.492	0.626
R-squared	0.992			
Adjusted R-squared	0.989			
Mean dependent var	5.637			
S.D. dependent var	2.145			
S.E. of regression	0.224			
Sum squared resid	1.399			
Log likelihood	10.308			
Akaike info criterion	0.085			
Schwarz criterion	0.591			
Hannan-Quinn criter.	0.268			
F-statistic	323.990			
Prob(F-statistic)	0.000			

***Note:** p-values and subsequent test results do not account for model selection effects.

The results of the ARDL(4,1,4) model estimation show a very high explanatory power for the independent variables. The detailed interpretation of the results is as follows:
The coefficient of determination (CID) was 0.992, meaning that the variables (AREA, AWATER) along with the lags explain 99.2% of the changes in agricultural GDP (AGDP), a very high percentage indicating a good fit.
The F-statistic was 323.9 with a significance level of 0.000, confirming the overall significance of the model and its explanatory power.

Analysis of Independent Variables Area:

It has a very significant positive effect in the short term at the (Prob = 0.000) level, where a one-unit increase in area leads to a 0.194 increase in AGDP**.** However, at the first lag, AREA(-1), the effect becomes negative, but with weak significance.(0.08)

Water Resources

It has a significant positive effect at the (Prob = 0.005) level**.** The most prominent effect appears at the fourth lag, AWATER(-4), with a very significant negative value (-0.026), which may indicate that the effects of water consumption or scarcity on agricultural output appear after widely spaced time intervals (4 intervals)**.**
The model chosen according to the Akaike criterion (AIC) is ARDL(4, 1, 4). The results indicate that cultivated area is the strongest driver of agricultural output in the short term, followed by water resources, whose effect fluctuates over time.

Table 4:

Variable / Statistic	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ*	-0.032	0.003	-9.826	0.000
D(AGDP(-1))	-0.696	0.105	-6.613	0.000
D(AGDP(-2))	-0.657	0.109	-6.044	0.000
D(AGDP(-3))	-0.588	0.101	-5.807	0.000
D(AREA)	0.194	0.032	5.979	0.000
D(AWATER)	0.014	0.004	3.302	0.002
D(AWATER(-1))	0.020	0.004	4.754	0.000
D(AWATER(-2))	0.026	0.004	6.595	0.000
D(AWATER(-3))	0.026	0.004	6.100	0.000
R-squared	0.874			
Adjusted R-squared	0.842			
Mean dependent var	0.176			
S.D. dependent var	0.534			
S.E. of regression	0.212			
Sum squared resid	1.399			
Log likelihood	10.308			
Akaike info criterion	-0.065			
Schwarz criterion	0.315			
Hannan-Quinn criter.	0.072			
F-statistic	26.891			
Prob(F-statistic)	0.000			
Durbin-Watson stat	1.237			

The table above represents the Error Correction Model (ECM) derived from the ARDL methodology. The error correction limit (COINTEQ*) was valued at -0.032, resulting in a statistically significant negative sign (0.000). This indicates a long-term cointegration relationship between the variables.

This value is interpreted to mean that 3.2% of the short-run imbalance in agricultural output (AGDP) is corrected in each time period to return to the long-run equilibrium path. (This rate is relatively slow, meaning that the return to equilibrium takes time.)

Short-Run Dynamics:

Change in Area (D(AREA)): This has a strong and significant positive effect (0.194), meaning that an immediate expansion in area directly increases output in the same period.

Change in water (D(AWATER)): The results show that water has a very significant and positive cumulative effect, with the effect persisting strongly from the current period until the third slowdown (coefficients range between 0.014 and 0.026). This means that water availability not only stimulates production now, but its positive effect extends to several subsequent periods.

Table 5:

Null hypothesis: No levels relationship	
Number of cointegrating variables: 2	
Trend type: Rest. constant (Case 2)	
Sample size: 40	
Value	**Test Statistic**
21.80010664762967	F-statistic

Table 6:

1%		5%		10%		
I(1)	**I(0)**	**I(1)**	**I(0)**	**I(1)**	**I(0)**	**Sample Size**
6.028	4.948000000000001	4.335	3.478	3.623	2.845	35
5.855	4.77	4.26	3.435	3.585	2.835	40
5	4.13	3.87	3.1	3.35	2.63	Asymptotic
* I(0) and I(1) are respectively the stationary and non-stationary bounds.						

Since the F-statistic value (21.80) is significantly larger than the upper limit critical value at all significance levels (1%, 5%, 10%), we reject the null hypothesis, which states that there is no relationship, and accept the alternative hypothesis, which confirms the existence of a long-run equilibrium relationship between agricultural output (AGDP), area (AREA), and water (AWATER). This demonstrates that the variables do not diverge from each other in the long run and that they move together in a stable equilibrium path. This fully justifies your use of the ARDL model and the error correction (ECM) results, which showed the significance of COINTEQ in the previous table.

Table 7:

Long-term equation				
Variable *	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
AREA(-1)	3.789	3.561	1.064	0.294
AWATER(-1)	-0.179	0.165	-1.089	0.283
C	3.890	7.269	0.535	0.596

Area variable (AREA): Coefficient (3.789): Indicates a positive relationship, but it is not statistically significant.

Reason: The Prob value is 0.294, which is much greater than the usual significance level (0.05). This means that the effect of area on the dependent variable is not statistically significant in the long run.

Water variable (AWATER):

Coefficient (-0.179): Indicates an inverse relationship, but it is also not statistically significant.

Reason: The Prob value is 0.283, which is greater than 0.05. Therefore, this variable cannot be relied upon to explain long-term changes.

Table 8:

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
Null hypothesis: Homoskedasticity			
0.791538757734311	Prob. F(11,28)	0.625775460841449	F-statistic
0.7228414718494082	Prob. Chi-Square(11)	7.893157665625856	Obs*R-squared
0.9831261647186482	Prob. Chi-Square(11)	3.460995124348397	Scaled explained SS

The model does not suffer from heteroskedasticity.

Statistical justification:

Null hypothesis ( ): states that the variance is homoskedastic.

Prob value: We observe that the values of Since these values are greater than 0.05 (significance level 5%), we accept the null hypothesis and reject the alternative hypothesis.

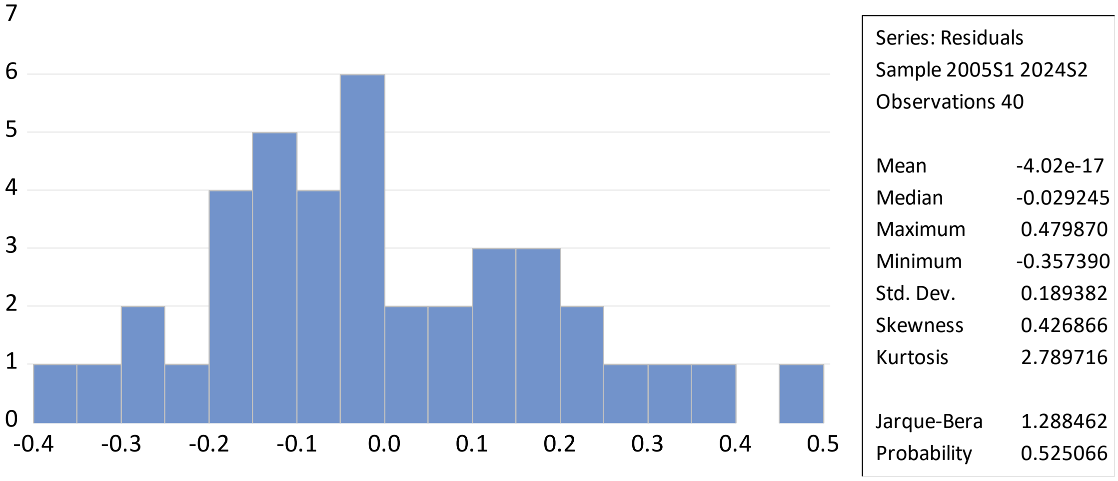


Fig 2:

The residuals follow a normal distribution, meaning your standard model passes one of the most important efficiency tests**.**
Jarque-Bera test: The test value is 1.288, and the corresponding probability value is 0.525**.**
Statistical basis: Since the probability value (0.525) is much greater than the significance level of 0.05, we accept the null hypothesis that "the residuals are normally distributed.".

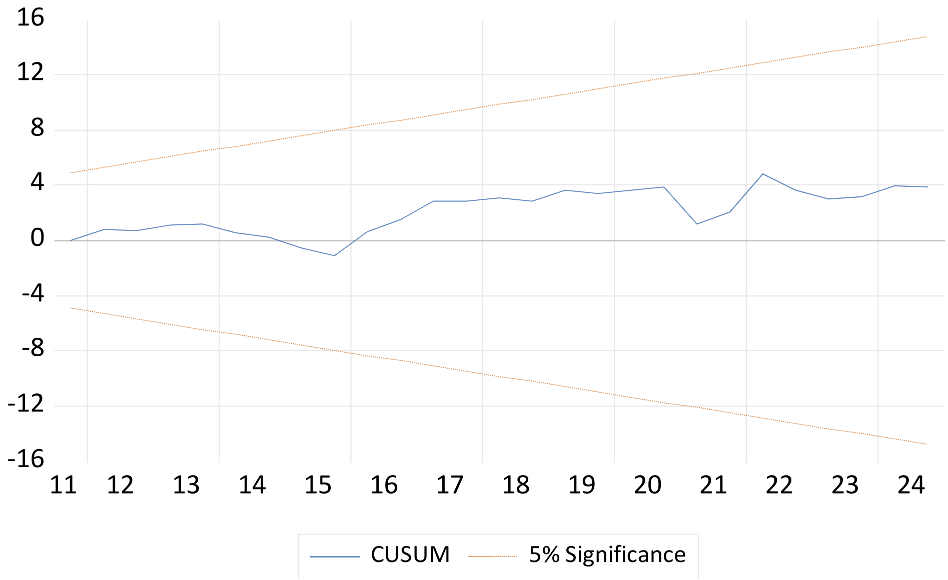


Fig 3:

Your standard model is statistically stable over time at a 5% significance level**.**

1. CUSUM line (blue): This represents the sum of the cumulative deviations of the residuals. Note that this line lies entirely within the critical boundary (red dotted lines)**.**

2. Critical boundary (5% significance): As long as the blue line does not cross or deviate from this boundary, it means there are no sudden structural changes in the model's coefficients during the study period**.**

3. Conclusion: The parameters you estimated in the "long-run equation" are constant and stable, and the model is valid for forecasting and policy decision-making**.**

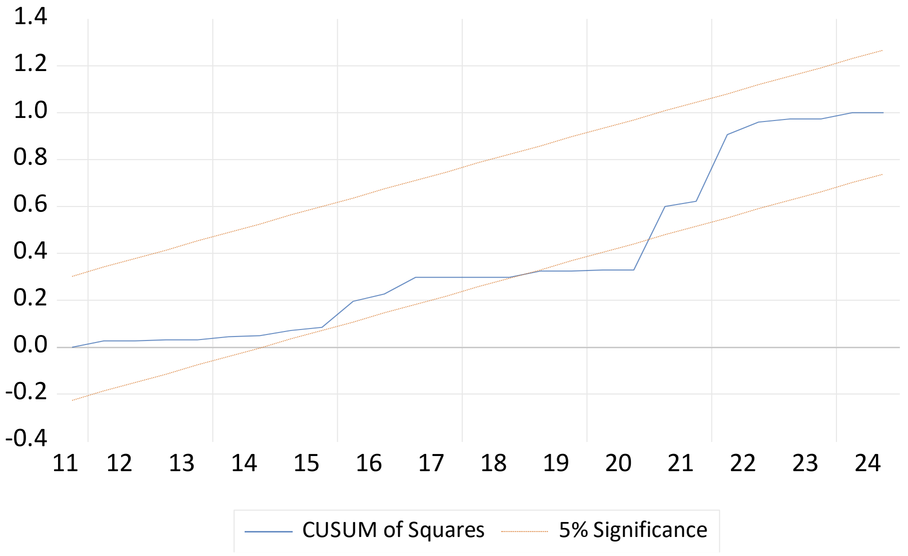


Fig 4:

The model is perfectly stable, and the equation parameters exhibit structural stability throughout the study period.

Path (solid line): This represents the sum of the cumulative squared deviations of the residuals. We clearly observe that this path lies entirely within the critical boundaries (dotted lines) at a significance level of 5%.

Absence of structural break: As long as the line remains within the boundaries, this confirms the absence of any "shocks" or sudden, unexplained changes in the model's variance over time.

Integration with the previous test: The test (which I sent previously) confirmed the stability of the "mean," while this test confirms the stability of the "variance".

Conclusions

There is a decline in agricultural production and a decrease in yield. Given that most agriculture relies on surface water, the reduction in water allocations will naturally affect the size of cultivated areas and the reality of agriculture and agricultural production, especially for major water-dependent crops such as wheat and rice, which are the subject of this study.

The shortfall in wheat and rice production must be compensated for through imports to meet local needs. This places an additional burden on the state budget by requiring the transfer of more hard currency, which should not be the case.

The failure to meet local needs through domestic production means a lack of self-sufficiency and is a negative step towards potentially threatening food security in an unstable international environment and the possibility of local wars.

The reduction in the agricultural workforce due to the shrinking of cultivated land indicates a decline in the overall employment level and lower income levels for many poor families engaged in agriculture. This, in turn, indicates rising unemployment levels. The spread of poverty and the decline in the standard of living for citizens.

Demographic change through population migration under the pressure of water scarcity, forcing them to seek new places of settlement that are not without economic and social problems and create an environment conducive to security violations.

A good agricultural environment and abundant water create a suitable climate for a natural, integrated life and an ecological chain of plants, animals, and humans. This will contribute to ensuring the preservation of soil from erosion and moderating temperatures through agricultural activity and vegetation cover during the summer.

The abandonment and migration of vast areas of arable land at an increasing rate makes them vulnerable to desertification and erosion due to the scarcity of water and the general drought afflicting the region.

The water problem between Iraq and Turkey is not without a political dimension. Turkey and the Zionist entity have ambitions to expand and control the resources of neighboring countries. Therefore, they use water control as a tool of pressure and blackmail, devoid of international regulations and respect for good neighborliness.

Despite Iraq's need for more water, it is observed that quantities of water are wasted through the Shatt al-Arab. Arabs to the Gulf.

A significant shrinkage of the marshes and their water bodies, rich in livestock and fish, and a stopover for migratory birds, is occurring. These areas are facing drought and desertification due to the substantial decrease in water flowing into them, endangering the environment and the lives of the inhabitants.

Recommendations

Intensive efforts should be made to negotiate with the Turks to sign binding agreements guaranteeing a sufficient water share to meet the needs of the agricultural sector and all other requirements.

Specialized committees should be tasked with studying and rehabilitating existing dams within the country, whether through repair, restoration, or the construction of new dams. Additionally, the existing lakes should be expanded, rehabilitated, and maintained to store excess water during periods of heavy rain and flooding.

Negotiating delegations should be instructed to utilize the principles of trade balance between Iraq and Turkey during negotiations and not to separate the scarcity of water flowing from Turkey from the large volume of Turkish trade with Iraq.

Programs should be developed to educate farmers on proper farming and irrigation methods, including providing sprinkler irrigation equipment for water conservation purposes, which was previously implemented. Irrigation using the old method of flooding leads to water seepage into the soil and increased salinity.

Utilizing abandoned agricultural lands by encouraging investment and other means. These lands have been left uncultivated due to drought and water scarcity. Emphasis should be placed on protecting them from erosion and salinity through afforestation, the construction of windbreaks, or the planting of self-sustaining trees.

Providing grants, subsidies, and loans with nominal interest rates to farmers and low-income citizens to revitalize and cultivate the land, particularly for residents of these areas, thereby reducing migration.

Conducting a geological survey of abandoned agricultural lands through specialized committees to identify groundwater reserves. Following this, artesian wells should be drilled to stimulate agriculture, as is being done in the Samawah desert and the Najaf desert.

Working to stop the large quantities of water flowing from the Shatt al-Arab into the Gulf. This can be achieved through plans and programs to capture this water or divert its course for various uses.

Promoting a culture of crop diversification. The focus should be on moving away from traditional varieties and supporting the cultivation of drought-, heat-, and salinity-tolerant varieties that require minimal water. The rice research station in Al-Mishkhab serves as a successful example, having successfully cultivated two rice varieties using modern irrigation methods and innovative techniques.

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