



Measuring the Impact of Policies and Some Environmental Constraints on the Agricultural Sector in Iraq for the Period (1990-2024): (Wheat Crop as a Case Study)

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Abstract

This study aims to measure the impact of policies and some environmental constraints on wheat production in Iraq during the period (1990-2024). The study focuses on the role of Agricultural policies, including environmental policies, in addressing the environmental and climatic challenges that hinder the growth of the Agricultural sector, particularly wheat production in Iraq. The study relies on annual data issued by the Ministries of Agriculture, Planning, Trade, and Water Resources, as well as the Food and Agriculture Organization of the United Nations (FAO). The FAO Analyzed the data using Eviews 12 software and the Fully Modified Least Squares (FMOLS) methodology. The results showed an explanatory power with a coefficient of determination ($R^2=0.886$). They revealed a negative impact of certain environmental constraints. Specifically, a 1.5°C increase in temperature and a 30% decrease in rainfall during the period 1990-2024 exacerbated desertification's, environmental degradation, and a decline in cultivated areas and productivity. Regarding pricing policy, a direct relationship was found between domestic prices and agricultural production; a one-unit increase in price led to a 1.68-unit increase in production. The use of modern technologies contributed to the growth of the agricultural sector and the achievement of sustainable development. The study recommends adopting policies aimed at addressing environmental pollution and utilizing modern technologies to enhance food security.

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Introduction

The agricultural sector in Iraq, particularly wheat as an essential staple crop, faces environmental challenges such as rising temperatures, decreased rainfall, and pollution resulting from the excessive use of chemical fertilizers and pesticides. These factors have led to soil fertility degradation and groundwater contamination, negatively impacting crop growth in response, environmental policies aim to address these challenges [1] by introducing smart technologies such as sensor-based irrigation systems supporting and funding research to reduce CO₂ emissions, and protecting water resources from general waste, all to ensure sustainable production and achieve self-sufficiency [2].

Economically, modern technologies, environmental, and pricing policies play a central role in resource allocation. Their objectives are reduce environmental pollution, minimize price gaps, and production costs, thereby encouraging farmers and protecting consumers from market fluctuations and the harms of pesticides, while ensuring the crop is available at affordable prices.

Locally, the water crisis is one of the most severe environmental constraints. The inflows of the Tigris and Euphrates rivers have declined by more than 50% due to upstream countries’ policies and dam construction, resulting in drought and causing Iraq to lose large areas of arable land because of soil salinity and erosion.

At the Arab level, countries such as Egypt, Iraq, and Morocco have recently made significant efforts by adopting modern irrigation technologies (such as pivot and fixed irrigation systems), which help reduce water consumption, and by developing scientific research programs to cultivate improved, pest- and disease-resistant seed varieties. Additionally, they are working to develop pricing policies aimed at providing production inputs at the lowest possible cost to achieve sustainable development [3].

Environmental Policy

Agricultural environmental policy is defined as a set of regulations and laws established by public institutions to protect the environment and improve resource quality. Its aims are [4]:

- 1- Reducing pollution levels
- 2- Minimizing the impact of climate change on the agricultural sector (wheat)
- 3- Preserving natural resources (soil, water, air)
- 4- Ensuring sustainable production

Agricultural Water Policy to Address the Water Crisis and Develop the Agricultural Sector

To increase the productivity of the agricultural sector, it is necessary to use a water policy that works to reduce the water crisis through smart irrigation systems and automated control (modern technologies), via: -[5]

- 1- Fixed irrigation systems and moisture sensors: Fixed irrigation systems can deliver water directly to the roots and provide gradual watering. Moisture sensors measure the amount of water in the soil and root zones, with the data sent wirelessly to mobile applications, helping to increase production.
- 2- Weather monitoring and proper irrigation: Water evaporation can be minimized and water loss prevented using an IoT system connected to control units and a dashboard linked to (4G/NB-IoT) networks that monitor the weather and automatically operate pumps remotely via mobile app controls.
- 3- Sprinkler irrigation systems and laser leveling: These are similar to rain using sprinklers or water guns that push water over a long distance. As for laser leveling, it uses large equipment like graders and a laser receiver to level the soil with very high precision. This leveling helps distribute water evenly, reducing loss and increasing fertilizer efficiency.

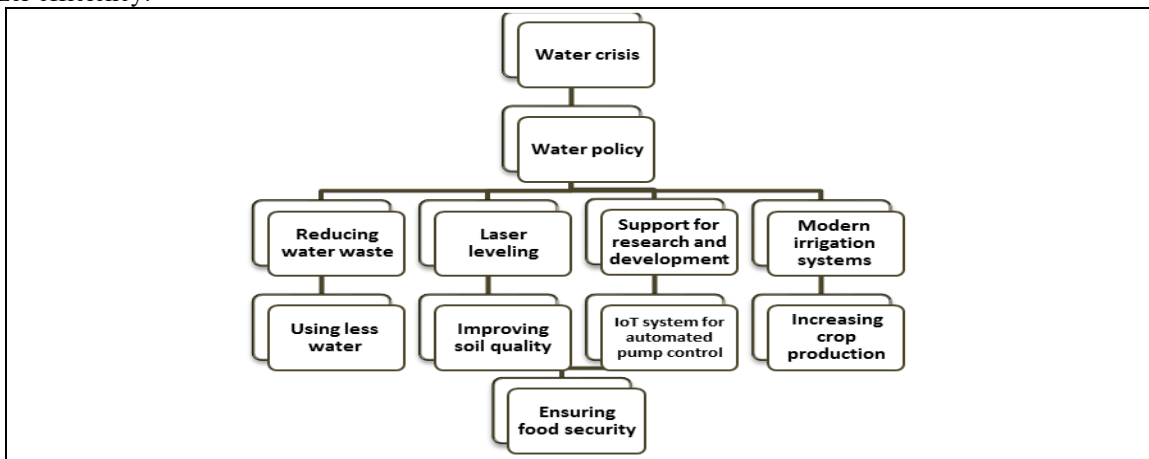


Diagram 1. Contribution of agricultural water policy in addressing the water crisis

Note: Prepared by the researcher based on the explanation above

Climate Policy:

These are strategic actions taken by governments in institutions (both public and private) to find solutions that reduce the impact of climate fluctuations and greenhouse gas emissions on crops by [6]: increasing green spaces (forests) and protecting them from illegal logging,

- 1- using clean energy sources (solar and wind) to reduce gas emissions,
- 2- activating an early warning system to avoid risks and uncertainties for agricultural lands,
- 3- enforcing environmental laws and regulations to protect natural resources and ensure them sustainably.

(Climate Impact Index: SCII)

The Climate Impact Index (CII) is an index used to analyze the effect of climate changes on the agricultural economy. This index is divided into [7]:

- 1- Climate Change Performance Index (CCPI): This index evaluates the EU countries by giving weighted percentages, for example, (Greenhouse gases 40%, Climate policy 20%, Renewable energy 20%, and Energy consumption 20%), making the total 100%. This index was issued by the organization Germanwatch [8].
- 2- Climate Risk Index (CRI): This index is used to measure the extent of damage that climate change causes to the human economy. For instance, if temperatures rise by 1%, productivity decreases by 0.1%. It shows the direct relationship between heat and productivity [9].

Materials And Methods

Data sources and study period

The study relied on annual secondary data for the period 1990-2024.

The analytical and econometric aspects of this study relied on primary data collected from ministries, government sectors, and official statistical reports related to the subject, including:

- Ministry of Planning (Central Organization for Agricultural Statistics) [10].
- [11] Ministry of Planning. (2023). Environmental statistics for Iraq: Natural conditions and geographic characteristics. Central Statistical Organization, Republic of Iraq.
- Ministry of Agriculture (Agricultural Meteorological Center) [12].
- Ministry of Water Resources (Tigris and Euphrates River Project Departments) [13].
- Ministry of Transportation (General Authority for Meteorology and Seismology) [14].
- Ministry of Trade (State Company for Grain Trade) [15].
- Food and Agriculture Organization of the United Nations [16].

Productivity was calculated by dividing total production (tons) by the cultivated area (dunams). The annual average temperature was determined by taking the mean of the highest and lowest recorded temperatures.

Statistical Population Size:

The study focused on the entire statistical population (number of observations) in the time series analysis, covering the period from 1990 to 2024, providing 34 annual observations for econometric analysis. No selective sampling method (such as surveys) was used.

Econometric Approach Used:

The study employed modern econometric techniques, including:

1. Unit root tests: Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP)
2. The Fully Modified Ordinary Least Squares (FMOLS) model
3. The use of Eviews 12 software for econometric analysis

Animal Ethics Approval

Not applicable. The study used only secondary time-series data from official institutional sources and did not involve humans or experimental animals.

FMOLS Model (Fully Modified Ordinary Least Squares) [3]:

This model is used to estimate the long-term relationships between variables that are integrated of order one, I (1), for a sample size of 35 observations covering the period from 1990 to 2024.

The model is applied to describe and estimate the impact of pricing policies and certain environmental constraints on the development of the agricultural sector, specifically focusing on wheat as a strategic crop in Iraq during the period 1990–2024.

The effect of pricing policies and some environmental constraints on wheat production was estimated using the variables listed in the model, in a linear form, over the study period (1990–2024):

$$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + B_6X_6 + B_7X_7 + B_8X_8 + B_9X_9 + B_{10}X_{10} + U_i$$

Where the variables are defined as follows: Y: Quantity of production (tons)

- X₁: Domestic price of wheat (Dinar/ton).
 X₂: Border price of wheat (Dinar).
 X₃: World price of wheat (USD/ton).
 X₄: Price of substitute commodity barley (1,000 Dinar).
 X₅: Cultivated area (dunam).
 X₆: Yield per unit area (kg/dunam).
 X₇: Imported quantities (tons).
 X₈: Population (million people).
 X₉: Average annual temperature (°C).
 X₁₀: Average annual rainfall (mm).

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Result And Discussion

Unit Root Tests:

Before estimating the FMOLS model, unit root tests were conducted using both the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests to examine the stationery of the time series. The results indicated the existence of a long-term relationship between production and the explanatory variables.

As shown in the table below, three variables were found to be stationary at level I (0): the border price of wheat (X₂), the cultivated area (X₅), and the average rainfall (X₁₀). According to the Phillips-Perron test, the border price (X₂) was stationary at the level (-3.136), while in the Dickey-Fuller test it was (-3.172). For the cultivated area (X₅), the Phillips-Perron test value was (-3.740) and the Dickey-Fuller test value was (-3.741). The average rainfall (X₁₀) was stationary at (-4.446) in the Phillips-Perron test and (-4.421) in the Dickey-Fuller test. The other eight variables were not stationary at level but became stationary after taking the first difference

Table 1. Unit Root Test Results

Degree of Integration	PP Test		ADF Test		Variable
	First Difference	Level	First Difference	Level	
I(1)	-9.058*	-1.346	-7.098***	-1.519	Y
I(1)	-6.256*	-0.364	-6.256*	-0.364	X1
I(0)	-8.393*	-3.136	-7.791*	-3.172	X2
I(1)	-5.714*	-2.162	-5.393	-2.120	X3
I(1)	-3.838*	-1.089	-3.837*	-1.257	X4
I(0)	-8.700*	-3.740	-8.573*	-3.741	X5
I(1)	-7.288*	-1.242	-5.470*	-1.420	X6
I(1)	-7.822*	-2.274	-7.050*	-2.274	X7
I(1)	-4.941*	2.218	-4.938*	1.884	X8
I(1)	-6.384*	1.193	-6.374*	0.853	X9
I(0)	-12.800*	-4.446	-5.769*	-4.421	X10

Source: Prepared by the researcher based on the outputs of Eviews12.

Note: a: (*) Significant at the 10% level, B: (**) Significant at the 5% level.

C: (***) Significant at the 1% level, No: Not significant.

Normality Test

The graph below illustrates the distribution of the residuals for the period (1990–2024). Residuals are defined as the difference between the actual value of the variable and its predicted value in the statistical model. The model is considered ideal when the residuals are close to zero. The X-axis represents the residual values, which range from (-1,000,000) to (+1,000,000), while the Y-axis represents the number of observations, totaling 34. Most of the residuals are distributed between (-500,000) and (+500,000) and are close to zero, with only a few residuals exceeding (+500,000) or falling below (-500,000). This indicates that the actual values are close to the predicted values, as evidenced by the peak around zero.

- **Mean:** The average of the residuals is (-32,433.98), indicating that the model tends to slightly underestimate the actual values overall.

- **Median:** The median value is (20,149.61), which is close to zero, meaning that half of the residuals are above this value and the other half are below it.
- **Standard Deviation:** The standard deviation is (402,289.2), showing that the residuals are widely dispersed around the mean.
- **Skewness:** The skewness value is (-0.294795), indicating that the distribution of residuals is slightly skewed to the left due to some large negative values.
- **Kurtosis:** The kurtosis is (4.596382), suggesting that the distribution of residuals is more peaked than the normal distribution and that some outlier values exist.
- **Jarque-Bera Test:** The value is (4.102741) with a probability (prob) of (0.128559), indicating that the distribution of residuals is approximately normal.

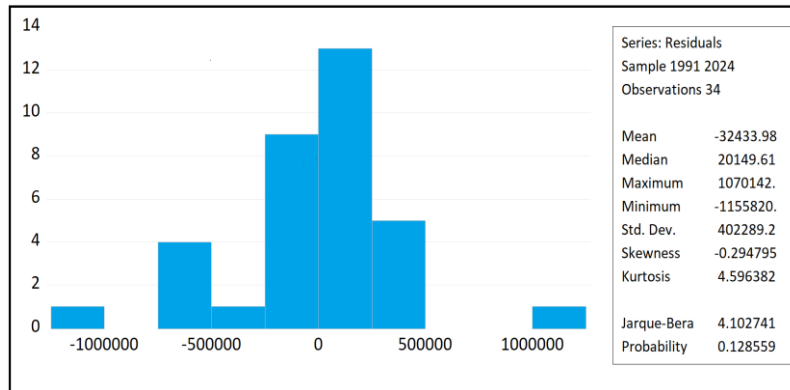


Figure 2. Residual Plot for Model Quality Assessment and Detection of Estimation Issues.

Source: Prepared by the researcher based on the outputs of Eviews12.

FMOLS Estimation Results

The results of the FMOLS model estimation showed that the coefficient of determination (R^2) is 0.885938, meaning that 88.6% of the variations can be explained by the model, while 11.4% are due to external variables not included in the model indicating the strength of the model. The adjusted coefficient of determination (R^2_{adj}) is 0.836346 ($R^2_{adj} = 0.848$ after adjusting some of the independent variables), further confirming the model’s quality.

The mean absolute deviation between actual and predicted values was $S.E = 483,482.6$, reflecting the prediction accuracy. The mean of the dependent variable (Y) was calculated at 2,402,575, with a standard deviation (S.D) of 1,195,135. The sum of squared differences was 5.38, representing the total squared differences between actual and predicted values.

The long-term variance, used to calculate standard errors corrected for autocorrelation and heteroskedasticity, was 4.01 overall, the model demonstrates very strong explanatory results and is highly suitable for the data.

Table 2. FMOLS Model Estimation Results for the Wheat Production Function

Probability	t-Statistic	Standard Error	Coefficient	Variable
14282037	2905923	4.914801	0.0001	C: Constant
1.675893	0.512544	3.269758	0.0034	X1: Domestic price
0.845514	0.380698	2.220956	0.0365	X2: Border price
294.308	1173.234	0.250852	0.8042	X3: World price
-5.339021	0.895459	-5.962331	0	X4: Barley price
0.320948	0.025965	12.36096	0	X5: Area
4774.293	414.2285	11.52575	0	X6: Productivity
0.09314	0.051208	1.818861	0.082	X7: Imported quantity
348803.8	53228.2	6.552989	0	X8: Population
-962026.7	155184.7	-6.199235	0	X9: Temperature
2659.107	860.9002	3.088752	0.0052	X10: Rainfall rate

Source: Prepared by the researcher based on the outputs of Eviews12.

Model Quality Indicator: $R^2=0.886, R^2_{adj} = 0.848$ S.E= 483.483, S.D= 1195135, Mean Var = 2402575, Sum Squared=5.38, Long-run variance = 4.01

Conclusion

1. The results indicate that certain environmental constraints, such as rainfall and rising temperatures, play a decisive role in determining production levels in the agricultural sector.

2. The ability for horizontal expansion (cultivated area) demonstrates a direct relationship (for the coefficients). Environmental policy has contributed to smart expansion through improved water management using sprinkler systems and modern irrigation technologies.
3. Investment in scientific research and the use of modern technology have a significant impact on both horizontal and vertical expansion.
4. The agricultural sector, especially wheat production, is affected by population size. An increase of one unit in the population leads to higher local demand for wheat. Meeting this increased demand requires providing local production inputs at lower prices to meet population needs and achieve sustainable development.
5. There is a weak correlation between the domestic price and the world price, which suggests that an independent agriculture policy focusing on environmental sustainability is being implemented, unaffected by global fluctuations.
6. There is a substitution relationship between wheat and barley, making agricultural diversification through the implementation of environmental policies essential. Such policy support farmers and encourage crop diversification to maintain soil health and ensure sustainable production.

Conflict Of Interest

The authors declare that there are no conflicts of interest related to this manuscript.

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References

1. **Sharaf, H. A.**, The role of environmental tax in establishing the environmental dimension of sustainable development. *University of Future Journal*, (2024). 12(2), 45-67. <https://doi.org/10.37092/ufj.v12i2.2024>
2. **Kim, J., Kim, S., Ju, C., & Son, H. I.**, Unmanned aerial vehicles in agriculture: A review of methodologies of control, planning, and application. *IEEE Access*, (2021). 9, 1-15. <https://doi.org/10.1109/ACCESS.2021.3050001>
3. **Jassim, R. M., & Hamad, A. G.**, Measuring and analyzing the impact of some macroeconomic variables and political stability on economic growth: An applied study using long-term estimation models. *Iraqi Journal of Economic Sciences*, (2025). 19(4), 45-60. <https://doi.org/10.31272/ijes.v19i4.2025>
4. **Sayari, N., & Jabali, H.** Smart agriculture: The future option towards development agricultural and enhancing food security. *Journal of Economic and Human Development*, (2023). 14(1), 1-20. <https://doi.org/10.37128/jehd.v14i1.2023>
5. **AL-Fellahin, A., et al.** An AI-driven precision irrigation framework for enhanced water efficiency in Iraqi agriculture. *Tikrit Journal for Agricultural Sciences*, (2025). 25(1), 12-25. <https://doi.org/10.25130/tjas.v25i1.2025>
6. **Venkatramanan, V., et al.** Global climate change and environmental policy: Agriculture perspectives. Springer Nature. (2020). <https://doi.org/10.1007/978-981-15-0690-1>.
7. **Letcher, T.**, Indicators of climate change. Elsevier Science. (2025).
8. **Mohammed, A. S., & Al-Rubaye, M. A.**, Integrating satellite and climate data for crop yield prediction: Spatiotemporal analysis and neural network based model. *Journal of Al-Qadisiyah for Computer Science and Mathematics*, (2024). 16(2), 1-18. <https://doi.org/10.29304/jqcm.2024.16.2.1402>.
9. **Ali, H., & Sadiq, E.**, An economic study on the impact of climate change on wheat crop productivity in Egypt. *Journal of Advances in Agricultural Research*, (2023). 28(2), 387-402. <https://doi.org/10.21608/jalexu.2023.195432>.
10. **Ministry of Planning.**, *Agricultural machinery statistics report*. Central Statistical Organization, Republic of Iraq. (2024a).
11. **Ministry of Planning.** Wheat crop production report in Iraq for 2024. (2024b). Statistics and Geographic Information Systems Authority, Republic of Iraq.
12. **Ministry of Agriculture.** *Iraqi agricultural meteorological extension center annual reports (1990-2024)*. Planning and Follow-up Department, Republic of Iraq. (2024).
13. **Ministry of Water Resources.** *Annual water resources reports (1990-2024)*. Tigris and Euphrates River Projects Departments, Republic of Iraq. (2024).
14. **Ministry of Transportation.** *Climate data records (1990-2024)*. General Authority for Meteorology and Seismic Monitoring, Republic of Iraq. (2024).
15. **Ministry of Trade.** *Annual trade statistics (1990-2024)*. General Company for Grain Trade, Planning Department, Republic of Iraq. (2024).
16. **Food and Agriculture Organization (FAO).** *Agriculture statistics database*. (2024). <http://www.fao.org>