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Environmental and climate changes and their effects on the agricultural sector in Iraq

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Abstract:

Purpose: The objective of this study was to aims to highlight the economic impacts of environmental and climate changes on both developed and developing countries, with a specific focus on Iraq's agricultural sector

Theoretical framework: The research dealt with environmental and climate changes and their effects on the agricultural sector in Iraq. The research problem revolves around the economic challenges facing Iraq, which revolve around the challenges of environmental and climate change, which exacerbate the problem of desertification, drought, and lack of water resources.

Design/methodology/approach: The researcher adopted the deductive approach and the analytical descriptive approach to study environmental and climate changes as experiences for selected countries in order to reach analyzes and conclusions related to them. The period (2004-2022) was chosen because this period witnessed confrontation with environmental and climate changes and the worsening of carbon emissions, global warming, desertification, and drought in Many countries of the world, including Iraq.

Findings: Environmental and climatic changes have a direct impact on the agricultural sector in Iraq, particularly amidst the challenges facing the global economy and food security. These changes pose an increasing threat to agricultural sectors worldwide, including in developing and Arab countries.

Research, Practical & Social implications: We propose a future research agenda and highlight environmental and climate changes and their impacts on the agricultural sector in Iraq.

Originality/value: The results indicate that the number of publications that addressed the impacts of environmental and climate change and their impacts on the agricultural sector.

Keywords: Environmental and climate change, Agricultural Sector, Desertification.

JEL Classification: M10, M12, M15, M19.

Authors' individual contribution:

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1. Introduction:

Over the past two decades, rapid growth in adaptation responses to climate change has occurred worldwide (Owen, 2020). During the past century, global climate change has entailed rising temperatures, heat waves, droughts, increasing precipitation, storms, and flood risk (Agovino et al., 2019) (Adamu & Negeso, 2020). Climate change is significant changes in the average values of meteorological elements, such as precipitation and temperature (Malhi et al., 2021). Precipitation is a key parameter in the context of climate and weather, and it is a major component of the hydrological cycle (Mekis et al., 2018). The changes in rainfall and temperature responsible for climate change will impact agricultural productivity heterogeneously (Prado Tanure et al., 2020). In developing countries, agriculture is the principal source of income for rural inhabitants and the most prominent feature of land use (Shiferaw et al., 2014). Furthermore, it is a mainstay of their economy and contributes to GDP (Keshavarz & Karami, 2014). It is widely recognized that climate change can potentially induce environmental catastrophes, such as ecosystem collapse (Lloyd & Shepherd, 2020). The reality of climate change is already evident, as demonstrated in more extreme weather events such as heat waves, heavy downpours, flooding, and droughts that threaten human health, well-being, livelihood, food, and water supply (Steg, 2023) (Clayton, 2020). Climate change has been described as the biggest global health threat of the 21st century (Beggs, 2021). There is now global concern about the damage to the ecosystem caused by climate change (Hou & Wang, 2021). In 2018, the US National Climate Assessment concluded that the "earth's climate is now changing faster than at any point in the history of modern civilization, primarily because of human activities (Dietz et al., 2020). Agriculture has been affected by three main factors, agricultural stress factors, which simultaneously affect plants: Desertification, global warming, and soil salinity (Zandalinas et al., 2021) (Mohammed, 2024). Desertification is one of the greatest environmental problems, affecting approximately one-fifth of the world's population and 25% of global terrestrial land (Ma et al., 2021). One major symptom of desertification is undoubtedly land degradation, and the driving forces are human activities and climate variation (Becerril-Piña & Mastachi-Loza, 2021). Global warming and climate change refer to the increase in average global temperatures due to the increase in greenhouse effect by the increase in greenhouse gases (Sivaramanan, 2015). Human and natural forces are drivers of global warming, resulting in temperature and rainfall variability (Berlie, 2018). The capacity of plants to adapt to the direct and indirect consequences of climate change will influence extinction risks, agricultural and environmental sustainability, and food security (Anderson & Song, 2020). However, agriculture is vulnerable to climatic risks and the negative consequences of anthropogenic climate change (Karimi et al., 2021). For instance, climate change has increased the frequency and intensity of drought events (Keshavarz et al., 2013). Climate change has increased the uncertainty in production and vulnerability in the agricultural sector worldwide (Ajay et al., 2022). Agriculture is one of the most land-intensive sectors worldwide, and the sector not only contributes to but is also influenced by climate change (Mutua & Goda, 2021). The debate about the consequences of climate change has become a dominant part of international political discourse about the future of armed conflict (Gleditsch, 2021). The agricultural sector is the sole sector to meet the food demand of people, provide raw materials to industries, create employment for agricultural laborers, and gives fodder to livestock (SINGH et al., 2022). Due to increased crop water usage and aridity, required water for food production may become deficient. Certain areas will become climatically inappropriate for production (Herlina et al., 2021). The effects of climate change on agriculture are a major area of concern (Anekwe et al., 2023). The research dealt with environmental and climate changes and their effects on the agricultural sector in Iraq. The research problem revolves around the economic challenges facing Iraq, which revolve around environmental and climate change, which greatly exacerbate the problems of desertification, drought, and lack of water resources.

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The importance of the research comes from the fact that it sheds light on environmental and climate changes and their economic impacts on the agricultural sector, which could affect food security in Iraq, noting that environmental and natural factors, in addition to external factors, have led to increasing amounts of agricultural imports to meet the growing local demand. The research aims to Highlight environmental and climate changes affecting the economies of developed and developing countries. Moreover, identifies environmental changes and their economic impacts and impacts on the agricultural sector in Iraq.

2. Literature Review and Hypothesis Development:

Iraq as a country is now suffering from Climate Change Impacts in similar or even worse ways than many other countries. The manifestations of these climate changes are being felt in global warming, changes to weather driving elements and sea level rise (Adamo et al., 2018). A study (Herlina et al., 2021) indicated that dramatic weather events associated with climate change led to a sudden decline in the total output of the agricultural sector. A study (Liu et al., 2020) indicated that climate is essential in agricultural production, and climate change certainly affects agriculture. Climate change has already negatively affected the economic growth and development of the agricultural sector (Habib-ur-Rahman et al., 2022). In the study (Wickramasinghe et al., 2021), the focus was on developing a framework to assess and map the vulnerability of the agricultural sector in Sri Lanka to climate change. The results confirmed a long-term relationship between agricultural productivity and climate change variables (Ozdemir, 2022). Descriptive results in the study (SINGH et al., 2022) indicate that agricultural sustainability was positively related to economic efficiency, social justice, and environmental security. A study (LADRERA & CAGASAN, 2022)also indicated that climate change is expected to decrease agricultural productivity. A study conducted by (Ashraf et al., 2022) indicated that climate change is one of the factors most affecting agricultural production, and its impact has increased rapidly. It also affected the production of major crops such as cotton, wheat, maize, rice, and sugarcane in Pakistan. In recent years, the adverse effect of climate change on soil properties in the agricultural sector has become a dreadful reality worldwide (Bibi & Rahman, 2023). A study (Anh et al., 2023) indicated that climate change poses a severe threat to the agricultural sector in Vietnam because it negatively affects food security in Vietnam and the world. In this context, (Dawadi et al., 2022) carried out this study to assess climate change and its impact on agriculture production as well as people's perceptions of the impact of climate change. The long-term. The effect of climate on agriculture directly relates to how the farmers adapt to the rate of climate change (Nkwi et al., 2023). The study (Mwangi, 2023) found out that the adverse effects of climate change include rising temperatures, changes in rainfall patterns, and increased frequency of extreme weather events on crop yields, livestock production, and viticulture. The findings consistently demonstrate that climate change poses significant risks to food security and agricultural livelihoods in different regions. Against this background, we hypothesize:

Environmental changes have a significant impact on the agricultural sector in Iraq, considering global economic challenges.

3. Methodology:

The researcher adopted the deductive approach and the descriptive analytical approach to study environmental and climate changes as experiments for selected countries in order to reach analyzes and conclusions related to them, as well as the experimental approach based on studying the economic effects of those changes by adopting international and local statistical bulletins in order to prove the hypothesis by relying on the inductive approach in Analyzing the reality and experiences of selected countries and the extent of benefiting from them.

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The spatial boundaries of the research are Iraq. As for the time of the data analyzed, the period (2004-2022) was chosen because this period witnessed the confrontation of environmental and climate changes, the worsening of carbon emissions, global warming, desertification, and drought in many countries of the world, including Iraq.

4. Results:

After (2003), the agricultural sector in Iraq witnessed an essential shift from a planned economy to market exploitation, but this shift has not been successfully implemented due to the lack of proper and thoughtful preparation for this shift (Mohammed, 2020). There are many sources of financing for the agricultural sector, some of which are self-financing and some in the form of bank loans (Mohammed, 2018). According to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change for the West Asia region in 2021, Iraq is facing the threat of climate change. This significantly impacts various economic sectors, water and food security, and broader health and environmental aspects. Rising Temperatures: Increased emissions of greenhouse gases, especially those resulting from fossil fuel production, lead to rising temperatures. Several variables accompany this increase. The increase in temperatures can lead to the erosion of agricultural lands, rendering them unsuitable for farming.

Additionally, it can contribute to the spread of desertification and deforestation in drought-prone areas, such as increasing forest fires. The total area affected by desertification in Iraq reached 401,290 hectares. As stated in the Global Environmental Report for 2021, Iraq is classified as one of the country's most vulnerable to environmental disasters due to rising temperatures, with the average temperature increase reaching 1.5 degrees Celsius. However, the average temperature change in Iraq has not been calculated yet. Projections based on numerical climate models indicate that temperatures could range between 0.9 degrees Celsius and 3.5 degrees Celsius by 2100. This further exacerbates critical temperature increases, which have already exceeded 50 degrees Celsius on numerous days during the summer season. Temperatures are rising, particularly in central and southern regions and across the country. The temperature in the country has risen by 0.7 degrees Celsius over the past 100 years. The average temperature in Iraq could increase by 2-3 degrees Celsius over the next century depending on how the world responds to climate change. This increase will have devastating effects, including decreased rainfall and severe impacts on water resources.

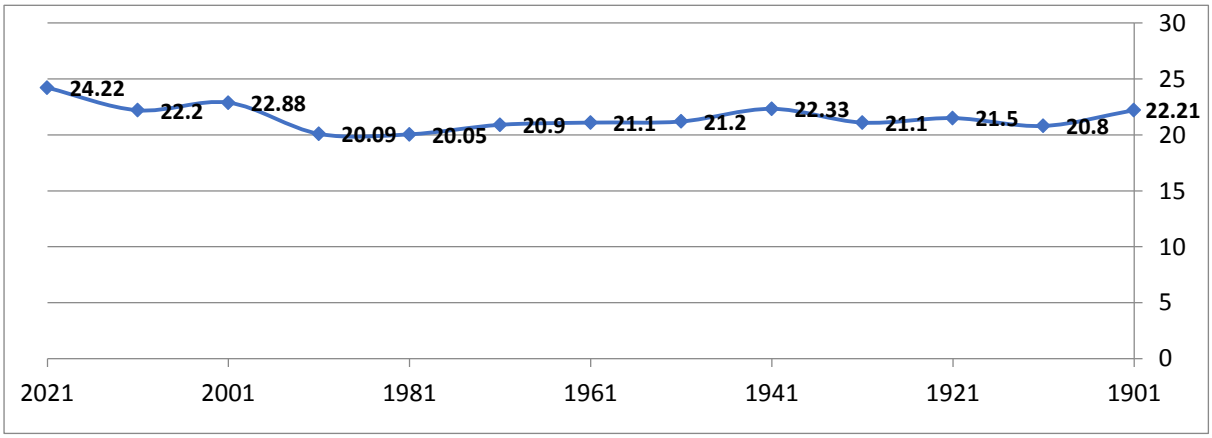

Figure 1 : Average temperatures in Iraq during the period 1901-2021

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Rainfall in Iraq is characterized by fluctuations even in humid and semi-humid areas, with 60% of rainfall amounts having limited benefits due to low rainfall and the limited area over which it falls. This is because of the loss of this water through various drainage routes into rivers, lakes, or groundwater, with the extent of loss determined by soil quality and porosity. Some of the water is also lost through evaporation, a process influenced by important factors such as temperature.

According to forecasts from the General Authority for Meteorology, rainfall in the year 2100 is expected to decrease by more than 30% compared to rainfall between 1938 and 1978. This is an essential indicator of the apparent increase in extreme weather events such as heatwaves, droughts, and heavy rainfall. Climate change exacerbates the problem of water scarcity in the Tigris and Euphrates rivers and their tributaries. According to estimates from the World Bank, renewable water sources in Iraq are significantly scarce. It is expected that this scarcity will reach 37% for the period from 2020 to 2030, increasing to 51% during the period from 2040 to 2050. This explains the collapse of the agricultural sector, which has left a clear impact on agricultural production, natural systems, and biodiversity, including the loss of vegetation cover in Iraq.

Due to the lack of precise data on the quantity of rainfall in Iraq during past epochs, data from Baghdad during the year 2021 were utilized. This year was considered a dry year, with rainfall reaching 25 millimetres. Baghdad's highest annual rainfall rate was recorded in 2013 at 296.7 millimetres, while rainfall in 2018 was approximately 284.2 millimetres. Between 2011 and 2021, rainfall fluctuated between increase and decrease, as depicted in the figure illustrating rainfall variability from 2010 - 2021.

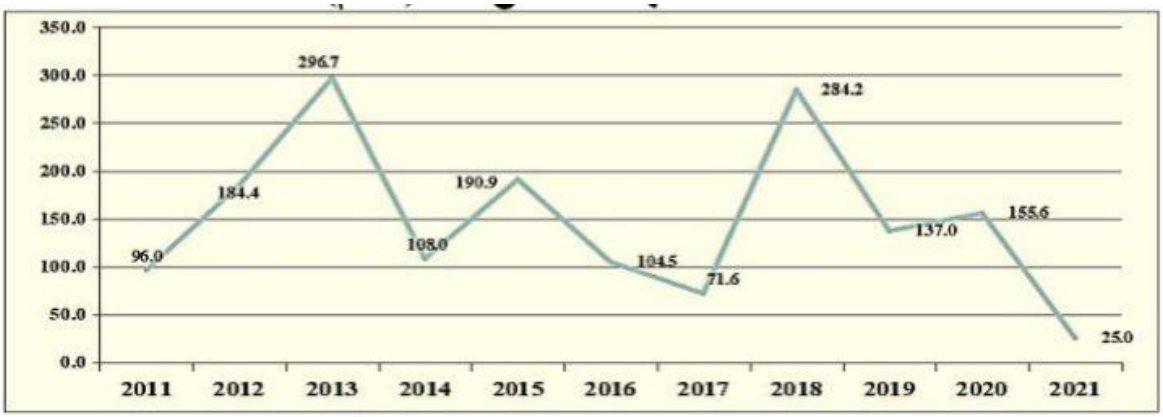

Figure 2: Annual average amount of rain falling on the city of Baghdad by year (mm)

After suffering from floods of the Tigris and Euphrates rivers, with the last major flood occurring in 1954, Iraq witnessed the construction of numerous dams, reservoirs, and other shared rivers by Turkey, Iran, and Syria in the second half of the twentieth century. Consequently, there was a significant decrease in water entering Iraq, leading to agricultural disasters. Currently, the country's water demand is around 50 billion cubic meters annually, which is increasing due to population growth. The country will face serious problems that are unimaginable. The problem is exacerbated by the fact that the Middle East region has been experiencing drought and frequent rainfall for the past ten years, directly contributing to the depletion of vital reservoirs in Iraq. Agricultural production is mostly linked to natural factors, which means that agricultural production fluctuates depending on those factors (Mohammed, 2016). Water scarcity has had a significant impact on the agricultural sector due to the increased annual fluctuations in rainfall, which are reflected in national food security. Iraq is exposed to the risks of water scarcity, according to the average Water Risk Index, which is determined to be between more significant than 3 (very high) and less than 1.25 (very low).

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Iraq scores a 5, indicating a moderately high water risk (2). Fluctuations in water flow and the decrease in the quantity of good-quality water make Iraq vulnerable to climate change, contributing to the increase in desertification and sandstorms. Recently, sandstorms have become more frequent due to the decline in vegetation cover, water scarcity, and soil degradation. The increase in temperature and the rise in evaporation rates accelerate soil salinization by facilitating the transport of harmful salts to the soil surface.

For this reason, a large area of agriculturally productive land may become unsuitable for cultivation in the future. Sensitive crops to drought and salinity may suffer due to high evaporation, limited water availability, and rainfall variability, particularly affecting the Tigris and Euphrates rivers. The Middle East region in general, and Iraq in particular, has experienced recurrent drought years since the beginning of the current century, such as in 1999-2001, 2008-2009, and 2014-2015. Land degradation in arid, semi-arid, dry, and semi-humid areas leads to a loss of the land's ability to produce agricultural output due to natural factors, with climate factors being prominent among them and human activities. This is defined as a decrease in the soil's productive capacity resulting from poor human use, such as the encroachment of desertification on agricultural lands and urban dominance at the expense of human settlement transformation into desert lands and agricultural lands. Table: 1 shows the area of arable and cultivated land according to the irrigation method for the period (2015-2021) dunums

Table: 1 shows the area of arable and cultivated land according to the irrigation method for the period (2015-2021) dunums

Years	Arable land (dunums)	Lands currently exploited according to the irrigation method		
		Traffic lands	Demo lands	Lands that use well water
2015-2016	52502424	4974294	498099	1439089
2016-2017	23446160	3922594	394592	1256374
2017-2018	23446160	4000000	5539999	1869152
2018-2019	23446160	2699972	902150	2667742
2019-2020	13487700	6030148	6837701	2722246
2020-2021	13487700	5022252	6722302	2815653
2021-2022	13487700	2500000	6880954	3107828

Source: Ministry of Agriculture / Department of Planning and Follow-up / Department of Statistics for the period (2015 - 2021)

Table (2) illustrates the areas of desert land and land threatened by desertification by province for the year 2020 :

Table 2 : Area and percentage of desertified and threatened lands and sand dunes by governorate for the year 2022

The provinces	Deserted lands (dunums)	Lands threatened by desertification (including desert lands)	Sand dunes
Nineveh	6.242.400	5.413.840.0	148.696.0
Kirkuk	78.205.6	1.503.900.0	0.0
Diyala	1.544.820.0	3.713.860.0	43.071.2
Anbar	10.539.400.0	42.948.400.0	7.637.0
Baghdad	38.026.0	620.208.0	0.0
Babylon	45.195.2	384.952.0	661.3
Karbala	932.344.0	550.208.0	12.449.0

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Wasit	1.838.700.0	2.538.230.0	4.935.4
Salahaddin	3.666.080.0	3.471.050.0	992.572.0
Najaf	1.264.460.0	9768.200.0	66.914.8
Al-Qadisiyah	282.104.0	1404.130.0	64.802.0
Al-Muthanna	6.795.080.0	13.598.500.0	1.252.380.0
Dhi Qar	1.266.270.0	2.521.980.0	104.578.0
Maysan	1.839.920.0	3.107.480.0	80.490.8
Basra	4.006.280.0	2.400.720.0	10.059.5
Total	40.379.284.8	93.945.658.0	2.789.246.9

Source: Ministry of Agriculture / Department of Planning and Follow-up / Department of Statistics

- *The decrease in desertified areas in some governorates in 2021, despite the increase in the total area, is due to the population expansion that it witnessed. As for the decrease in sand dune areas, it is due to the operations to stabilize sand dunes represented by planting salt-resistant trees and afforestation campaigns. Farmers' agricultural lands affected by encroachment were also treated. Sand dunes
- Sand dunes are part of decertified lands.
- km^2 = 400 dunams
- The total area of Iraq, including territorial waters (km2) = 435,052 km^2

Table (3) shows the continuation of desertified and desertification-threatened lands for 2022, reaching approximately 10,539,400 dunums in Anbar Province, ranking first. Al-Muthanna ranks second with approximately 6,795,080 dunums, and Nineveh Province ranks third with 6,242,400 dunums. As for lands threatened by desertification, they also increased in 2020, with Anbar Province ranking first with 42,948,000 dunums, Al-Muthanna ranking second with 13,598,500 dunums, and Nineveh ranking third with 5,413,840 dunums. Conversely, Dunes, also represented by Anbar Province, reached approximately 7,637,000 dunums in 2022. The marshlands constitute an optimal environment for attracting migratory birds annually. Iraqi marshlands are inhabited during the breeding season or serve as a transit route for numerous bird species across Iraq's southern and central regions. However, their existence has begun to face threats of extinction due to unsustainable hunting practices amidst attempts to economically revitalize the marshlands after their inclusion on the UNESCO World Heritage List in 2016. Figure (2) indicates a decrease in the water inflow into the marshlands until 2021, and some reports suggest that unsustainable hunting threatens the extinction of 200 bird species in Iraq. The situation in the marshlands, particularly in Thi Qar Province alone, has seen the number of unlicensed fishermen exceed 3,000, who do not abide by laws prohibiting toxic substances or nets in fishing. Despite the Iraqi Parliament issuing Law No. 17 of 2010 aimed at regulating fishing operations and protecting the environment, illegal fishing has not ceased, posing a threat to the extinction of 200 bird species in the Iraqi marshlands. The excessive pressure on the Iraqi environment, the draining of palm orchards, and the increasing agricultural pests amid governmental neglect to combat them, are linked to the decline in food security and self-sufficiency in Iraq. They also cause other severe problems with significant implications for national security, exacerbating the challenges faced by Iraq.

The Iraqi Ministry of Environment has provided a report on the environmental situation in Iraq for the year 2017, addressing climate change indicators in Iraq. It pointed out the rise in temperatures and the expectation of longer heatwaves, leading to increased water evaporation. There are also indications of the possibility of a temperature increase between (0.5 - 1) degrees Celsius during the first thirty years of this century. As for rainfall in Iraq, climate forecasts from stations in Syria, Iran, and Turkey suggest a decrease in annual rainfall amounts. Additionally, future statistical analyses predict a 6% decrease in annual rainfall by 2050 (USAID, 2017). These changes illustrate current and future climate variations as follows :

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Table 3: Current and future climate changes

Future climate changes	Past climate changes
Annual temperatures rise by 0.7°C. Rainfall amounts increased by 2.4 mm in the northeast. Low rainfall of 0.88 mm in the southeast Low annual rainfall amounts to an average of 5.93 mm in the west.	Annual temperature will rise by 2°C in 2050 More frequent heat waves Rainfall will decrease by 9% in 2050. Surface runoff decreased by 22%.

Source: Prepared by the researcher based on: Ministry of Agriculture / Statistics Department

It was revealed through the water resources strategy that there is a decline in water revenues in Iraq, and therefore this will be reflected in meeting water needs, and that the expected water revenues in 2035 are (59.73) billion m3 compared to water revenues in 2015, which are (77.37) m3, and this indicates a deficit of (10.94) billion cubic meters for water needs in 2035. In the event of continued lack of rainfall due to climate change, it will lead in the future to an exacerbation of the problem of water scarcity.

The agricultural sector is one of the important productive sectors in contributing to the Gross Domestic Product (GDP) by providing food commodities to society and supplying raw materials to the industrial sector. Approximately 35% of the population in Iraq resides in rural areas or is directly or indirectly employed in agriculture. The importance of this sector has been emphasized through the utilization of available resources to find suitable solutions for its development. Iraq has prioritized food security, aiming to achieve the highest levels of self-sufficiency through agricultural policy. The focus has been on increasing agricultural productivity by optimizing the utilization of production factors and investing in them more efficiently. The state has sought to provide locally and internationally produced production methods if not available domestically. Additionally, several strategies have been adopted, including self-reliance policies to enhance self-sufficiency levels in food commodities, utilizing scientific methods to increase agricultural production, increasing investments directed towards the sector, establishing agricultural companies to expand sector activities, and implementing pricing policies to support producers. The government has focused on providing and distributing all production requirements, promoting the use of improved seed varieties, especially grains, providing and distributing various irrigation systems, promoting their use among farmers, and adopting developmental projects and programs based on the dissemination and use of modern production technologies, conducting research, and transferring its results to farmers. Despite these efforts, the challenge of ensuring food security remains one of the most significant challenges facing the Iraqi economy due to the increased consumption needs resulting from population growth. This has led to the importation of large quantities of food, negatively impacting the balance of payments. Consequently, the government has placed significant emphasis on agricultural development.

There is an inverse relationship between the productivity of cultivated land and its share of output, and the productivity of agricultural crops. This relationship is influenced by environmental and climatic changes, and the wider these changes become, the more negatively they affect arable land. Consequently, the productivity of agricultural crops decreases. This is evident from the data, which confirms that the productivity of agricultural crops, even relatively, has significantly declined due to the land allocated for agriculture. Table (4) show GDP and the relative importance of agricultural output in Iraq for the period (2004-2022):

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Table: 4 shows the gross domestic product and the relative importance of agricultural output in Iraq for the period (2004-2022) (at current prices / million dinars)

Years	GDP	Agricultural Output	Agriculture's contribution to the GDP %
2004-2007	298526079	4955281.1	1.65
2008-2011	1725221401	77897797.5	4.51
2012-2015	2472066617	34796185.4	1.41
2016-2019	683995967	5760967.8	0.84
2020-2021	301152818	9970509	3.31

Source: Prepared by the researcher based on: Ministry of Agriculture / Statistics Department for the years (2004-202

5. Conclusion:

Environmental and climatic changes directly impact the agricultural sector in Iraq, particularly amidst the challenges facing the global economy and food security. These changes pose an increasing threat to agricultural sectors worldwide, including in developing and Arab countries. Climate change leads to rising temperatures, increased heatwaves, and drought, affecting the growing season's quality. Farmers may suffer increased damage to their crops due to intensified droughts, floods, or fires, as well as decreased irrigation efficiency, leading to higher water loss in agriculture. This has resulted in the loss of arable land and increased desertification due to poor agricultural management practices, along with a rise in dust storms, leading to decreased crop and livestock production, increased plant water requirements, and the spread of pests and diseases. The limited use of agricultural machinery and modern technology, reliance on traditional farming methods, and the inability to afford technological packages due to the financial constraints of Iraqi farmers contribute to these challenges. The decrease in major crop yields will affect food production, leading to increased food prices and food insecurity, higher unemployment rates and increased poverty levels closely associated with access to food and food insecurity. The increase in salinity levels in the Tigris River, due to decreased rainfall and rising temperatures, has led to reduced flow in rivers, dried-up wells, and a clear correlation between declining water revenue, decreasing rainfall, and rising temperatures at most stations in Iraq. This has affected the decline in water supply from various river sources and reduced irrigation water use efficiency due to wastage. Iraq heavily imports crops, food and agricultural commodities, with an estimated dependence rate of over 60%. The lack of state attention to the agricultural sector's infrastructure in all fields except for limited areas has led to the deterioration of the agricultural sector, hindering private agricultural activities from contributing to agricultural development due to their limited financial, administrative, scientific, and technological capabilities.

Authors Declaration:
Conflicts of Interest: None
-We Hereby Confirm That All The Figures and Tables In The Manuscript Are Mine and Ours. Besides, The Figures and Images, Which are Not Mine, Have Been Permitted Republication and Attached to The Manuscript.
- Ethical Clearance: The Research Was Approved By The Local Ethical Committee in The University.

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