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Measuring The Impact of Water Scarcity on Agricultural Economic Development in Iraq

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ABSTRACT

Water provision is sensitive to climate change, and agricultural production and food supply are sensitive to water availability. Water scarcity affects food security and agricultural economic development through changes in agricultural production and changes in the composition of produced goods. Recent droughts also led to a decrease in the volume of water allocated to agriculture, which led to a decrease in total agricultural production and exports, and this has subsequent impacts on food security and economic development. The research aimed to measure the impact of water scarcity on agricultural economic development for the period 1990-2022. The research included three behavioral equations with three endogenous variables: the cultivated area, the value of agricultural output, and the value of gross domestic product, and four exogenous variables: the amount of available water, agricultural labor, and the value of agricultural investments and the income of other sectors, the studied model is called the sequential model, which was estimated using the Recursive method, using the ordinary least squares (OLS) method. The results indicated that increasing the amount of available water will lead to an increase in the cultivated areas by 141,129.2 dunums, and that increasing one thousand dunums of the cultivated area will increase agricultural output by 0.00821, and that agricultural labor is inversely proportional to agricultural output. It became clear that if the income of the rest of the sectors increased by one unit, the domestic product would increase by 0.1873. Water scarcity will reduce cultivated areas, which in turn will decrease agricultural output, causing the value of agricultural output to decrease and its contribution to the gross domestic product to decrease. In turn, it will have serious repercussions on agricultural economic development. Therefore, the research recommends the necessity of integrated water management and improving the efficiency of its use, as well as the application of modern technologies in agriculture, such as sprinkler irrigation, hydroponics, and redrawing crop compositions to ensure maximizing the net return per unit of water.

Keywords- climate change, recursive, water security, water management, poverty.

I. INTRODUCTION

Water scarcity is increasingly viewed as a global systemic risk (Vörösmarty *et al*., 2010; Bakker, 2012). Efficient and sustainable use of water resources is the basis for maintaining social and economic development and demand for environmental management. Agriculture uses the largest amount of water, meaning agricultural production has accounted for 80% of global water. Furthermore, 90% of human water footprint comes from agricultural products (Hoekstra and Mekonnen, 2012). Thus, improving the efficiency of agricultural water use and alleviating water stress caused by agricultural production, which is an important measure to improve the sustainable use of regional water resources. (Xinchun et al., 2017). Sustainable use of water resources is an important policy goal. Climate changes are considered one of the important factors that have a significant and clear impact on agricultural production, whether directly or indirectly. Agriculture is considered one of the most sensitive economic sectors to climate change, as the expected increase in

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temperatures and decrease in rainfall will negatively affect crops and water availability, which will decisively affect agricultural production patterns in the future. In addition, old methods of agricultural practices and mismanagement of water resources have exacerbated the effects of climate change and contributed to an increase in areas of desertification and the loss of agricultural land due to drought and the accompanying increase in salinity, as the increase in temperature and decrease in rainfall is expected to lead to a 15-20% decrease in the production of major field crops and vegetable crops by 2050 (Zureiqat, 2022). Climate changes have a major impact on the decline of water resources, and Iraq's position as a downstream country puts it in a critical situation because it is negatively affected by the actions of the countries located upstream of the Tigris and Euphrates rivers. Iraq's water yields coming from outside are subject to decline as a result of the construction of dams and agricultural development work in the countries of the upper basins, population growth and industrial development therein, and in the absence of permanent agreements to determine the water shares of each participating country, these challenges are exacerbated when accompanied by the phenomenon of climate change, which has made Iraq exposed to major environmental challenges as a result of its geographical location within the arid and semi-arid regions, as well as the economic, political and security conditions it faced. The phenomenon of desertification is at the forefront of these challenges, as it is considered one of the dangerous environmental manifestations because it directly affects food security.

The optimal economic use of agricultural productive resources, including water resources, is one of the goals of economic development, especially under the limited and scarcity of most elements of agricultural production, which necessitates the need for efficient and optimal use of those resources, as the issue of optimal use of water resources in agriculture represents one of the main economic issues of concern to decision makers and those responsible for setting Iraqi agricultural water policies. The problem of lack or scarcity of water represents one of the main problems facing the agricultural sector in Iraq. It is limited to how to rationalize the use of water in this sector in the current situation, as the water supply from the Tigris and Euphrates rivers has decreased in recent years, and on the other hand, the demand for water unit revenue has increased. Excessive use of water also leads to the absence of a water surplus that would allow irrigating new areas of reclaimed land. Therefore, the best alternatives to the current crop composition must be found, as the agricultural sector depends fundamentally on the availability of water more than any other productive sector in the national economy. The availability of water needed to irrigate various agricultural crops is considered the most important factor determining the expansion of this sector. Therefore, it was necessary to restore the area of currently available agricultural land resources to their alternative uses without large investment spending, with the aim of maximizing net agricultural income and maximizing the net return per unit of water under the balanced agricultural development with all other components of economic, social, organizational and political development.

The agricultural sector faces several problems and challenges, the impact of which increases with successive years of drought, fluctuating rainfall, environmental and climate changes, and the increasing demand for agricultural products, which is reflected in the demand for water, with limited supply as a result of population growth, which has led to a lack of self-sufficiency and a decline in the agricultural sector's contribution to the gross domestic product to its lowest levels, and as a result, the state turned to importing from abroad to fill the deficit, and this costs the Iraqi economy large sums, in addition to low productivity per unit area, with a large waste of water as a result of inefficient irrigation due to the use of old and conventional irrigation methods, as well as a large percentage of the governorate's lands being affected by desertification due to the geographical location within arid or semi-arid areas. Desertification is a dangerous phenomenon that has recently worsened due to climate change, decreased rainfall, unsustainable agricultural methods, and the increasing decline in water levels in the Tigris River. This leads to a deterioration in the productivity of economic resources and a decrease in agricultural land productivity, which has an impact on a drop in farm income and a rise in the poverty rate, which directly affects food security and delays the economic development. The utilization of water and land is under increasing pressure due to population growth and economic development, especially in developing regions of the world. Unfortunately, the areas most in need of economic development are areas with a fragile environment (Sun, 2006), and it can be said that problems associated with water shortages or pollution of water bodies will affect almost everyone. Water shortages and needs are increasing, and competition for water between urban, industrial and metropolitan areas is increasing. The agricultural sectors, as well as other resource users, are growing intensively, due to the growing population in the developing world, which leads to increasing demand for water resources, unfortunately, it will lead to more pollution which effectively reduces the availability of water to meet human needs. At present, due to increasing water scarcity, food security in most developing countries and then achieving economic development is very doubtful (Hamdy *et al*., 2003). Here two important matters must be asked: What should be done? What is the appropriate balance between water strategies on the supply side and the demand side? Considering the resources at hand, there are no specific answers to such questions. Therefore, there is a need to deal with the management of land and water resources within a comprehensive framework through which policies and projects can be formulated and their implementation can be planned in an integrated manner. We need to improve management at the farm level and the irrigation system to improve the productivity of the water unit through efficient management, which improves agricultural productivity rates and then achieve agricultural and then economic development. Water is the most important resource, it is used largely in agricultural production and is fundamental to ensuring food security and economic development.

The issue of water, its scarcity, and its serious repercussions on agricultural development has received the attention of many international organizations and researchers because ensuring water availability and sustainable management is included in the sixth goal of the sustainable development goals set by the United Nations, as well as goals 13 and 14, which emphasized taking the necessary measures to address climate change and its effects, and to conserve ocean and marine waters and use them sustainably to achieve sustainable development. Among these studies are:

A study by Leszek Labedzki (2016), which aimed to identify the phenomenon of drought and water scarcity in Polish agriculture and its impact on crop yields, and the preventive measures that must be taken to mitigate the harmful effects of drought and water scarcity. He pointed out that there is increasing pressure on Polish water sources and the need to increase water supplies. The study recommended searching for ways to develop water resources to achieve this goal, implementing small water retention projects, developing irrigation development programs in many provinces of Poland, effective use of irrigation water, improving water distribution, applying agricultural rotation for crops, rehabilitating and modernizing current irrigation systems, and reclaiming soil. Alrwis *et al*. also measured the impact of water scarcity on agricultural economic development in the Kingdom of Saudi Arabia during the period (1990-2018) by studying the current situation of available water resources and their uses, the study relied on descriptive and standard economic analysis to estimate a regression model consisting of behavioral equations to study the impact of water scarcity on agricultural income and gross domestic product during the same time period. The results showed that a (10%) change in the amount of available water resources leads to a (1.5%) change in the crop area. Also, a (10%) change in the estimated crop area leads to a (5.1%) change in the total value of agricultural production. A (10%) change in employment and agricultural loans results in a change in the value of total agricultural production of (1.5%) and (2.7%), respectively. A (10%) change in the total value of estimated agricultural production results in a (9.2%) change in GDP. Therefore, the lack of water resources will reduce the crop area and have a negative impact on the value of agricultural output, thus affecting the GDP. Therefore, the study recommends that in order to preserve water resources, the government must stop exporting virtual water, especially for water-depleting products. Among other studies is the study of (Elina Valino *et al*., 2020), which aimed to determine whether Integrated Water Resources Management (IWRM) system is suitable to represent a valid measure for measuring early warning systems, as well as analyzing whether the indicator can predict typical early warning situations such as low agricultural productivity and inefficient use of water, using the analytical statistical approach. The study reached results, the most important of which is the presence of a positive and significant correlation between the level of IWRM and yield, and thus a negative and equal correlation between the level of IWRM and the water footprint of the crop. Good water management, as can be discovered through the IWRM, works to improve land productivity and water availability, and therefore the study recommended using the Integrated Water Resources Management as a valuable tool to measure early warning in Agriculture, and bridging the gap in the possibility of measuring economic water scarcity. Muhammad also, in 2022, conducted an economic analysis of the actual and proposed use of water resources in the Egyptian agricultural sector, through which he aimed to identify the current and future water balance of water resources in Egypt and to identify the actual and proposed use of resources in the Egyptian agricultural sector under minimizing water requirements for the crop composition and then estimating the water availability in the proposed crop composition. The research concluded that the proposed crop composition achieves a water saving of 2.4 billion cubic meters compared to the current crop composition. The proposed crop composition also achieves an increase in net agricultural income by 12% compared to the current crop composition. The study also recommends the need to reconsider the current crop composition in order to reduce water consumption and develop modern irrigation techniques that contribute to rationalizing water use. A study by the Food and Agriculture Organization indicated that renewable water resources are expected to decrease from 6,600 m^3 to 4,800 m^3 due to population growth. Between 2000 and 2025, about 3 billion women and men live in countries where the per capita share of water is less than 1,700 cubic meters, with improving the efficiency of water use leads to a decrease in agricultural use, but a rapid increase in service use and industrial use due to rising income and population. This perspective is supported by environmentalists and a number of stakeholders in the field of agriculture, and thus they see that the cultivated area will be distributed by 17% (FAO, 2006).

As indicated by the World Water Forum, based on global cereal production, which amounted to 1.72 billion tons in 1995 (FAO, 1996), a water volume of 1,720 cubic kilometers, or 300 cubic meters per capita, is needed. The amount of cereals produced worldwide in 1995, 300 kg per capita, is exactly the amount needed to cover the population's caloric needs. Given 100% efficiency and a diet of plant foods, only 300 cubic meters of water per capita per year is theoretically enough to supply the world with food. Current consumption of cereals is about 150 kg per capita per year on a global average, thus meeting only half of humanity's caloric needs (2200 calories per person per day). Based on the above water consumption, an additional 51.3 billion cubic meters (51.3 km^3) of water is required annually to cover the additional food needs of a growing population of 90 million people. Given a constant average per capita food consumption, an additional 1,556 billion cubic kilometers of water will be needed to produce food in 2025. This is 18 times the amount of water that flows annually into the Nile River, or 58% of the amount used in agriculture in 1990. These numbers do not take into account water losses due to inefficient irrigation. If current production conditions in irrigated agriculture are applied to 2025, water withdrawal for food production will rise by another 20%, reaching 1,867 billion cubic kilometers (World Water Forum, 2000). To use water properly and achieve economic development, we need a new approach to managing water resources. It is clear that current approaches in many countries are not sustainable in a physical, economic or environmental sense mainly due to misallocation of water, as the low-value uses consume a large share of the resource, while high-value uses suffer from shortages, the other reason is that water quality is not monitored, which leads to inappropriate use of low-quality water with unfavorable long-term impacts on land and groundwater quality, also, the costs of new water development are increasing significantly. These issues cannot be addressed through the current fragmented approach to water resources because it leads to inappropriate investments in different water sub-sectors.

Falkenmark also considered in 2012 that water shortages constitute insecurity and must be overcome in the process of social and economic development, therefore, he presented a research paper in which he attempted to analyze the origin and manifestation of blue and green water scarcity at different levels with a particular focus on the risks to food production and water supply. He analyzed water scarcity resulting from both climatic phenomena and water division disturbances at different levels, including at the field level and at the state level. He started his research from an important question for the future of humanity, which is whether there is enough water in the global system to meet the requirements of the world's population in future. Unless action is taken now, water insecurity is likely to become a major geopolitical issue affecting the entire global economic system, and this requires harnessing the social and productive potential of water and reducing its destructive impacts. The results of the research indicated the risks of water security and that there is a strong correlation between poverty and the inability to access land and water, as the poorest people have the least access to land and water and are confined to small farms with poor quality soil, elevated risk of land degradation and an uncertain climate. Water scarcity impedes water security in several ways. In 2015, Shmuel and others considered the challenge of meeting the doubling of global food demand by the year 2050 to be a huge challenge, and this challenge is increased by the dwindling water resources. Therefore, they presented research on balancing water scarcity and quality for sustainable irrigated agriculture.

II. MATERIALS AND METHODS

To achieve the research objectives, time series data for the period 1990-2022 were obtained from approved secondary sources, which are the Ministry of Planning, the Central Organization for Statistics /Environmental Statistics for Iraq and the Directorate of National Accounts. As for the research method, the quantitative method was adopted and the three behavioral equations were estimated using the simultaneous equations and using the Recursive model, which is the model in which all relative effects are unidirectional, disturbances are uncorrelated, and contains more feedback loops. The model is estimated using the ordinary least squares (OLS) method.

III. RESULTS AND DISCUSSION

The impact of water scarcity on agricultural economic development

One of the most important issues of the day, both locally and globally, is the water resources, it is one of the most significant challenges facing decision-makers around the world, especially since it is closely linked to achieving development at all economic, social and environmental levels. There is a clear decline in the amount of water resources coming into Iraq, whether coming from the Tigris and Euphrates rivers outside the Iraqi borders, or the feeder rivers from inside Iraq, which also declined due to drought conditions, which was reflected in the tributaries, groundwater, and storage rates in dams and reservoirs. In addition to the destruction and damage of a number of important installations, such as the Ramadi and Fallujah dams, Warrar canal, and Taqsim canal, in addition to a number of other secondary facilities. Water resources in Iraq suffer from various environmental problems, the severity of which has increased at the present time, and at the same time they represent environmental obstacles and challenges that hinder the integrated water resources management, as Iraq faces two basic challenges in providing its water needs, which are:

1- External challenges

A- Decrease in water yields:

Iraq's location as a downstream country puts it in a critical situation because it is negatively affected by the actions of the countries located upstream of the Tigris and Euphrates rivers (Turkey and Syria), and the completion of Turkish and Syrian plans to invest the waters of the Tigris and Euphrates, especially Turkey, by completing the Eastern Anatolia Project by building (22) dams to meet the requirements of its irrigation projects. The projects implemented by Iran also affected the border rivers shared with Iraq, diverting the course of some rivers into its territory, in addition to draining drainage water toward Iraqi rivers. Thus, these projects for the three countries are expected to pose two major challenges by 2035, also: (Ministry of Planning and National Development Plan, 143)

A decrease in Iraq's water yields at a rate of up to one billion cubic meters annually, which leads to a reduction in water yields at the borders from 43.7 billion cubic meters in 2015 to 28.5 billion cubic meters by 2035, in addition to the presence of water losses, which weakens the efficiency of field irrigation to reach less than 50%.

Salt concentrations increased from 320 parts per million to 500 parts per million for the Tigris River and from 540 parts per million to 930 parts per million for the Euphrates River.

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Weak security and political stability in neighboring countries sharing water (Syria) and failure to reach partnership agreements that guarantee fair water rights for Iraq.

B- Climatic and geological changes:

It is expected that the phenomenon of climate change will negatively affect the reality of water resources in Iraq, leading to a variation in the amount of water coming into Iraq from the Tigris and Euphrates rivers, between sudden increases that may lead to floods or scarcity that leads to drought, especially since the rate of rainfall in Iraq has declined from what it was decades ago, which has led to increase desertification in the country, in addition to the Iraqi geography entering into seismic rebounds, which may affect existing dams. (Al-Shammari, 2012, 59)

2- Internal challenges

- The most important of which are the following: (Ministry of Planning and National Development Plan, 143)
- The rate of wastage of irrigation water is high, reaching more than 50% due to field losses and low irrigation and transportation efficiency as a result of using old and conventional methods of water management. In addition to the poor efficiency of water use, some specialists believe that the real problem lies in water management and the efficiency of its use.
- The weakness of the institutional and legislative system, which no longer has the ability to confront the serious challenges facing our water resources.
- Low level of investments in water resources projects.
- The high rate of pollution resulting from the decrease in the number of sewage treatment plants and drainage of waste water.
- Problems of controlling water storage and water drainage through dykes.
- Iraq entered the seismic line and the dykes and dams were affected by this.
- Loss of large quantities of available storage due to military operations against terrorism, which negatively affected the environmental, agricultural, service and humanitarian aspects.
- The rate of groundwater withdrawal has increased, reaching approximately 5.243 billion m^3, which represents 8.8% of freshwater sources. This represents a new water withdrawal of approximately 1.472 billion m^3 annually through groundwater systems.
- Description of the economic variables affecting economic development

The study of econometrics is an important part of general economic research and is of increasing importance when evaluating economic theories. Setting hypotheses on the basis of the existing relationship between economic variables inspired by economic theory must be estimated quantitatively on the basis of data extracted from experimental reality. The relationship between economic variables may affect their variables in others and may, in certain circumstances, cause the occurrence of a phenomenon called the result. The description of the standard model in research and studies concerned with economic affairs and its variables, it is the first and basic step in this research and building models. It determines the variables used in the model and the requirements for its formulation, and based on the information and data available about the phenomenon under study, it explains the changes that affect the dependent variable under study, and the relationship between the variables in a mathematical form.

This research relied on econometric analysis to estimate the proposed regression model to show the impact of water scarcity on agricultural income and gross domestic product during the period 1990-2022. The proposed regression model consists of the following behavioral equations: (Green, 2003) ,(Gujerati, 2003).

$$a_0+a_1X_{1t}+e_{1t}=Y_1t$$
$$Y_2t=b_0+b_{1\ 1t}+b_2X_{2t}+b_3X_{3t}+e_{2t}$$
$$Y_3t=C_o+C_{1\ 2t}+C_2X_4t+e_{3t}$$

The equations of the proposed model include the following variables: three endogenous variables: the total cultivated area (dunams) (Y_{1t}), the value of agricultural output (thousand dinars) (Y_{2t}), the gross domestic product (thousand dinars) (Y_{3t}), and four exogenous variables: the amount of water available for the agricultural sector (million cubic meters) (X_{1t}), the number of agricultural labor (thousand workers) (X_{2t}), the value of agricultural investments (thousand dinars) (X_{3t}), and the national income for the rest of the sectors (million dinars) (X_{4t}). What is clear from the proposed model is that the water resources affect the cultivated area, which in turn affects agricultural output and thus the gross domestic product. Therefore, the causal line goes in one direction. Models that follow this pattern are called the sequential model, and the proposed model is estimated using the least squares (OLS) method (Vallina$laio, 2020),(Alrwis *et al*., 2021). Before estimating the study model, it is necessary to identify the variables included in the analysis, which are as follows:

1- Cultivated areas

The agricultural development strategy in any developing country depends on two main aspects: expanding

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agricultural lands through reclaiming new lands to achieve horizontal development, and achieving vertical development by improving the productive efficiency of production factors and increasing productivity per unit area, cultivated areas mean all areas suitable for agriculture and exploited in the field of agricultural production (Yahya, 2005). The average cultivated area during the study period reached (12,988,985.42) dunums, with a standard deviation of (5,187,742.062). The lowest cultivated area amounted to (1,302,181) dunums in 2011, while the highest area amounted to (28,354,342) dunums in 1993. Figure (1) shows the cultivated areas for the period (1990-2022), and that the cultivated areas fluctuated during the study period and under the influence of many factors, including water and climate variables, as well as the security and political conditions that the country experienced and were reflected in the reality of agricultural production in general.

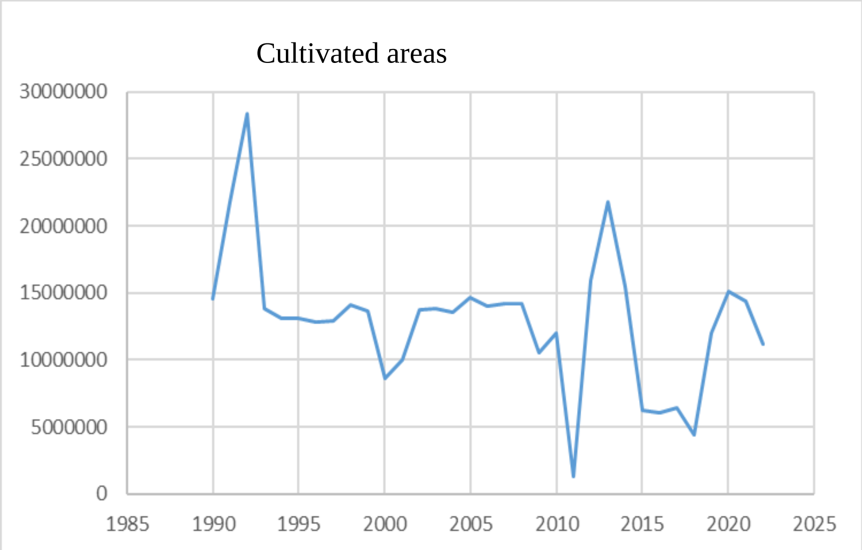

Figure (1) Cultivated areas for the period (1990-2022)
Source: Prepared by researchers based on Table (1).

2- Agricultural domestic product

The agricultural domestic product expresses the level of the national economy and the extent of its development and growth. The most clear and expressive indicator of the level of economic activity. It also expresses economic growth, as it represents the value of all agricultural goods and services produced in a country during a period of time, usually a year (Rashad, Al-Hadithi: 2018). The average value of the gross domestic product was (45821703.2258) thousand dinars, with a standard deviation of (21845798.09281) thousand dinars. The lowest value of this variable was (2877200) thousand dinars in 1991, while the highest value reached (6195900) thousand dinars in 2006, and Figure (2) shows the value of GDP for the period (1990-2022). The value of agricultural output is the product of multiplying output by prices, and it is affected by many factors, especially prices and their fluctuations, as well as macroeconomic factors such as inflation and others.

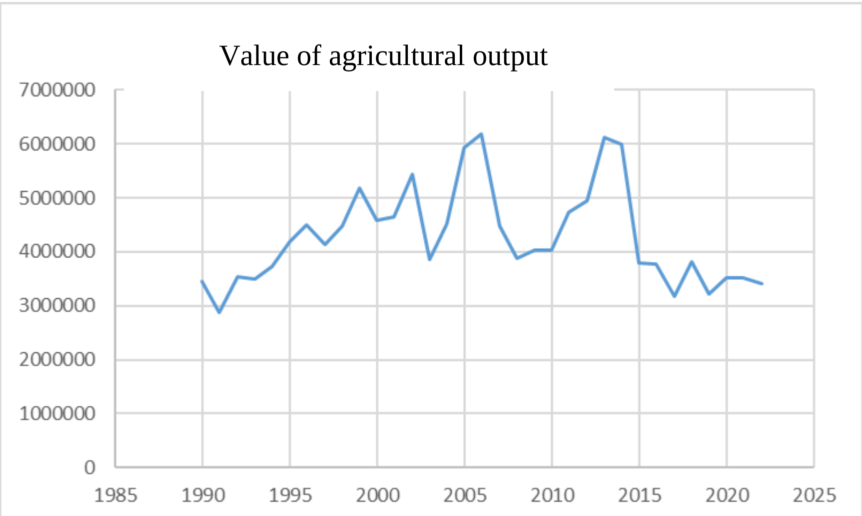

Figure (2) The value of agricultural output for the period (1990-2022)

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Source: Prepared by researchers based on Table (1).

3- Gross Domestic Product

It is defined as the total value of goods and services produced and marketed within the country's borders during a certain period of time (three months or a year). This indicator reflects the economic situation of the country. An increase in production in any country reflects an improvement in the economic situation of the country and the ability of this country's economy to provide more job opportunities and thus increase the individual's income, which is reflected in an increase in their consumption as well as their savings and investments, which leads to an increase in production again and vice versa (Magdy, 2021, 7).

Gross domestic product is an important economic indicator that can be used for economic analyses, developing development plans and policies, and knowing current economic trends. The average value of the gross domestic product during the study period was (45821703.2258) thousand dinars, with a standard deviation of (21845798.09281). The highest value of this variable reached (3217800) thousand dinars in 2019, while the lowest value reached (11087200) thousand dinars in 1991. Figure (3) shows the movement in the value of the gross domestic product for the period (1990-2022), Table (1).

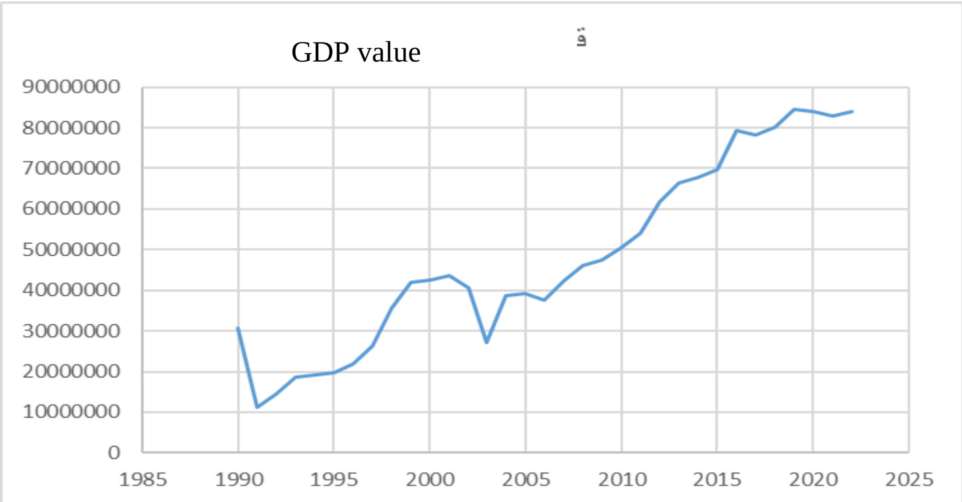

Figure (3) Value of GDP for the period (1990-2022)
Source: Prepared by researchers based on Table (1).

4- The amount of available water:

Water resources constitute one of the decisive factors in developing the agricultural sector and in achieving food security and economic development, but they are considered a rare resource, which requires policies and strategies to manage this scarcity, as water resources face political challenges represented by the fact that Iraq's main rivers originate from outside its territorial borders, which are under the sovereignty of Arab or non-Arab countries, and the practices undertaken by these countries have had negative effects on economic development (Ministry of Financial Resources and Economic Department, 2011). Water is one of the most important factors determining production in arid and semi-arid regions. The misuse of water resources has led to a noticeable decline in productivity, which leads to the transformation of fertile lands into barren areas that are not suitable for agriculture. Iraq has been suffering from the problem of water scarcity for years, and this problem has worsened in recent years due to several factors, including the fact that Iraq's rivers originate from outside its territorial borders, which are under the sovereignty of Arab or non-Arab countries, and the practices undertaken by these countries have had negative effects on water strategies and thus on the economic development, including building dams from upstream countries (Turkey, Iran, Syria). The two rivers (Tigris and Euphrates) originate in Turkey, the Euphrates River flows through Syria, and some other tributaries flow through Iran. Until the 1970s, Iraq was considered a water-rich country, but since Turkey began building dams on the two rivers, it has greatly reduced Iraq's water resources, as the Turkish government began the Southeastern Anatolia Project, building (22) dams and (19) hydraulic power stations for the developing provinces in the southeast. The water policies of neighboring countries have led to a decline in water supplies in Iraq, which affected the agricultural sector on the one hand, and increased water pollution in most parts of the country on the other hand. In addition, the population increase in Iraq, the government's mismanagement of water, and climate change have had a negative impact, the current trends for water security in Iraq do not bode well (Al-Shammari, 2015, 7). The average amount of available water reached (37.9352) billion cubic meters, with a standard deviation of (14.4915), and the lowest value for this variable was (14.9) billion cubic meters in 2021, while the highest value was (70.71) billion cubic meters in 1994. Figure (4) shows the amount of available water for the period (1990-2022), Table (1).

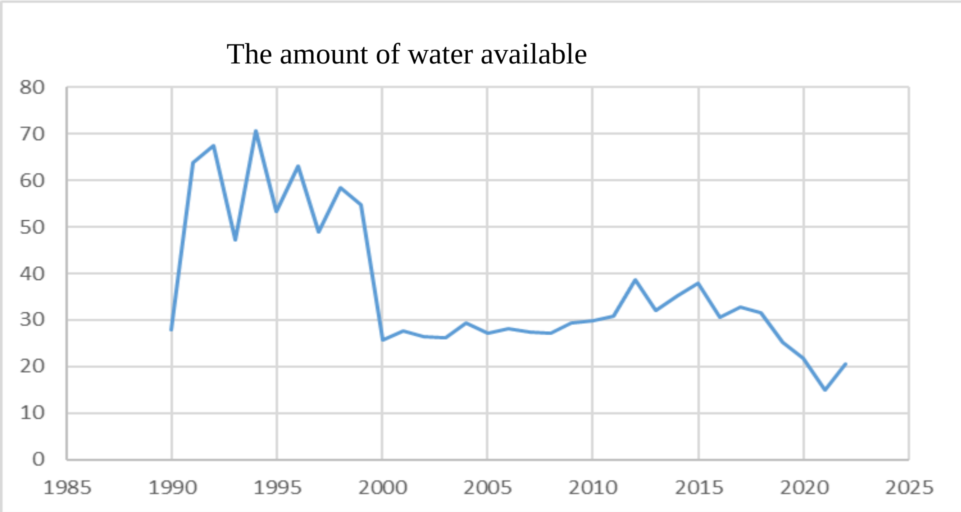

Figure (4) The amount of available water for the period (1990-2022)
Source: Prepared by researchers based on Table (1).

5- Agricultural labor force

The population is the main source of the labor force, which in turn is one of the important production elements necessary for the success of the process of economic development. The labor force is one of the most important sources of wealth in any society, and it is the most important source of wealth, especially in the agricultural field and its activities. The labor force still has an active and fundamental role, even with the highest levels of technological and electronic development. As for the agricultural labor force, it represents great importance as one of the elements of production contributing to the production process. Ranis pointed out the importance of the agricultural labor force in his model presented by Ranisovay in the field of economic development, in which he relied on the Lewis model as its basis, which includes the role that the surplus agricultural labor can play, which is one of the channels for feeding the industrial sector with cheap agricultural labor, by attracting workers with low productivity without affecting agricultural output (Zidan, 2018, 60). The average labor force in the agricultural sector reached (1178.2903) thousand workers, with a standard deviation of (267.09489), the lowest number for this variable was (896) thousand workers in 1990, and the largest number of workers was (1,806) thousand workers in 2020. Figure (5) shows the movement of the labor force in the agricultural sector for the period (1990-2022). The agricultural sector, due to its conditions and decline, has become a push sector due to its low returns on labor.

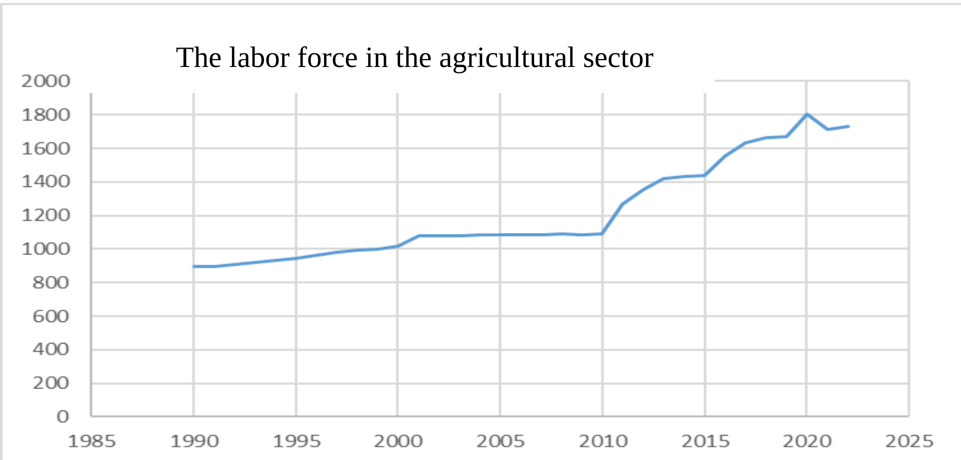

Figure (5) The labor force in the agricultural sector for the period (1990-2022)

6- Agricultural investments

The concept of agricultural investments in general is to invest money in economic, social and cultural projects to

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achieve the accumulation of new capital, increase production capacity, and identify or compensate for old capital for agricultural investment. It is a stream of spending on new agricultural capital goods, such as equipment factories, machinery, and equipment, in addition to commodity storage of agricultural raw materials. It is also the investment of money in agricultural, plant and animal projects, with the aim of obtaining satisfactory returns for the individual or investor. Agricultural investments play an important role in economic and social development, as they help increase productivity, provide job opportunities, and achieve food security. Iraq and its natural and human potential are environmentally attractive for agricultural investments, but the country's conditions are among the most important push factors (Ahmed, 2022, 62). The average agricultural investments reached (169,185.6787) thousand dinars, with a standard deviation of (126,421.8580), and the lowest value for agricultural investments amounted to (4638.2) thousand dinars in 2009, while the highest value reached (517427.3) thousand dinars in 2012, Figure (6) shows the flow of agricultural investments for the period (1990-2022).

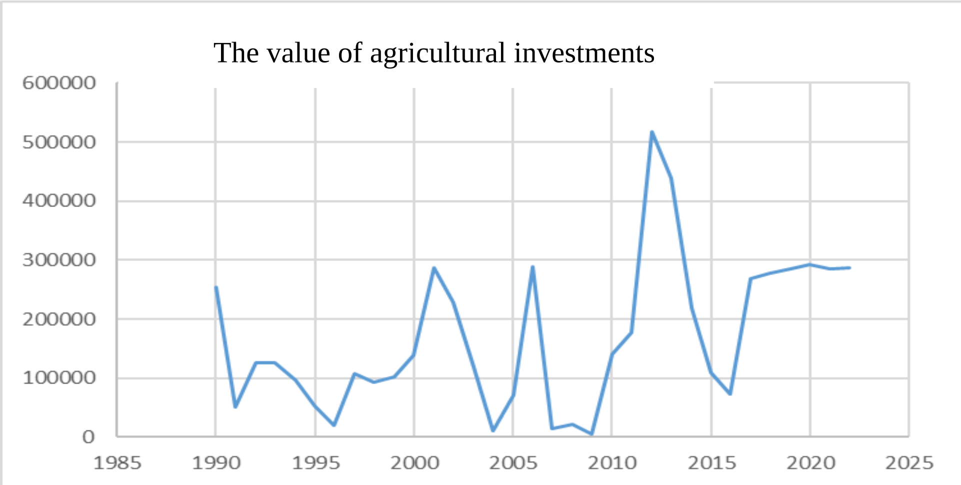

Figure (6) Agricultural investments for the time period (1990-2022)

7- Income from other sectors:

National income expresses the value of production of goods and services in a country, during a specific period of time, usually a year. That is, it is equivalent to the sum of incomes paid to all factors of production in the various production processes. (Abdul Latif, 2006, 69) National income has been adopted as a representative of economic development.

The concept of national income differs from one economic system to another. The socialist system considers national income as one of the most comprehensive indicators for expressing economic conditions as well as the economic well-being enjoyed by individuals. As for the capitalist system's definition of national income, it is the sum of incomes and compensation or rewards provided to the factors of production employed in the production process in exchange for its use in producing goods and services during a specific period of time, which is usually one year (AIarajy, 2012, p3). The average income of the other sectors was (99105649.7290), with a standard deviation of (91667834.22697), and the lowest value for this variable was (36922.2) million dinars in 1991, while the highest value was (253526242) million dinars in 2013, Figure (7) shows the income flow for the period (1990-2022). Table (1).

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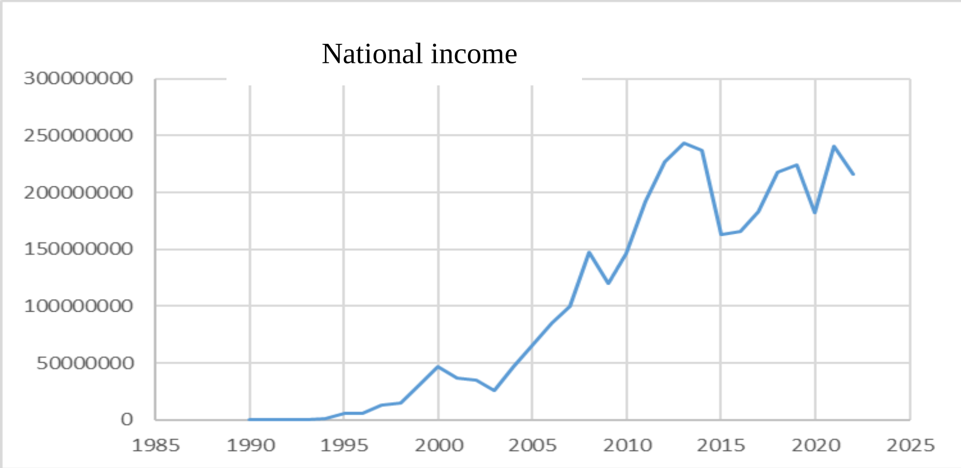

Figure (7) National income for the time period (1990-2022)
Source: Prepared by researchers based on Table (1).

Table (1) Economic factors for the period (1990-2022) in Iraq

Year	Cultivated areas (dunum)	Value of agricultural output (thousand dinars)	Gross Domestic Product (thousand dinars)	Quantity of available water (million cubic meters)	Agricultural labor (thousand workers)	Agricultural investments (thousand dinars)	Income from other sectors (million dinars)
1990	14575106	3447800	30672900	27.88	896	253996	3399858
1991	21837165	2877200	30672900	63.72	897	51769	2840277
1992	28354342	3531903	30672900	67.55	908	125568	3432259
1993	13836115	3492402	30672900	47.16	918	126454	3212597
1994	13130469	3741001	30672900	70.71	930	97134	2300043
1995	13070557	4188200	30672900	53.28	943	51836	1619174
1996	12783885	4498300	30672900	62.96	961	19425	1143124
1997	12956769	4133800	30672900	48.81	978	107743	9101690
1998	14126038	4475100	30672900	58.49	996	92358	10538322
1999	13687349	5188300	30672900	54.69	1000	102852	26192748
2000	8657220	4589000	30672900	25.6	1015	138686	42045634
2001	10000262	4644000	30672900	27.66	1078	287373	32082500
2002	13714912	5432600	30672900	26.5	1079	228233.2	29245122
2003	13874780	3850300	30672900	26.12	1080	119173.9	21878448
2004	13519582	4521800	30672900	29.33	1082	10114.6	42401515
2005	14697937	5939600	30672900	27.15	1083	71027.8	59858966
2006	14046330	6195900	30672900	28.16	1085	288997.6	79235638
2007	14158805	4479900	30672900	27.4	1086	14108.2	95620916
2008	14235579	3889000	30672900	27.2	1088	20663.4	143752254
2009	10513473	4020700	30672900	29.45	1085	4638.6	116408577
2010	11984533	4036700	30672900	29.78	1089	140335.8	142416768
2011	1302181	4739700	30672900	30.89	1270	177044.9	187497370
2012	15967489	4941400	30672900	38.57	1355	517427.3	222280451
2013	21769580	6123800	30672900	31.95	1423	438501.1	237394858
2014	15522022	6000600	30672900	35.27	1432	218576.1	230707436

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2015	6254433	3787400	30672900	37.8	1440	110244.2	158952068
2016	6034979	3775700	30672900	30.71	1555	71932	161858717
2017	6431305	3171700	30672900	32.7	1635	269156.3	180264473
2018	4426262	3811900	30672900	31.5	1666	277089.5	213941973
2019	12047494	3217800	30672900	25.1	1668	285022.8	220944419
2020	15141595	3513800	30672900	21.9	1806	292956.1	178870672
2021	14425000	3514500	30672900	14.9	1713	285022.8	237723769
2022	11224000	3415366	30672900	20.6	1729	287667.2	212512954

Source: Ministry of Agriculture, Ministry of Planning.

After reviewing the endogenous and exogenous variables of the study and learning about the direction and change of these variables, we analyzed and estimated the three behavioral equations using the simultaneous equation and using the Recursive model, which is the model in which all relative effects are unidirectional, the disturbances are uncorrelated, and it contains more feedback loops. The model was estimated using the ordinary least squares (OLS) method and the results are shown in Table (2).

Table (2) Function of the impact of water scarcity on economic development in Iraq

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System: SYSTEM_OLS Workfile: SYSTEM1_ESTIMATIO...

View | Proc | Object | Print | Name | Freeze | InsertTxt | Estimate | Spec | Stats | Resids

System: SYSTEM_OLS
Estimation Method: Least Squares
Date: 12/20/23 Time: 11:39
Sample: 1990 2022
Included observations: 33
Total system (balanced) observations 99

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	8384708.	2234571.	3.752266	0.0003
C(2)	125145.2	56533.23	2.213658	0.0294
C(3)	5493456.	1005692.	5.462361	0.0000
C(4)	-0.011886	0.034014	-0.349436	0.7276
C(5)	-1288.095	707.6136	-1.820336	0.0720
C(6)	2.951334	1.532731	1.925539	0.0573
C(7)	36013241	8332718.	4.321908	0.0000
C(8)	-2.842552	1.880599	-1.511514	0.1342
C(9)	0.233801	0.018641	12.54219	0.0000

Determinant residual covariance 1.05E+39

Equation: Y1 = C(1) + C(2)*X1
Observations: 33

R-squared	0.136497	Mean dependent var	12979017
Adjusted R-squared	0.108642	S.D. dependent var	5039079.
S.E. of regression	4757483.	Sum squared resid	7.02E+14
Durbin-Watson stat	1.194649		

Equation: Y2 = C(3) + C(4)*Y1 + C(5)*X2 + C(6)*X3
Observations: 33

R-squared	0.139011	Mean dependent var	4278399.
Adjusted R-squared	0.049943	S.D. dependent var	894729.2
S.E. of regression	872100.2	Sum squared resid	2.21E+13
Durbin-Watson stat	0.854639		

Equation: Y3 = C(7) + C(8)*Y2 + C(9)*X4
Observations: 33

R-squared	0.840375	Mean dependent var	48099632
Adjusted R-squared	0.829733	S.D. dependent var	23029700
S.E. of regression	9502828.	Sum squared resid	2.71E+15
Durbin-Watson stat	0.702734		

Source: Prepared by researchers using EViews 10

It is noted from the results of the estimated function that although it passed some statistical and economic tests, the function has an autocorrelation problem through the Durbin-Watson test, amounting to (1.19 and 0.70). These are low values, which indicates that there is a second-degree autocorrelation problem, so we addressed it by using the (Cochrane-Orcutt method) Table (3).

Table (3) Function of the impact of water scarcity on economic development in Iraq after treatment

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System: CO_SYSTEM Workfile: SYSTEM1_ESTIMATION...

View | Proc | Object | Print | Name | Freeze | InsertTxt | Estimate | Spec | Stats | Resids

System: CO_SYSTEM
Estimation Method: Least Squares
Date: 12/20/23 Time: 22:36
Sample: 1991 2022
Included observations: 32
Total system (balanced) observations 96

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	7661176.	2807693.	2.728637	0.0077
C(2)	141129.2	67661.96	2.085799	0.0399
C(3)	5445442.	1288308.	4.226818	0.0001
C(4)	0.008210	0.028397	0.289122	0.7732
C(5)	-1316.184	967.1912	-1.360831	0.1771
C(6)	2.370023	1.315517	1.801591	0.0751
C(7)	32476277	8930651.	3.636496	0.0005
C(8)	-0.728891	1.793547	-0.406396	0.6854
C(9)	0.187343	0.033398	5.609488	0.0000

Determinant residual covariance 3.21E+38

Equation: Y1 = C(1) + C(2)*X1 + (0.397466)*(Y1(-1) - C(1) - C(2)*X1(-1))
Observations: 32

R-squared	0.281148	Mean dependent var	12929139
Adjusted R-squared	0.257186	S.D. dependent var	5111426.
S.E. of regression	4405367.	Sum squared resid	5.82E+14
Durbin-Watson stat	1.753227		

Equation: Y2 = C(3) + C(4)*Y1 + C(5)*X2 + C(6)*X3 + (0.524185)*(Y2(-1) - C(3) - C(4)*Y1(-1) - C(5)*X2(-1) - C(6)*X3(-1))
Observations: 32

R-squared	0.455906	Mean dependent var	4304356.
Adjusted R-squared	0.397610	S.D. dependent var	896333.7
S.E. of regression	695678.3	Sum squared resid	1.36E+13
Durbin-Watson stat	2.090289		

Equation: Y3 = C(7) + C(8)*Y2 + C(9)*X4 + (0.647712)*(Y3(-1) - C(7) - C(8)*Y2(-1) - C(9)*X4(-1))
Observations: 32

R-squared	0.914233	Mean dependent var	48644220
Adjusted R-squared	0.908318	S.D. dependent var	23181308
S.E. of regression	7019067.	Sum squared resid	1.43E+15
Durbin-Watson stat	1.331558		

Source: Prepared by researchers using EViews 10

When observing the estimation results shown in Table (3), we see the first model that shows the relationship between the cultivated areas (Y_1) and the amount of available water (X_1). The results indicate the significance of the variable (the amount of available water) in the positive effect on the cultivated areas, and its parameter reached (141129.2), which reflects the direct relationship between it and the dependent variable. This means that whenever the amount of available water increases by 1,000 cubic meters, the areas will increase by (141,129.2) dunams, this reflects the importance of the water element, which is the main determinant of the cultivated areas. This is consistent with what was stated in the previous table, which clearly indicated the positive relationship between the quantities of water and the cultivated areas, as we noticed that when water was increased to 67.5 billion cubic meters in 1992, the cultivated areas reached their maximum, reaching 28.3 million dunums, and when the water decreased during the study period to 14.9 billion cubic meters, the cultivated areas decreased to 14.4 million dunums, and this decrease causes a decrease in agricultural production, it had a negative impact on agricultural development and then economic development, which made Iraq import large quantities of agricultural goods to cover consumption. The value of R^2 also showed that water is responsible for 28%

of the changes in the cultivated area.

The second model also shows that 45% of the total changes occurring in agricultural output were caused by cultivated areas, agricultural labor, and agricultural investments. The effect of cultivated area was insignificant and positive, meaning that by increasing agricultural areas by one unit, agricultural output will increase by 0.00821 units, and this effect may be weak, but it is attributed to the decrease in cultivated areas during the study period. The value of agricultural output also increased due to the rise in prices more than its dependence on production. The effect of agricultural labor was insignificant and had a negative effect on the parameter of the aforementioned variable, as it reflects the inverse relationship between it and agricultural output, as the increase in the number of labors by one unit leads to a decrease in agricultural output by 1,316,184 units, and this contradicts the theory, this is due to several reasons as a result of the periods of war and siege that Iraq went through, which resulted in the migration of agricultural labor in search of better job opportunities and more comfortable living conditions due to the low level of basic services and the dwindling opportunities for meaningful work. Also, the work in the agricultural sector cannot be considered all effective, as a large portion of it is considered disguised unemployment, and a large portion of it is affiliated with rural and agricultural labor, but it works outside the agricultural sector due to the decrease in the performance of the agricultural sector and it is considered inappropriate for it (Ali at ell ,2022). Therefore, increasing wages for agricultural work is not necessarily leads to an increase in agricultural production. The effect of the investment's variable was significant and had a positive effect, meaning that by increasing investments by one unit, agricultural output will increase by 2.370 units, and that investments in the agricultural aspect are important and necessary to increase agricultural output and thus domestic product. The significant variable was at the level of 10%, which is acceptable at the level of macroeconomic studies.

The third model also explains the relationship between the agricultural output variables and the national income of the rest of the sectors and its impact on the GDP. It is noted that the value of R^2 reached about 0.45, meaning that 45% of the changes in the GDP are due to these variables, while the rest is due to other unstudied factors. The effect of agricultural output is negative, meaning that when agricultural output increases by one unit, the GDP will decrease by 0.728891 units. This is contrary to economic theory, but the reason is likely that agricultural output constitutes only a small portion of the GDP. As for the effect of the national income variable for the rest of the sectors, its effect was positive, meaning that by increasing the income of the rest of the sectors by one unit, the gross domestic product will increase by 0.187343 units.

IV. CONCLUSION

The recent droughts have led to a decrease in the volume of water allocated to agriculture, which has led to a decrease in total agricultural production and exports. In addition, Iraq's position as a downstream country puts it in a critical situation because it is negatively affected by the actions of countries located upstream of the Tigris and Euphrates rivers, which has led to a decrease in Iraq's water yields at a rate of up to one billion cubic meters annually, which leads to a reduction in water yields, and this has serious impacts on agricultural development and on global food security. The cultivated area in Iraq during the study period decreased clearly due to neglect of the agricultural sector and making it vulnerable to external challenges and flooding of the market, as well as the phenomenon of desertification. The agricultural domestic product has grown in a fluctuating manner, affected by the same factors, as well as the fluctuation of agricultural prices, the reliance of agriculture in many cases on conventional techniques, and the failure to apply the recommended quantities of fertilizers. The gross domestic product has developed clearly due to the growth of the rest of the sectors. The amount of water available to the agricultural sector has decreased in a worrying manner due to climate change and drought, as well as the construction of dams and cutting rivers by neighboring countries, which negatively affected the available quantities. Agricultural investments benefited from the changes that occurred after 2003 and grew clearly in addition to oil prices, but they began to decline after 2015 due to the decline in oil prices and the security situation, which was reflected in the reduction of investment allocations to the agricultural sector. These variables have a common effect, and one of them affects the other, and thus affects agricultural economic development, therefore, estimating them within the simultaneous equations is important, so there are three behavioral equations estimated using the simultaneous equations and using the Recursive model, which is the model in which all relative effects are unidirectional and the disturbances are uncorrelated and contains more feedback loops. The model was estimated using the ordinary least squares (OLS) method. From this it was shown that water clearly affects the expansion of cultivated areas, and the cultivated areas positively affected agricultural output as well as investments, while the value of agricultural output does not affect the GDP. This may be considered contrary to economic theory, but it is attributed to the deterioration of the agricultural sector and the weakness of its contribution to the GDP and thus all of these variables affected agricultural economic development. Accordingly, the research recommends the necessity of securing the amount of water available to the agricultural sector by opening serious negotiations with neighboring countries to guarantee Iraq's water share as well as confronting climate change, and adopting modern irrigation technologies such as sprinkler irrigation and hydroponics, which ensures improved water use efficiency, as well as applying the concept of integrated water management, and the application of crop compositions that contribute to maximizing the yield per unit of water, and the necessity of drawing up an agricultural policy that includes developing the agricultural sector and providing infrastructure that helps increase agricultural production, and the necessity of paying attention to agricultural legislation that is concerned with the issue of tenure.

CONFLICT OF INTEREST

The authors declare no conflicts of interest associated with this manuscript.

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