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WATER SCARCITY AND IMPACT ON SUSTAINABLE ECONOMIC DEVELOPMENT IN THE AGRICULTURAL SECTOR AND TOOLS TO ADDRESS IT IN IRAQ

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ABSTRACT

The study aims to use some strategies such as water footprint and water trade to confront the challenges of water scarcity to promote sustainable development in the agricultural sector and its development. In recent years, Iraq has been suffering from water scarcity due to the lack of water releases in the Tigris and Euphrates rivers as a result of their reduction by upstream countries such as Turkey and Iran. Water revenues in 2022 amounted to about 25.5 billion cubic meters after reaching about 93 billion cubic meters in recent years. Which requires working on proper water management, involving all stakeholders in making the necessary decisions, drawing up appropriate agricultural policies, and making use of water footprint concepts to determine which crops can be grown that need small amounts of water and have a good economic return that does not conflict with the level of self-sufficiency as well as using Virtual water trade to enhance water and food security and achieve sustainable development in the agricultural sector. Therefore, the government is requested to develop a plan to program water uses, determine the best ways to manage the water crisis, and name a high-level committee that takes responsibility for all water-related decisions.

Keywords: sustainable agricultural development, integrated management, Water footprint, virtual water.

الشحة المائية وأثرها على التنمية الاقتصادية المستدامة في القطاع الزراعي والادوات المستخدمة في معالجتها في العراق

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الخلاصة

يهدف البحث الى استخدام بعض الاستراتيجيات مثل البصمة المائية وتجارة المياه الافتراضية لمواجهة تحديات شحة المياه في العراق لتعزيز التنمية المستدامة في القطاع الزراعي وتطويره. حيث ان العراق في السنوات الأخيرة يعاني من شحة مائية بسبب قله الاطلاقات المائية في نهري دجلة والفرات نتيجة تخفيضها من قبل دول المنبع مثل تركيا وايران حيث بلغت الإيرادات المائية في عام 2022 حوالي 25.5 مليار متر مكعب بعد ان وصلت الى حوالي 93 مليار متر مكعب في السنوات السابقة مما تطلب العمل على إدارة المياه بشكل صحيح واشراك جميع أصحاب المصلحة في اتخاذ القرارات اللازمة ورسم السياسات الزراعية الملائمة والاستفادة من مفاهيم البصمة المائية لتحديد أي المحاصيل التي يمكن زراعتها والتي تحتاج الى كميات قليلة من المياه ولها مردود اقتصادي جيد ولا يتعارض مع مستوى الاكتفاء الذاتي كذلك استخدام تجارة المياه الافتراضية لتعزيز الامن المائي والغذائي وتحقيق التنمية المستدامة في القطاع الزراعي. لذا تتطلب من الحكومة ان تضع خطة لبرمجة استخدامات المياه وتحديد أفضل الطرق لإدارة الازمة المائية وتسمية لجنة رفيعة المستوى تأخذ على عاتقها جميع القرارات المتعلقة بالمياه.

الكلمات المفتاحية: التنمية الزراعية المستدامة، الإدارة المتكاملة، البصمة المائية، المياه الافتراضية.

INTRODUCTION

Iraq has been considered an agricultural country since ancient times due to the abundance of the basic components of agriculture, which are financial, human and natural resources. The area of Iraq is about 174.021 million dunums, of which arable land constitutes 28 million, representing 16.1% of the total area of Iraq. For irrigated lands, they amount 61.9% of the total actually cultivated lands. Irrigated agriculture is concentrated in the central and southern regions, while the percentage of irrigated lands is about 38.1% of the total cultivated lands in Iraq, and most of these lands are located in the north and northeast. Water resources consist of surface water represented by the Tigris and Euphrates rivers, the Shatt al-Arab, and lakes and their quantities vary from year to year depending on the variation in the quantities of water received from outside Iraq and the amounts of rain and snow falling (**CSO, 2021**). Water is the secret of life and every drop is a legacy from the present to future generations (**Mahmoodi, 2008**). The main user of fresh water around the world is agriculture, which represents about 70% of the water supply (**Jensen & Allen, 2016**). As for Iraq, it is about 83.12%. Therefore, water has become one of the important and vital issues for achieving economic development in general and agricultural development in particular, since water represents the basic basis for achieving food security and its necessity in the production of agricultural crops to satisfy human needs (**Salim, 2022**).The water shortage and the need of economic sectors for the purpose of continuing development processes, as well as cross-border conflicts and crises and international agreements on water, all of this requires improving the management of water resources and finding strategies that take it upon themselves to address the water shortage. In the recent years, the signs of water scarcity in Iraq have become clear, which led to the reduction of cultivated areas to confront this shortage and the adoption of areas that are irrigated on a daily basis to reduce the pressure on local water resources, which led to the migration of peasants and farmers and abandoning their lands. This migration has social, economic and environmental effects.

Aim of the study:

Using some strategies, such as water footprint and virtual water trading to confront the challenges of water scarcity in Iraq to promote and develop sustainable development in the agricultural sector.

Sustainable Agricultural Development:

Sustainability is defined as an environmental term that describes how biological systems remain diverse and productive over time. Sustainability in agriculture means the ability to continue production while preserving natural resources (**Arab Organization for Agricultural Development**). Agriculture is capable of managing resources successfully to meet human needs while maintaining and improving the environment (**Al-Hayali, 2019**). It is the process of managing and protecting the economic resource base and directing technical and institutional change in a way that ensures the achievement, continuity and satisfaction of human needs for current and future generations (**Al-Atabi & Al- Badri, 2014**). It can be defined as preserving the rights of present mountains without prejudice to the rights of future generations, which extends for a period wider than the period of conventional development plans. This is done through rational exploitation of natural resources and focusing on respecting and preserving the environment (**Bouihi, 2012**). However, if water supplies cannot meet demand, further development in the country will not be sustainable (**Dongare *et al*., 2024**).

Farmers are also very environmentally inefficient (**Jbara *et al*., 2018**). The extent to which agricultural development achieves its goals in the agricultural sector in general is measured by a set of indicators and standards, such as the ratio of agricultural output to gross domestic product. This criterion indicates that the higher it is, the more effective it is in agricultural development and the improvement in the level of agricultural output, as it reached its lowest value in Iraq for the period from 2000 - 2022, amounting to about 2.8% in 2018. The reason for the decline in value during this year was due to the circumstances that the country was going through, which led to the failure to exploit large areas on Mosul Island and some other governorates for agriculture. The highest value was 8.6% in 2002. There was a keenness on the part of most farmers to exploit their lands in that period because it was almost mainly linked to their livelihood and income and because there were no other job opportunities that they could resort to, the land was exploited as best as possible. The criterion of per capita agricultural production can also be used (**Al-Hayali, 2019**).

It is calculated by dividing the value of agricultural output valued at current prices by the population in that year, as the standard indicates that the higher its value, the better the condition of the farmer or farmer, given the increase in his income and the fair distribution of land, and thus there is development and improvement in agricultural development. The lowest

value was about 94,413 dinars in 2003, which was a year of transformation and turmoil in the situation inside Iraq. There was a significant decrease in the per capita share. The highest value was 371,722 dinars in 2013. As for the standard for the annual per capita share of water, the standard was calculated by dividing the amount of water. This standard reflects the amount of water resources available to each individual. The higher the standard indicates an improvement in the country's water security. These resources can be utilized in the process of building agricultural development, as the lowest annual water per person was 603.6 m^3/year in 2022.
Iraq faces a theoretical water scarcity that has decreased over the past years due to the reduction in water revenues from upstream countries. The highest annual water share per capita was in 2003, which reached 2774.8 m^3/year. It is noting that the average global per capita share is 1000 m^3/year (**El-Feky *et al*., 2021**). Therefore, the Iraqi people have been living in water poverty. It must be addressed and the best available means used to raise this level using integrated management of water resources, which the government's efforts must be combined with stakeholders and there must be public awareness of the importance of water and its effects on agricultural development projects through the use of methods that can rationalize water consumption.

It is no secret that there is a significant impact of the country's political situation on agricultural development plans and development. Therefore, sustainability is represented in the relationship or mutual influence between development and the environment, meaning that economic development takes into account the preservation and sustainability of the environment in order to achieve economic and social well-being for current and future generations (**Omar, 2020**; **Mohammed *et al.*, 2020**). The development of any sector must not take place in isolation from other sectors (**Maki, 2012**). The problem of weak agricultural production is not only determined by the lack of resources, but rather by their poor distribution and lack of optimal exploitation. Agricultural policies are one of the most important means that help manage resources and increase agricultural production. It is the management that accompanies sustainable agricultural development plans and programs and is the most important link in linking national programs and strategies. Implementation plans and responsible for achieving integration, exploiting resources, and providing food (**Mohamed *et al*., 2019; Husain & AlKhafaji, 2022**). Therefore, requires developing plans and drawing up policies that would prevent countries sharing the water from encroaching on Iraq's share and its international legal right to enhance its water security (**Al-Mansory, 2024**).

The ways to address water scarcity:

There are a group of solutions that can be used to reduce the severity of water scarcity and scarcity, and we can discuss some of them, such as:

Integrated Water Resources Management (IWRM):

IWRM has been defined by the Global Water Partnership as a process that promotes the coordination and management of water, land and related resources with a view to achieving the maximum possible economic and social well-being in an equitable manner prejudice Sustaining vital ecosystems (**Nahrain, 2023**). The Integrated Water Resources Management Index aims to achieve a sustainable balance between meeting the different water needs of users and maintaining the health of aquatic ecosystems (**Jønch & Clausen, 2004**). Components of integrated water resources management include coordination between sectors that require effective coordination, such as agriculture, industry, drinking water, and the environment, to ensure that the needs of all sectors are met and to avoid competition and conflict over water, while taking the needs and opinions of society into account. (**Alrwis *et al*., 2021**). Therefore, there must be integration between land management, surface and groundwater, and water-related interests upstream and downstream, which is known as the complete hydrological cycle (**Ibisch *et al*., 2016**). Water management is improving land productivity and water availability (**Alrwis *et al*., 2021**). It is not the annual availability of water that has the greatest impact on the economic development of countries, but rather the variation in available water resources in space and time. In other words, it is a country's ability to manage water, more than the abundance of its water resources that affects economic development (**Brown & Lall, 2006**). Non-governmental organizations and other civil society sectors should also be involved, all of whom have an important role to play in promoting access to water management, achieving a balance between conservation and development, making water an economic and social commodity, and preserving ecosystems (**Lenton & Muller, 2012**). It can be say that management Integrated Water Resources works to impart a spirit of cooperation and coordination between economic sectors to achieve their sufficiency of this rare and scarce resource during periods of drought or lack of water. Therefore, it requires integrated management of water resources in Iraq, and it becomes the government's first priority, especially since the water sector will play a vital role in the success of sustainable economic development goals, which makes the government's role major in effective coordination in cross-border management. The sources of the Tigris and Euphrates rivers are located in neighboring countries and stakeholders. Those who are interested in maintaining water revenues at the required level should help the state understand the state of its internal water resources and the potential issues that affect sustainable agricultural production, including the future behaviors that are expected to occur under different strategies in the region.

Water Footprint (WF): The concept of water footprint was first introduced by the scientist Hoekstra in 2002 (**Hoekstra, 2019**). It is a multi-dimensional concept that can be measured at the level of the individual, commodity, or any commercial or industrial entity, up to the state level (**Walaa & Khadiga, 2016**). It is a modern tool for measuring water consumption and the volume of polluted water. The concept of water footprint also relates to the fact that water is not completely returned to the environment or perhaps not in a clean state. This means that industries such as mining, business and agricultural use more water in the production process (**Guarino, 2017**). It is an indicator that takes into account direct (domestic water use) and indirect (water needed for the production of industrial and agricultural products) use by the consumer or producer (**Vanham & Bidoglio, 2013**). It is one of the concepts used in evaluating freshwater resources. The WF reflects how much, when and where water was used and the goal is to determine the water footprint per ton of production (m3/ton) of the crops that can be grown (**Ewaid et al., 2020**). Therefore, the water footprint of agricultural crops represents the total amount of water consumed in all stages of production of a particular agricultural crop (**Hoekstra, 2011**) and consists of (WF) the green, blue and gray water used in growing crops (**Hoekstra, 2014**). The blue water footprint represents fresh surface and groundwater and is an indicator of consumer use (**Hoekstra, 2011**). Likewise, the green water footprint indicates the consumption of rainwater (**Deepa & AL Hashim, 2021**). The water footprint indicates the volume of fresh water required to absorb the amount of pollutants given natural concentrations and water quality standards (**Franke *et al*., 2013; Hoekstra, 2019**). The aim of water footprints is to analyze how human activities or specific products are linked to the impacts of water scarcity and pollution and to see how activities and products can become more sustainable from a water perspective (**Hoekstra, 2011**). Water scarcity occurs when there is not enough water to meet demand, while economic scarcity is due to lack of investments that do not allow the natural resources in the region to be exploited efficiently (**Buccola, 2020**). Rapidly changing food systems and increasing concerns about water security underscore the need to better understand the quantity and quality of water used in food production to make informed policy decisions (**Harris *et al*., 2020**). Therefore, the water footprint provides us with the appropriate basis for making the appropriate decision whether or not to grow this crop based on the volume and type of water used during the crop's growth stages.

There is also an expectation that water scarcity will continue in Iraq, so it is important to take measures to reduce the water footprint, whether internal or external, by strengthening the management of water resources to ensure that water is used more efficiently. Determining the crops appropriate to Iraq's conditions requires taking into account the sustainability of water resources and achieving food security in effective and sustainable ways without compromising the country's sovereignty, which requires that the production of some crops be relatively close to self-sufficiency. Thus, it is preferable to expand the cultivation of wheat, even though its water footprint is higher than barley, amounting to (1876 and 1729) m^3/ton, respectively (**Ewaid *et al*., 2019**; **Jabaar and Abed 2023**). However, the wheat crop is considered a strategic crop linked to the livelihood of the majority of individuals, and therefore its cultivation can be expanded on non-irrigated lands. As for barley and yellow corn, the yellow corn crop depends on blue water because it is grown in the summer and there is no rain during this season in Iraq, and its water footprint is about 2793 m^3/ton (**Jabaar & Abed 2023**). It is possible to bypass these two crops and increase the quantities imported from them. As for rice, its water footprint is very large, amounting to about 3072 m^3/ton (**Ewaid *et al*., 2021**). Also, it depends entirely on blue water, so its cultivation can be limited to limited areas and very small areas in order to preserve the Iraqi varieties because they are rare. As for the date crop, it is important despite its medium water footprint, amounting to about 2205 m3/ton (**Sporchia *et al*., 2023**). However, through modern technologies and rationalization of water, it can be grown on a limited scale.

Virtual water:

Virtual water (VW) means the volume of water included in the good as a result of the production process. It is a term that was first proposed in the nineties of the last century by the British geographer Tony Allan, who defined it as the amount of water necessary to produce a good or service (**Allan, 2002**). He saw the possibility of importing water as a valid means and

solution to the problems of water shortages in the Middle East (**Buccola, 2020**). The demand for water in the world is increasing rapidly with the growing population, the virtual or economic circulation does not take place through the transfer of actual water across borders, but rather the amount of water that is consumed indirectly in crop production is calculated or estimated. If this crop is exported, the virtual water turns into indirect trade, representing the import of the amount of water that was used in production (**Rosegrant et al., 2002**).
For countries that suffer from water scarcity, it may be beneficial to import virtual water by importing water-intensive products, thus relieving pressure on local water resources (**Chapagain & Hoekstra, 2003**). The production of goods and services requires water, whether the product is vegetable or industrial. (**Hoekstra, 2019**). The concept of virtual water is key not only because it allows for a more complete assessment of the impact of human activities on the environment, but also through international food trade, countries experiencing water scarcity can conserve their domestic water resources by actually importing water through trade International Foods (**Buccola, 2020**). So, if a country exports a water-intensive product to another country, it exports water by default. Virtual water is also called combined water or external water which refers to the fact that importing virtual water into a country means using the external water of the importing country. Therefore, external waters must be added to the country's domestic waters (**Haddadin *et al*., 2003**).

It is interesting for water-scarce countries to achieve water security by importing water-intensive products rather than producing all water-requiring products domestically. In contrast, water-rich countries can benefit from their abundant water resources by producing water-intensive products for export purposes (**Hoekstra, 2003**). Therefore, virtual water trade is used as a tool to achieve regional water security and the political argument put forward by Tony Allan from the beginning is that virtual water trade can be a tool in solving geopolitical problems and even preventing wars over water (**Allan, 2002**). In addition, to the political dimension, there is the economic dimension, and the economic argument behind virtual water trade is that, according to international trade theory, countries should export products in which they have a comparative or comparative advantage in production. It should import products that it has a relative disadvantage (**Wichelns, 2001**). By definition, virtual water means the water contained in the product, that is, the water consumed during the production process. Since the water needs for food are the highest ever, a person needs between 2 and 4 L of water per day to meet biological needs (drinking water) and about 1,000 times more to produce food. This is why the concept of virtual water is so important. Therefore, a country that imports one million tons of wheat increases its water resources by one billion cubic meters of water. The virtual water balance is the sum of virtual water exchanged during a certain period of time for a country. It represents the difference between the virtual water content of exports and imports according to the needs of each crop. If what the country exports exceeds what it imports, it represents a deficit, but if the import exceeds the export. It is also representing a virtual water surplus that the difference between the water footprint of consumption (WFcons) and the water footprint of production (WFprod) of agricultural products (**Vanham, 2013**). The total quantities of virtual water imported into Iraq for the period from 2000 - 2022 ranged between a minimum and a maximum of (0.671 - 23.621) billion meters for the years 2020 and 2011, respectively.

The total quantities of virtual water exported ranged between (0.001- 1.758) billion meters for the years 2016 and 2007, respectively. It indicates that there is a surplus of virtual water. The quantities of virtual water imported are greater than the exported for all years, as the surplus ranged between (0.187 - 23.518) billion cubic meters for the years 2021 and 2011, respectively. The virtual water estimate also indicates the amount of water that crops need for their growth and production during different growth stages. Virtual water estimation can also help identify gaps and challenges in water resource management and identify opportunities for improvement. It is making a simple comparison between the average water revenues in the Tigris and Euphrates rivers during the period from 2000- 2022, amounting to about 47.88 billion meters, and the amount of water received in 2022, which is the lowest water revenues during the period, amounting to 25.5 billion meters, we notice that there is a large deficit of 22.38 billion meters. However, the virtual water balance is free of water deficit in all years, but there is a surplus even in 2022, when the surplus reached about 3.078 billion meters. The reason is due to the virtual water trade, which shows the importance of virtual water and its impact on the heart of water balances. It is a step that those interested in drawing up agricultural policy can benefit from in making decisions related to water, agricultural plans, and choosing the crops that are most appropriate for the conditions that Iraq is currently experiencing and in the future.

CONCLUSIONS

The study concludes that:

1. Use good management of water resources can overcome the effects of this scarcity in economic and social terms for a large segment of society represented by peasants and farmers, and enhance water and food security.
2. It is possible to identify crops that need small amounts of water to grow and stay away from water-intensive crops, thus saving large amounts of water that can be used to grow other crops that support the national economy.
3. One of the methods that used to confront the decrease in water imports is the use of virtual water trade, which works to enhance national water security.
4. The Iraqi people have been living in water poverty in recent years, which is less than 1000 m^3/year, which requires concerted efforts to increase the level to enhance water and food security.

RECOMMENDATIONS

1. The government must develop a plan to program water uses, determine the best ways to manage the water crisis, and name a high-level committee that takes responsibility for all water-related decisions.

2. Spreading awareness among people of the importance of water, especially in the current period, preserving this national wealth and rationalizing its consumption in all economic sectors.
3. It is necessary to set a price for water, given that water is an economic commodity that must be preserved by consumers, which leads to rationalization of water consumption.
4. Iraq suffers from a lack of water imports, so it must follow an agricultural policy based on the involvement of all stakeholders in making decisions related to agricultural production.

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