An economic study of the most important indicators of virtual water and the water needs of strategic crops in Iraq for the period (2000-2022).

Sura Sael Abdul[1], Bassem Hazem Hamid Al-Badri[2] and Mohammad Omar Sharif[3]
[1,3]College of Agriculture, Tikrit University, Tikrit, Iraq.
[2]College of Agricultural Engineering Sciences, University of Baghdad, Baghdad, Iraq.

[1]E-mail: sura84@uomosul.edu.iq

Abstract:

One of the problems facing Arab countries, including Iraq, is the problem of fresh water due to the population increase that has occurred in recent years with limited water resources. In this research, the focus was on the principle of virtual water and how to benefit from this principle in the field of the agricultural sector, by calculating the amount of virtual water in relation to a group of agricultural crops, which are considered important strategic crops in Iraq, hypothetical water indicators have been estimated due to the importance of these criteria in determining the amount of increase and decrease in the area of crop cultivation and in line with foreign trade policy. The study has reached the average water requirement for crops (Wheat, barley, rice, corn) during the study period respectively (2976.08, 3779.00, 11451.81, 9307.64) m3/ton, and the average amount of water used in local crop production is (8.07, 2.82, 2.47, 2.71) billion cubic meters, and that The average amount of virtual water imported for crops is (2.92, 0.001, 14.94, 0.001) thousand dollars. The study reached a set of recommendations to include the virtual water strategy within water resources departments and link agricultural policies to water and economic policies to achieve the aim of water and food security.

Keywords: virtual water, strategic crops, water needs, water rationing

introduction:

Although 71% of the world's surface is covered by water, the amount of water available to humans is very limited to meet all needs such as biological activities, agricultural irrigation, and energy production. Factors such as global climate change, spatial and temporal

ISSN 2072-3857

variations in rainfall and water resources, and increased human activity have led to Compared to previous years, increased pollution in surface and groundwater and rapid population growth have created negative pressures on the limited available water resources and caused risks in many countries. In line with this, the number of national and international agreements, research and practices has increased rapidly in recent years to protect water resources. Studies have begun on water management and the introduction of the concepts of virtual water transportation and trade [2]. Virtual water is the water included in the product, good, or service, not in the real sense, but in the virtual sense. It refers to the water needed to produce these products or goods, as it is called. Sometimes "external water", which refers to the virtual water imported to a country, which means that this water is used in the importing country and added to the country's "original water" [8] as a large amount of water resources can be saved if crops are grown in Areas with low virtual water content and then transferring it to areas with higher virtual water content for consumption. On the other hand, countries with abundant water make profits by exporting these products [5]. The assumption of virtual water trade is based on the fact that all water sources It has the same value, and moving towards less water-intensive activities is often not a good option from an economic standpoint. This concept does not provide any information about whether water resources are being used sustainably or not, and therefore this trade has limited value to support environmental and political decisions. [6] and it should be noted that there are a number of studies that have dealt with applications of the concept of virtual water trade, such as a study in 2024 that odey presented a research entitled Measuring the relationship between resources: virtual water flows, water stress indicators, and the unsustainable import rate in Mashhad. Grain trade in South Korea, where the study aimed to evaluate the temporal development of virtual agricultural water trade in South Korea for several crops (wheat, corn, and soybeans) using a method that evaluates virtual water flows. Al-Emadi also presented in 2022 a study entitled An Economic Study of the Water Footprint and Virtual Water of the Most Important Food Imports. For Iraq, the study aimed to identify the concept of water footprint and virtual water trade and how these two concepts can be used to achieve water abundance. In 2022, Muhammad presented a study on the role of virtual water trade in water challenges in the Middle East, which aimed to identify the truth about the importance of virtual water as a tool. To conserve water resources and increase the efficiency of their use, Ehghanpir D and Azrafshan B presented a research in 2020 entitled Application of the water footprint, virtual water trade, and the economic value of the water footprint of citrus products in Hormuzgan province in Iran. The study aimed to estimate virtual water at the provincial level and determine priorities for citrus production[5] A study that aimed to evaluate the water footprint of wheat and virtual water trade, a case study of Turkey for the period 2008 to 2019, where he used the Hosketra methodology.

research importance :

The study came to know water and the crops' need for water and not to determine the export and import of food crops. This is different from what the researcher stated. The importance is restated according to the researcher's study.

Research problem :

The problem of research is represented in water resources in Iraq and the expansion of scarcity in them and its negative effects on the production of strategic crops, especially wheat, barley, rice and corn, which represent a pillar of national security because of their importance in food

Research hypotheses

1- the water footprint and virtual water of the study crops must be calculated. This is an important determination for policy makers to know the agricultural foreign trade policy.

2- High virtual water exports contribute to the scarcity of water resources

Search aim:

The aim of the research is to identify the concept of virtual water as a tool for preserving water resources and raising the efficiency of their use, because the availability of fresh water has become an important and worrying matter, and the main aim is to benefit from the principle of virtual water in order to

Estimating the most important indicators of virtual water for the study crops: wheat, barley, rice, and corn. These criteria are not

ISSN 2072-3857

important in determining the amount of increase and decrease in the area of the studied crops in accordance with foreign trade policy.

Materials and methods:

To achieve its objectives, the research relied on the method of quantitative economic analysis of the available data, as some indicators and standards were applied in calculating the virtual water for the most important selected food commodities.

Virtual water and its most important indicators were calculated and estimated:

1- The amount of water used in local production

2- Water needs for crop production

3- The amount of virtual water imported

3- The virtual value of imported water

Results and discussion

Estimating virtual water and its indicators for the study crops in Iraq for the period from (2000-2022)

Table 1 Column (1) Water requirements = water rating per unit area/crop productivity.

Column (2) Quantity of water used in production = Quantity of production in tons * Water needs (total).

Column (3) Hypothetical amount of imported water = Quantity of imports in tons * Water needs (total).

Column (4) Value of virtual water imported = Quantity of virtual water imported * Unit price imported.

Table 2: Column (1) Water requirements = water rating per unit area/crop productivity.

Column (2) Quantity of water used in production = Quantity of production in tons * Water needs (total).

Column (3) Hypothetical amount of imported water = Quantity of imports in tons * Water needs (total).

Column (4) Value of virtual water imported = Quantity of virtual water imported * Unit price imported.

Table 4 : Column (1) Water requirements = water rating per unit area/crop productivity.

Column (2) Quantity of water used in production = Quantity of production in tons * Water needs (total).

ISSN 2072-3857

Column (3) Hypothetical amount of imported water = Quantity of imports in tons * Water needs (total).

Column (4) Value of virtual water imported = Quantity of virtual water imported * Unit price imported.

Wheat :

By studying and reviewing the data in Table (1) and Figures (1), (2), (3) and (4), it becomes clear that the water needs in wheat production ranged between a minimum of about (1456.94) m3/ton in 2001 and a maximum of about (5841.50) m3/ton in 2004 because it was a year with little rain and therefore wheat production there was less than usual, with an average of about (2976.08) m3/ton, and the amount of water used in wheat production ranged between a minimum of (0.98) billion cubic meters per year. 2000, as the reason is due to the operation of dams and resistance reservoirs in the upper rivers shared with Turkey, Syria, and Iran, which led to a decrease in the water share in Iraq’s imports and its fluctuation, which caused damage to agricultural crops, in addition to a decrease in the areas of cultivated land, while the upper limits of the amount of water used in crop production were reached. The aforementioned (13.14) billion cubic meters in 2020, as the reason for this lies in the combination of a number of factors, including the state’s adoption of lined irrigation projects with electronic regulators, the rise in groundwater levels following the melting of snow, the improvement of weather conditions, and the rise in rainfall rates that contributed to achieving the aforementioned upper limit, with an average of (8.07 billion cubic meters, and the amount of virtual water imported ranged between a minimum of (0.0044) billion cubic meters in 2001 and a maximum of (13.39) billion cubic meters in 2008, with an average of (2.9277) billion cubic meters. The value of virtual water imported ranged between The lowest was about (0.61) thousand dollars in 2001 and the highest was about (2774.41) thousand dollars in 2011, and the average was (735.12) thousand dollars

ISSN 2072-3857

Table (1) Virtual water and its indicators for wheat crop in Iraq for the period (2000-2022)

Virtual value of imported water (thousand dollars)	**Unit price of wheat**	**Quantity of virtual water imported (billion m3)**	Quantity of water used in production **(billion m3)**	**Water requirements (m3/ton)**	**years**
0.95	117	0.0081	0.98	2558.68	2000
0.61	139	0.0044	1.32	1456.94	2001
1.35	142	0.0095	10.21	3943.95	2002
1.30	151	0.0086	10.60	4552.94	2003
21.45	144	0.1489	10.70	5841.51	2004
7.94	176	0.0451	3.96	1779.31	2005
314.62	247	1.2738	9.36	4486.96	2006
320.52	299	1.0720	9.74	4422.86	2007
2745.63	205	13.3933	5.67	4519.71	2008
2280.64	227	10.0469	5.60	3293.62	2009
1736.91	301	5.7705	8.55	3111.56	2010
2774.41	304	9.1264	8.87	3159.18	2011
1830.70	295	6.2058	7.84	2558.68	2012
1592.35	265	6.0089	11.20	2680.52	2013
595.55	205	2.9051	13.04	2580.00	2014
157.80	172	0.9174	5.73	2165.03	2015
57.47	176	0.3265	5.69	1865.06	2016
220.33	207	1.0644	6.48	2180.28	2017
858.30	206	4.1665	4.85	2227.34	2018
289.21	230	1.2575	9.57	2203.56	2019
672.55	299	2.2493	13.14	2106.12	2020

ISSN 2072-3857

320.13	406	0.7885	9.86	2327.82	2021
107.10	198	0.5409	12.71	2428.24	2022
735.12		2.9278	8.07	2976.08	**Average**
0.61		0.0044	0.98	1456.94	**minimum limit**
2774.41		13.3933	13.14	5841.51	**Maximum limit**

Source: Calculated by the researcher according to the equations:

Figure (1) Water requirements for the wheat crop in Iraq for the period (2000-2022)

Source: From the researcher’s work based on Table (1).

Figure (2) The amount of water used in local production of wheat in Iraq for the period (2000-2022)

Source: From the researcher’s work based on Table (1).

Figure (3) The hypothetical amount of water imported for the wheat crop in Iraq for the period (2000-2022)

Source: From the researcher’s work based on Table (1).

Figure (4) The value of the hypothetical water imported for the wheat crop in Iraq for the period (2000-2022)

Source: From the researcher’s work based on Table (1).

barley:

By studying, and reviewing the data in Table (2) and Figures (5), (6), (7) and (8), it becomes clear that the water needs in barley production ranged between a minimum of about (1925) m3/ton in the year 2016 a maximum of about (10266.67) m3/ton in 2000 because it was a year with little rain and therefore barley production was less than usual, with an average of about (3779) m3/ton, and the amount of water used in barley production ranged between a minimum of (0.50) billion cubic meters per year. 2018 This is due to the

ISSN 2072-3857

deterioration of irrigation projects in Iraq, especially the northern governorates, due to wars and the lack of interest in their regular maintenance, which disrupted several units of these projects, amounting to about 35% of the total number of operating units, in addition to the decrease in rainfall rates in the aforementioned year. The results of the same table showed that The maximum amount of water used in barley production reached (4.83) billion cubic meters in 2002, due to the conditions of the economic blockade imposed on Iraq and its closure to the outside world, which led to agricultural policy makers making exceptional efforts in developing local agriculture, including irrigation projects. Which made the aforementioned quantity reach its maximum with an average of (2.82) billion cubic meters, and the amount of virtual water imported ranged between a minimum of (0) billion cubic meters from 2001 to 2017 and a maximum of (0.0021) billion cubic meters in 2000, With an average of (0.0001) billion cubic metres, the value of virtual water imported ranged between a minimum of about (0) thousand dollars from 2001 to 2014 and a maximum of about (0.2743) thousand dollars in 2000, with an average of (0.0169) thousand dollars.

Table (2) Virtual water and its indicators for the barley crop in Iraq for the period (2000-2022)

Virtual value of imported water ((thousand dollars	Unit price of barley	Quantity of virtual water imported ((billion m3	Quantity of water used in domestic production ((billion m3	Water requirements ((m3/ton	years
0.2743	131.6	0.0021	4.11	10266.67	2000
0.0000	134.222	0.0000	4.42	8034.78	2001
0.0000	136.394	0.0000	4.83	4678.48	2002
0.0000	128.92	0.0000	3.93	4562.96	2003
0.0000	124.829	0.0000	3.54	4400.00	2004
0.0000	129.825	0.0000	3.93	5205.63	2005
0.0000	148.503	0.0000	3.77	4106.67	2006

ISSN 2072-3857

0.0000	245.473	0.0000	4.07	5435.29	2007
0.0000	255.458	0.0000	1.59	3931.91	2008
0.0000	155.108	0.0000	1.45	2887.50	2009
0.0000	194.879	0.0000	3.72	3270.80	2010
0.0000	252.596	0.0000	2.66	3242.11	2011
0.0000	278.329	0.0000	1.95	2339.24	2012
0.0000	262.113	0.0000	3.01	3004.88	2013
0.0000	245.833	0.0000	4.22	3300.00	2014
0.0001	222.736	0.0000	0.98	1965.96	2015
0.0002	163.482	0.0000	0.96	1925.00	2016
0.0002	190.579	0.0000	0.73	2415.69	2017
0.0336	259.567	0.0001	0.50	2602.82	2018
0.0235	235.783	0.0001	3.32	2186.98	2019
0.0000	204.896	0.0000	4.16	2369.23	2020
0.0256	246.913	0.0001	0.64	2400.00	2021
0.0307	321.34	0.0001	2.41	2384.52	2022
0.0169		0.0001	2.82	3779.00	**Average**
0.0000		0.0000	0.50	1925.00	**minimum limit**
0.2743		0.0021	4.83	10266.67	**Maximum limit**

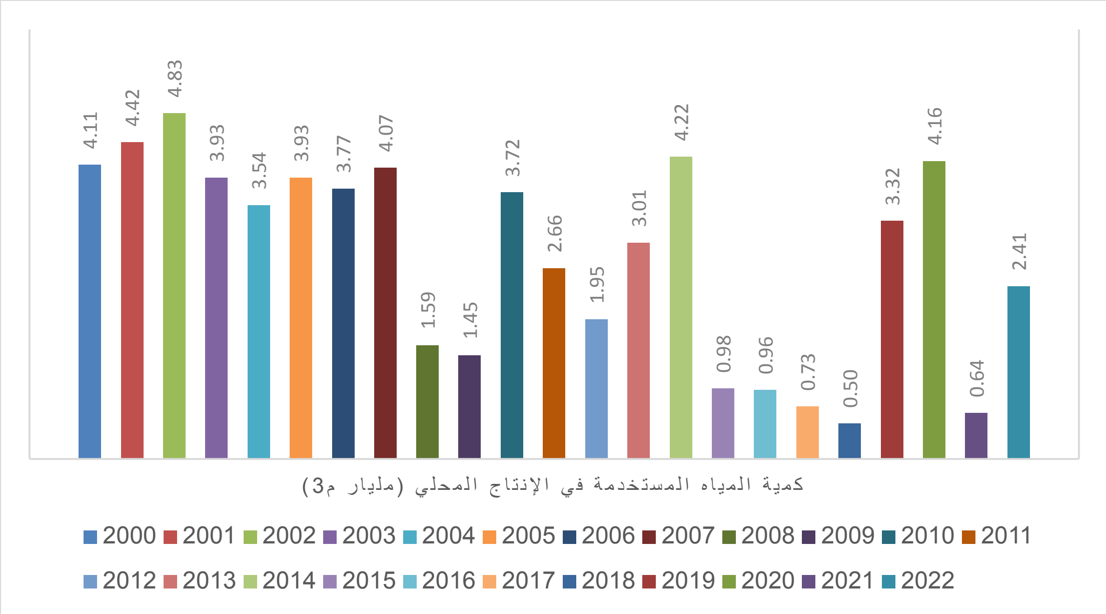
Source: Calculated by the researcher according to the equations:

Figure (5) Water requirements for the barley crop in Iraq for the period (2000-2022)

Source: From the researcher's work based on Table (2).

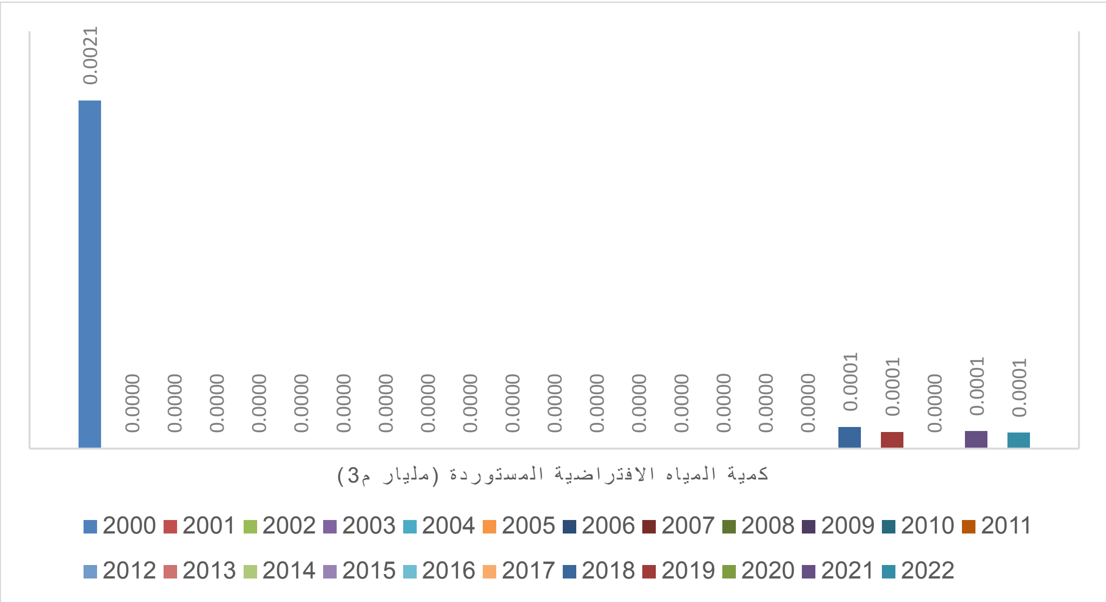
ISSN 2072-3857

Figure (6) The amount of water used in local production of barley in Iraq for the period (2000-2022)



Source: From the researcher's work based on Table (2).

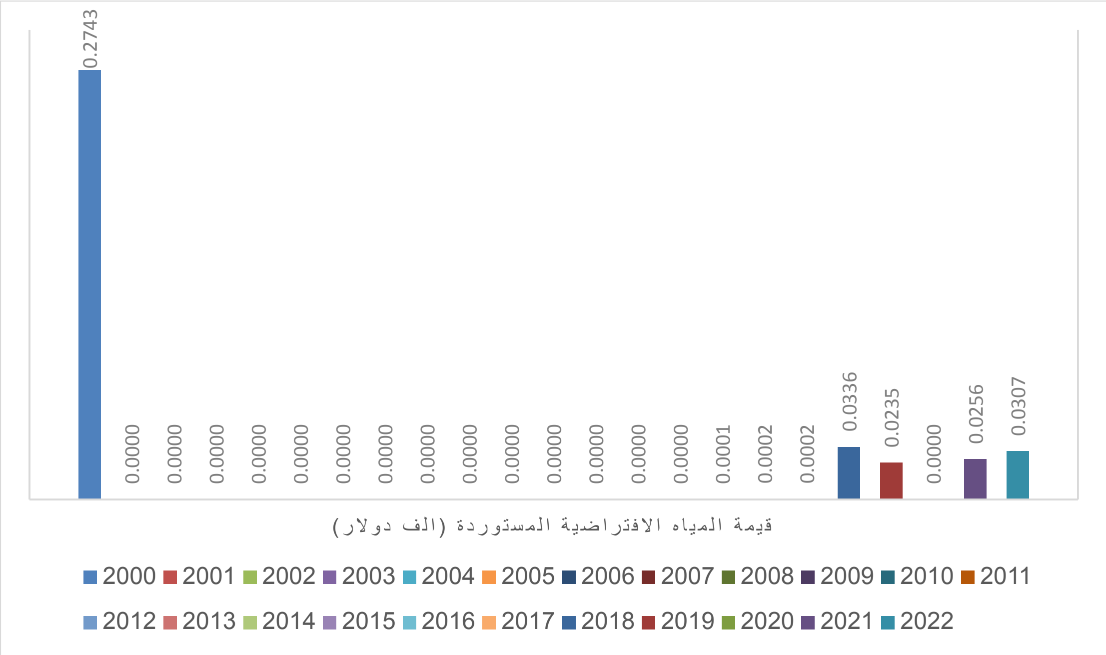
Figure (7) The hypothetical amount of water imported for the barley crop in Iraq for the period (2000-2022)



Source: From the researcher's work based on Table (2).

ISSN 2072-3857

Figure (8) The value of the hypothetical water imported for the barley crop in Iraq for the period (2000-2022)



Source: From the researcher's work based on Table (2).

rice:

By studying, , and reviewing the data in Table (3) and Figures (9), (10), (11), and (12), it becomes clear that water needs in rice production ranged between a minimum of about (6327.06) m3/ton in 2014 and a maximum of about (53,780) m3/ton in 2000, with an average of about (11,451.81) m3/ton, and the amount of water used in rice production ranged between a minimum of (0.17) billion cubic meters in 2018, as the reason for this is due to the policy of Turkey and Syria aimed at developing their agricultural projects, as It cultivated 2.4 million hectares in the Euphrates Basin and about 1 million hectares in the Tigris Basin, which resulted in a deficit in revenues from the two rivers, which reflected its impact in a decline in the Iraqi water share to the extent mentioned above, while our water share witnessed an increase until it reached its maximum level of about (4.12). One billion cubic meters in 2019, as the reason for this is the increase in water imports from upstream countries, as well as the improvement in weather conditions and rainfall rates and their increase compared to previous years, with an average of (2.47) billion cubic metres, and the amount of virtual water imported ranged between a minimum of (0.06) billion cubic meters in 2000 and a maximum of (72.33) billion cubic meters in 2021, with an average of (14.94) billion cubic meters. The value of imported virtual water ranged between a minimum of about (13.29) thousand dollars in 2000 and a maximum of about (28424.54) thousand dollars. In 2022, the average amounted to (5886.16) thousand dollars.

Table (3) Virtual water and its indicators for rice crops in Iraq for the period (2000-2022)

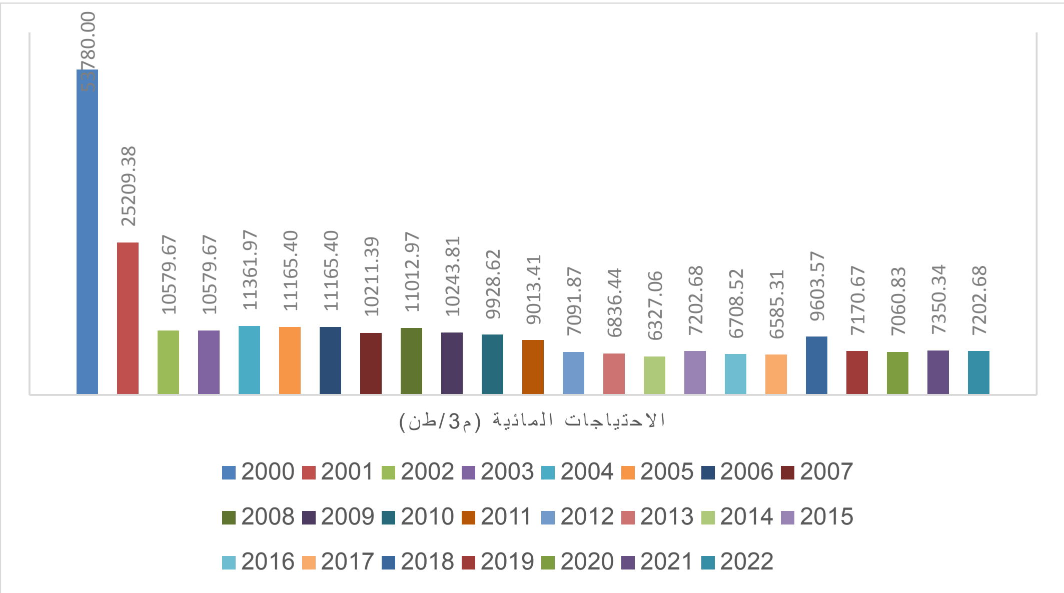
Virtual value of imported water (thousand (dollars	Unit price of rice	Quantity of virtual water imported (billion (m3	Quantity of water used in domestic production ((billion m3	Water requirements ((m3/ton	years
13.29	206	0.06	3.23	53780.00	2000
6959.91	216	32.22	3.23	25209.38	2001
3048.81	248	12.29	2.64	10579.67	2002
908.11	198	4.59	0.95	10579.67	2003
1762.17	238	7.40	2.84	11361.97	2004
2652.50	286	9.27	3.45	11165.40	2005
4526.22	305	14.84	4.05	11165.40	2006
2450.21	326	7.52	4.01	10211.39	2007
7559.42	650	11.63	2.73	11012.97	2008
6266.71	555	11.29	1.77	10243.81	2009
5453.24	489	11.15	1.55	9928.62	2010
5492.58	543	10.12	2.12	9013.41	2011
5526.69	563	9.82	2.56	7091.87	2012
4558.84	506	9.01	3.09	6836.44	2013
2490.31	423	5.89	2.55	6327.06	2014

ISSN 2072-3857

2755.39	386	7.14	0.79	7202.68	2015
2453.30	396	6.20	1.22	6708.52	2016
2287.88	399	5.73	1.75	6585.31	2017
4553.31	421	10.82	0.17	9603.57	2018
3866.94	418	9.25	4.12	7170.67	2019
3524.48	497	7.09	3.28	7060.83	2020
27846.74	385	72.33	3.11	7350.34	2021
28424.54	418	68.00	1.68	7202.68	2022
5886.16		14.94	2.47	11451.81	**Average**
13.29		0.06	0.17	6327.06	**minimum limit**
28424.54		72.33	4.12	53780.00	**Maximum limit**

Source: Calculated by the researcher according to the equations:

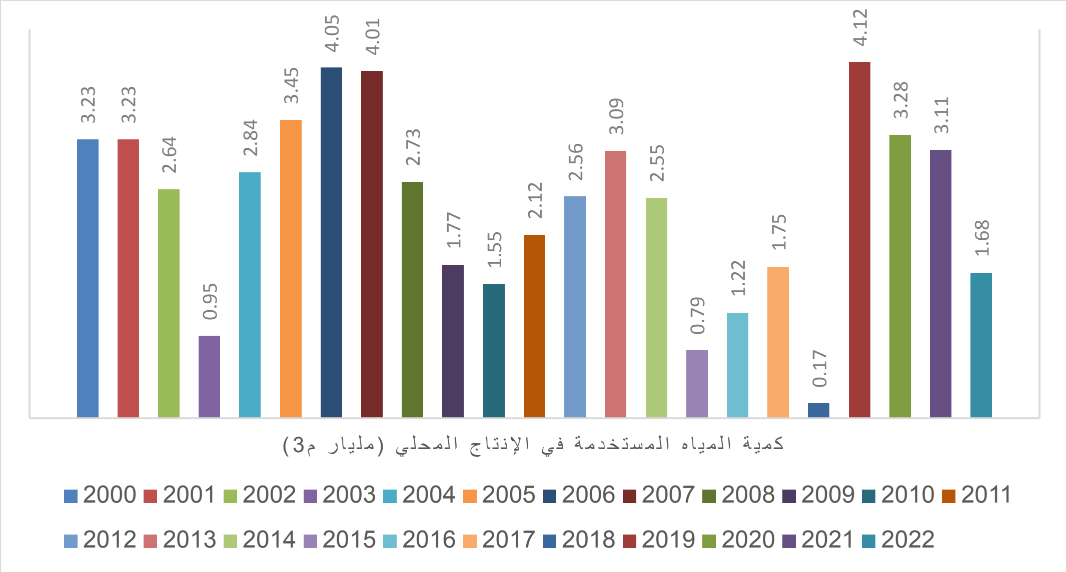
Figure (9) Water requirements for rice crops in Iraq for the period (2000-2022)



Source: From the researcher's work based on Table (3).

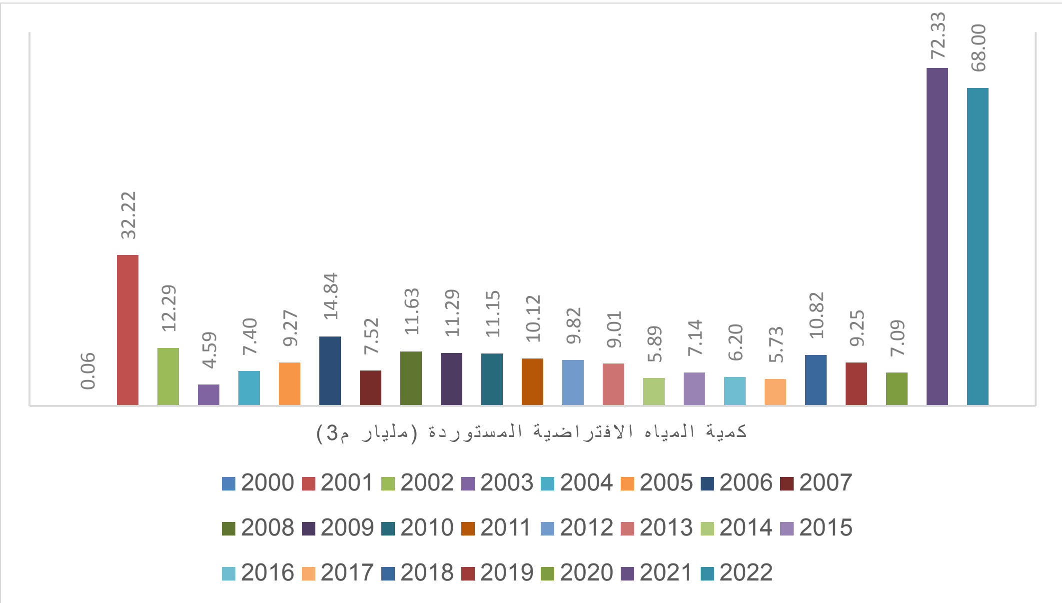
ISSN 2072-3857

Figure (10) The amount of water used in local production of rice in Iraq for the period (2000-2022)



Source: From the researcher's work based on Table (3).

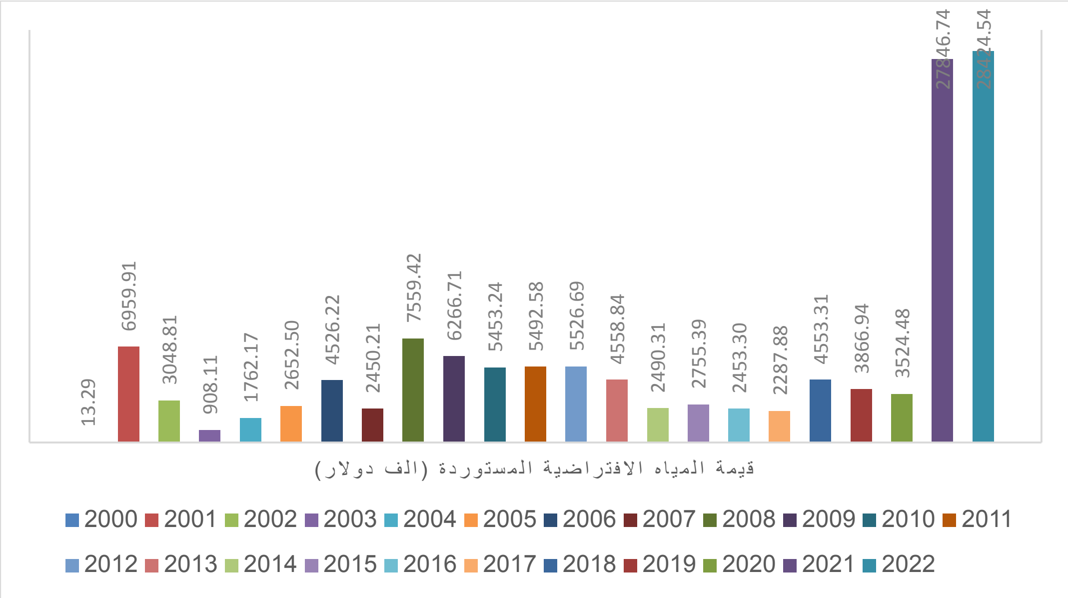
Figure (11) The hypothetical amount of water imported for the rice crop in Iraq for the period (2000-2022)



Source: From the researcher's work based on Table (3).

ISSN 2072-3857

Figure (12) The value of the hypothetical water imported for the rice crop in Iraq for the period (2000-2022)



Source: From the researcher's work based on Table (3).

corn:

By studying, reviewing and reviewing the data in Table (4) and Figures (13), (14), (15) and (16), it becomes clear that the water needs in corn production ranged between a minimum of about (5110) m3/ton in 2021 and a maximum of about (32273.68) m3/ton in 2000 average of about (9307.64) m3/ton, and the amount of water used in corn production ranged between a minimum of (1.23) billion cubic meters in 2018, as the reason for this is insufficient surface water resources. And underground water, which is often used in growing corn, was accompanied by bad weather conditions, which reflected its impact in the decrease in the crop's share of water resources to the aforementioned level, while the maximum amount of water used in producing the same crop was (4.83) billion cubic meters in 2013. This is due to This is due to improved weather conditions and an increase in the levels of surface and groundwater used to irrigate the crop under study, with an average amounting to (2.71) billion cubic metres. The amount of virtual water imported ranged between a minimum of (0) billion cubic meters from 2000 to 2010 and a maximum of (0.0048). (billion cubic meters in 2019, with an average of (0.0012) billion cubic metres. The value of the virtual water imported ranged between a minimum of about (0) thousand dollars from 2000 to 2010 and a maximum of about (0.8559) thousand dollars in 2022, with an average of (0.2149).) one thousand dollars.

Table (4) Virtual water and its indicators for yellow maize crop in Iraq for the period (2000-2022)

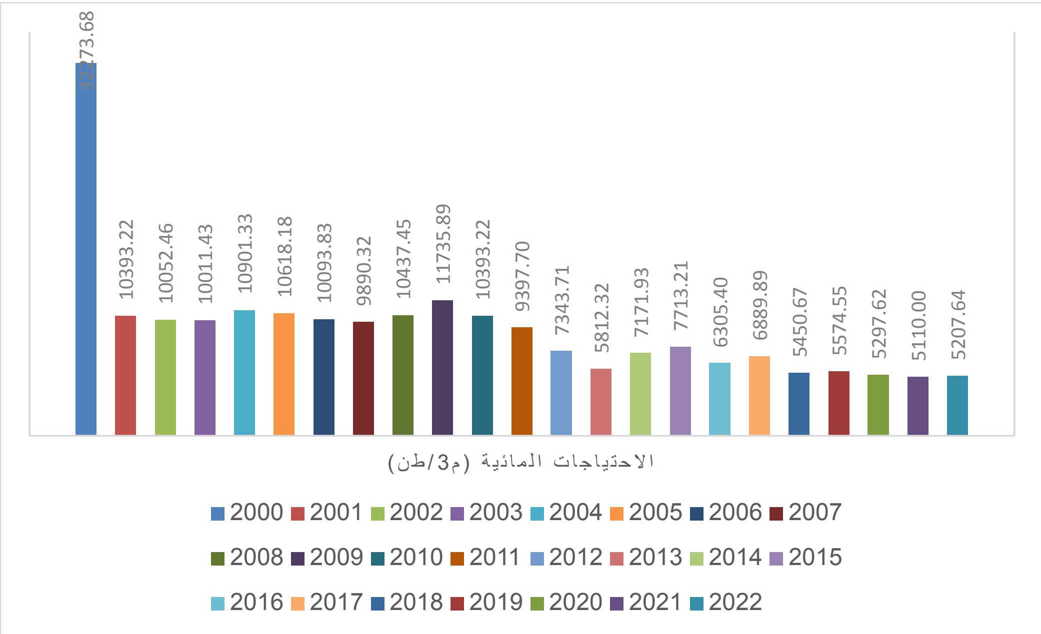
Virtual value of imported water (thousand (dollars	Unit price of corn	Quantity of virtual water imported (billion (m3	Quantity of water used in domestic production ((billion m3	Water requirements ((m3/ton	years
0.0000	109.28	0.0000	1.78	32273.68	2000
0.0000	137.24	0.0000	2.41	10393.22	2001
0.0000	141.8	0.0000	2.49	10052.46	2002
0.0000	145.4	0.0000	2.33	10011.43	2003
0.0000	155.1	0.0000	4.53	10901.33	2004
0.0000	151.6	0.0000	4.26	10618.18	2005
0.0000	170.5	0.0000	4.03	10093.83	2006
0.0000	218.7	0.0000	3.80	9890.32	2007
0.0000	224.3	0.0000	3.01	10437.45	2008
0.0000	198.2	0.0000	2.79	11735.89	2009
0.0000	185.4	0.0000	2.77	10393.22	2010
0.3477	183.2	0.0019	3.15	9397.70	2011
0.2730	184.1	0.0015	3.70	7343.71	2012
0.1140	176.3	0.0006	4.83	5812.32	2013
0.0147	178.1	0.0001	2.07	7171.93	2014
0.0917	180.13	0.0005	1.41	7713.21	2015
0.3256	185.4	0.0018	1.64	6305.40	2016

ISSN 2072-3857

0.3202	182.3	0.0018	1.28	6889.89	2017
0.2950	179.66	0.0016	1.23	5450.67	2018
0.8559	177.87	0.0048	2.64	5574.55	2019
0.7417	181.35	0.0041	2.22	5297.62	2020
0.7944	184.61	0.0043	1.91	5110.00	2021
0.7684	179.48	0.0043	2.07	5207.64	2022
0.2149		0.0012	2.71	9307.64	**Average**
0.0000		0.0000	1.23	5110.00	**minimum limit**
0.8559		0.0048	4.83	32273.68	**Maximum limit**

Source: Calculated by the researcher according to the equations:

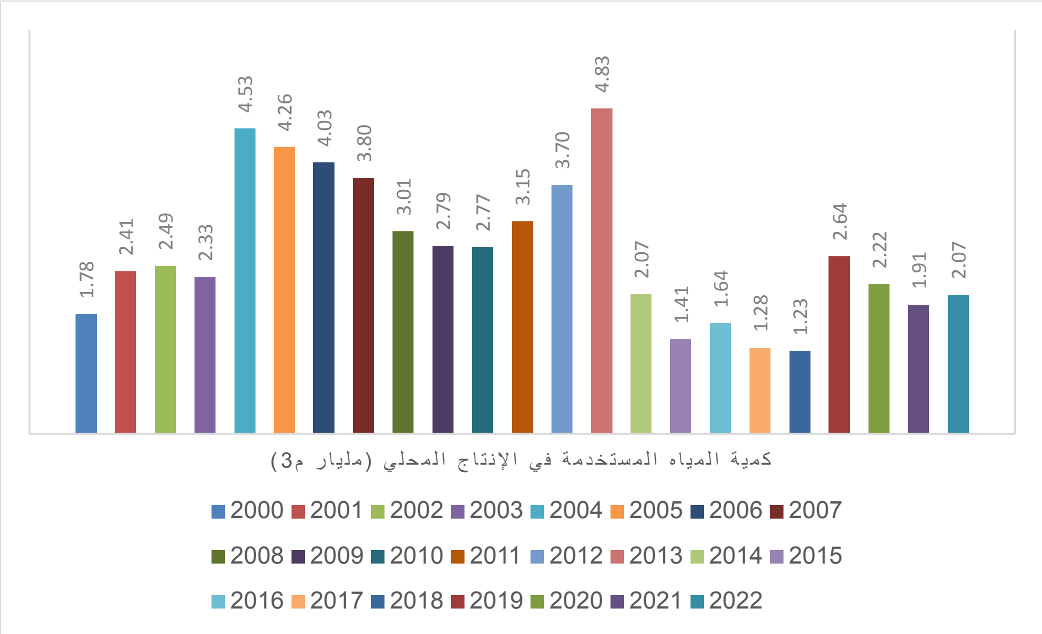
Figure (13) Water requirements for the corn crop in Iraq for the period (2000-2022)



Source: From the researcher's work based on Table (4)

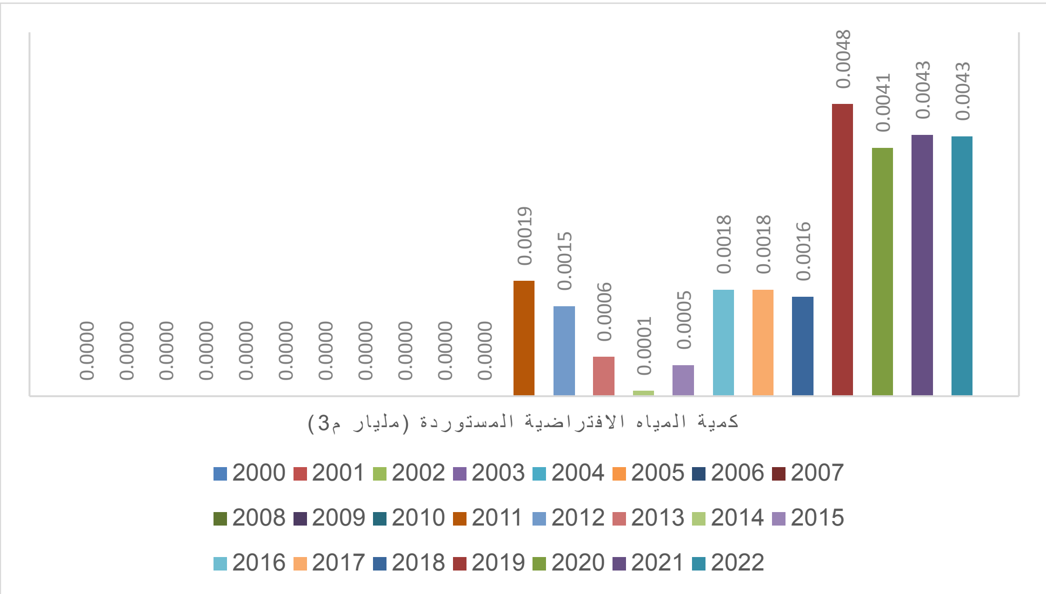
ISSN 2072-3857

Figure (14) The amount of water used in local production of yellow maize in Iraq for the period (2000-2022)



Source: From the researcher's work based on Table (4).

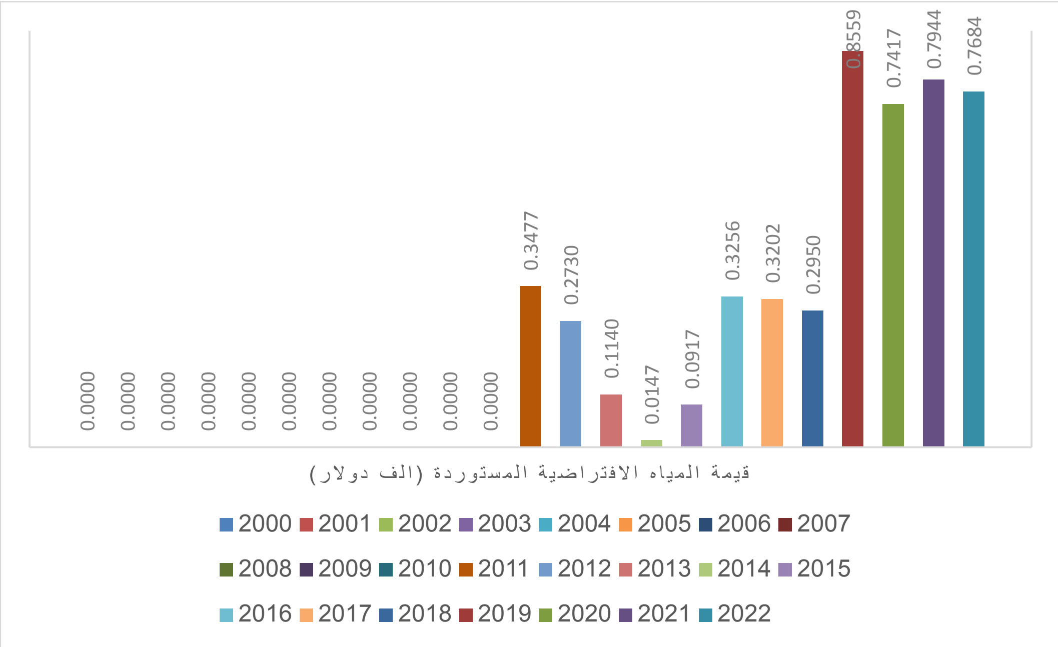
Figure (15) The hypothetical amount of water imported for the corn crop in Iraq for the period (2000-2022)



ISSN 2072-3857

Source: From the researcher's work based on Table (4).

Figure (16) The value of the hypothetical imported water for the corn crop in Iraq for the period (2000-2022)



Source: From the researcher's work based on Table (4).

Conclusions:

Grain crops (wheat and rice) in Iraq are water-consuming crops, and therefore their water footprint is high and their virtual water content is also high. Thus, they constitute a large burden on water resources, especially since they are crops of large and widespread use.

There is a decrease in the water supply in both Iraq and Egypt, as they are among the countries that are subject to the water policies of the upstream countries (upstream countries). This makes the concept of virtual water impose itself strongly on the agricultural foreign trade of the mentioned countries.

The rice crop in Iraq was one of the highest crops in terms of the virtual imported water index because it is one of the water-consuming crops and is widely used in the country in question.

Recommendations:

ISSN 2072-3857

- Paying attention to the concept of water footprint and virtual water in order to achieve efficient use of water resources.

- Including the virtual water strategy within water resources departments and linking agricultural policies with water and economic policies to achieve the aim of water and food security.

- Study the impact of changes in global prices of strategic crops on food needs and the food gap by adopting the principle of virtual water.

- Different countries must adopt different policies than others in achieving water and then food security

References:

1. Bazrafshan, O., & Dehghanpir, S. (2020). Application of water footprint, virtual water trade and water footprint economic value of citrus fruit productions in Hormozgan Province, Iran. Sustainable Water Resources Management, 6(6), 114
2. Ewaid, S. H., Abed, S. A., & Al-Ansari, N. (2020). Assessment of main cereal crop trade impacts on water and land security in Iraq. Agronomy, 10(1), 98
3. Mekonnen, M., & Hoekstra, A. Y. (2011). National water footprint accounts: the green, blue and gray water footprint of production and consumption. Volume 2: appendices
4. Muhammad, Amani Essam, (2022). The role of virtual water trade in water challenges in the Middle East. Journal of the Faculty of Economics and Political Science, 23 (4), 123-144.
5. Muratoglu, A. (2020). Assessment of wheat's water footprint and virtual water trade: a case study for Turkey. Ecological processes, 9, 1-16
6. Oki, T., & Kanae, S. (2004). Virtual water trade and world water resources. Water Science and Technology, 49(7), 203-209
7. Salam, Osama Muhammad, 2016, The Water Footprint of the United Arab Emirates, Water and Food Security Index, (I-Books), London, April.
8. sallamsama@hotmai.com

ISSN 2072-3857