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The Water Footprint and Virtual Water and Their Effect on Food Security in Iraq

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The Water Footprint and Virtual Water and Their Effect on Food Security in Iraq

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Abstract. The study aimed to explaining the concepts of water footprint and virtual water and how these two concepts could use to achieve water savings at the local level to meet the water supply deficit in Iraq, which is expected to increase in the coming years and influence of that on food security in Iraq by using these concepts when drawing production, irrigated and import plans in Iraq. The study aimed to studying the water footprint and virtual water and their impact on the foreign trade for wheat and rice crops during the period 2000-2022 and estimating the most important indicators of virtual water and the water footprint of the study crops due to the importance of these criteria in determining the amount of increase or decrease in the area of the studied crops, according to the foreign trade policy. This study was concluded that the average total water footprint of the wheat and rice crops during the study period is (20.27,13.89) billion m3 respectively, and the average percentage of dependence on external water resources for both crops are (20.49%,67.98%) respectively, and the average percentage of self-sufficiency in water resources are (79.51%,32.01%) respectively, and the average unit productivity of irrigation water for both crops is (0.19,0.10) kg/m3 respectively during 2000-2022.The average for the water needs of wheat and rice crops during the study period were (6.04,10.19) m3/kg respectively , the average amounts of water used in local production for both crops are (14.23,4.01) billion m3 respectively, the average amounts of virtual water imported for both crops are (6.19,10.03) billion m3 respectively, and the average value of the imported virtual water for both crops is (382,529) thousand dollars during the period 2000-2022. The study recommended to taking in account these concepts in plans of production and distributing irrigation water.

1. Introduction

Iraq suffers a severe declining catastrophic in water resources; due to disagreement share water to the neighboring countries Turkey, Syria and Iran. The water crisis has turned into a global problem with the effects of both economic and social growth and climate change. The researchers came up with important water concepts and terms that not only have an environmental dimension, but also carry important political and economic dimensions. Among these concepts, the concept of "water footprint" appeared in 2002 [1]. The water footprint defined as the amount of fresh water used in the production of a particular product, directly or indirectly, from the moment of production and processing of the raw materials constituting the product until it reaches to the final consumer [2]. Just as the production of any goods or service must require water, the water that enters the production process called virtual water, and the term virtual water means the amount of water requires producing a commodity [3,4]. The importance of foreign trade in the economies of different countries around world is due to the difficulty of dispensing any country from the rest of the world, regardless of their level of development and to live in isolation from the outside world and that developing countries vary in terms of natural or relative and absolute advantages that are specialized in producing certain types of goods and they works to export the surplus out of it, which allows them to cover the other imported goods[5]. The foreign trade in agricultural products form an important factor for developing countries, including Iraq, because of their great importance in the conduct of agricultural products to regional and global markets and supply their agricultural products from the world [6]. Foreign trade in general and in agricultural products in particular especially in Iraq has a vital role in growth of the agricultural sector, which it means that they have a long-term co integration relationship between agricultural growth and foreign trade [7]. Water is one of the important and vital issues to achieve economic development and agricultural development, and the world facing in recent times scarcity on the one hand and the growing of needs requirements of it on the other hand. Since the demand for food is in essence a demand for water in one way or another, which led to the emergence of the concept of virtual water [8]. The issue of water scarcity is one of the major challenges facing Iraq, due to the severe shortage of imports of the Tigris and Euphrates rivers and the lack of rain and snow [9]. Wheat and rice crops were chosen from among the strategic crops, due to their importance in the livelihood of the Iraqi citizen, and no Iraqi table is devoid of one of the derivatives of these two crops, and the government policy focused on these two crops, especially in providing support and attention to each of them, for this reason they were chosen to be the focus of this study. The research started from a problem that could be identified that Iraq has been suffering for years from a continuous decline in water revenues across the Tigris and Euphrates until it entered the stage of water scarcity, and several factors stand behind this critical water situation, the most important of which are climatic changes represented in the lack of rainfall and the drought of rivers, in addition to the factors negatively affect water imports from the two rivers and This calls for focusing on concepts related to the water footprint and virtual water for its important role in the production of strategic crops, which are among the most important crops for food security, especially since Iraq is almost a net importer of these agricultural commodities. This study was aimed to: Estimating the most important indicators of the water footprint of the study crops (wheat and rice) due to the importance of these criteria in determining the amount of increase or decrease in the area of the studied crops in accordance with the food security policy and estimating the most important indicators of virtual water for the study crops (wheat and rice).

2. Materials and Methods

There is no doubt that any agricultural policy will not achieve success if water policy and foreign trade policy do not have a presence based on economic and environmental foundations. Structure of foreign agricultural trade in Iraq and foreign Iraq's agricultural trade, in both exports and imports, is highly volatile due to its many factors, political and economic and their association with the economic conditions of the major rowers, making them susceptible to the effects of extreme fluctuations in the prices of international commodities and the volatility of the world economy [4]. Water footprint studies have different multiple purposes and are applied in many contexts. Each purpose requires its own scope analysis. Water footprint can be estimated for different entities, so it is very important to determine which water footprints can studied and estimated. Estimating the water footprint of a consumer or a group of consumers or an entire economic sector of consumers has become a matter of interest, and this done within a specific geographical area such as a governorate or a country, and for surface water collection basins or river basins. The water footprint of a region is the product of compiling a number of water footprints for a number of products, goods and services in this region, and the water footprint as an analytical tool that can be useful in understanding the activities and services related to the scarcity and pollution of fresh water and the expected effects, as well as understanding what can be done to ensure that these activities and products do not affect the sustainability of fresh water in terms of quantity or quality, and it is a tool that provides a vision for learners, helping them understand what needs to be done [10]. The data was obtained from its official sources represented by the Ministry of Planning / Central Statistical Organization and the Iraqi Ministry of Water Resources Estimating and measuring the actual water content of a product or commodity is not an easy task, because there are many factors that affect the amount of water used in production processes, and the following factors should at least taken into consideration when estimating and calculating the virtual water content of any product or commodity:

- The place and time period (season) for the production of the product, commodity or crop.

- Measuring the quantities of water used in the case of irrigated crop production, as well as the quantities of water polluted because of irrigation, if any.
- Measuring the efficiency of water use in the production of goods, products and crops.
- Calculation and inclusion of wasted and polluted water in the estimation.
- Calculating the virtual water ratios of the intermediate inputs to the virtual water content of the commodity, final product or crop. To achieve its objectives, the study relied on the descriptive economic analysis method in explaining some economic aspects in addition to quantitative economic analysis, as some indicators and standards applied in calculating the water footprint and virtual water. The study relied mainly on the exploitation of blue water in irrigated lands. The virtual water and the water footprint were calculated and estimated, and their most important indicators are:
  - Amount of water used in local production.
  - Water requirements for the production of the crop.
  - Default amount of imported water.
  - Default value of imported water.
  - External water footprint.
  - Internal water footprint.
  - Total water footprint.
  - Percentage of dependence on external water resources.
  - Percentage of self-sufficiency from the local water resources.
  - Unit productivity of irrigation water.

3. Results and Discussion

3.1. Estimation of the water footprint and its indicators for the study crops in Iraq for the period 2000-2022:

The water footprint has an important impact in shaping agricultural policy, especially with regard to production policy, irrigation policy and foreign trade policy for agricultural products. The study estimated the most important indicators of the water footprint of the study crops during the period (2000-2022).

3.1.1.Wheat

Wheat is strategic economic and food security crop, so various development projects adopted by the government to improve the level of production of this crop[11]. Despite the efforts to increase the production of grain crops, especially the wheat, the total production is still insufficient to meet the growing consumption needs, which led to widening of the food gap in addition to the increase in population and the increasing demand for food [12]. By studying and reviewing the data of table 1 and figure 1, found that the external water footprint of wheat crop reached its lowest in 2003, estimated at 0.01 billion cubic meters, and reached its highest value in 2008 when it was estimated at 34.48 billion cubic meters, with an average of 6.19 billion cubic meters. It also found that the internal water footprint reached its lowest in 2000, estimated at 4.04 billion cubic meters, and reached maximum in 2020, when it estimated at 21.85 billion cubic meters, with an average of about 14.08 billion cubic meters. The total water footprint of the wheat crop ranged between a minimum of about 4.07 billion cubic meters in 2000, as this year was scarce of rain and a maximum of about 49.08 billion cubic meters in 2008, with an average of about 20.27 billion cubic meters. The total water footprint is the sum of the internal water footprint and the external water footprint, the water footprint of the wheat crop may be large, because it is the most important cereal crop in Iraq and cultivated in large areas as well as the exposure of its cultivated areas to high evaporation rates. It was also found that the percentage of dependence on external water resources for the wheat crop ranged between a minimum of about 0.06 % in 2003 due to lack of imports or not being recorded in this year due to abnormal conditions, and a maximum of about 70.25 % in 2008, with an average of about 20.49% , while the percentage of self-sufficiency of the local water resources for the wheat crop ranged between a minimum of about 29.75 % in 2008, and a maximum of about 99.94 % in 2003, with an average of about 79.50 %. This represents a great pressure on Iraqi water resources, which have already entered the stage of water scarcity. The unit productivity of irrigation water for wheat crop ranged between a minimum of 0.09 kg/m3 in 2000 and 2008, and a maximum of 0.32 kg/m3 in 2016, and an average of 0.19 kg/m3, which is low productivity.

Table 1. Water footprint and its indicators for the wheat crop in Iraq during the period 2000-2022

Years	**External water footprint (1)**	**Internal water footprint (2)**	**Total water footprint (3) (1+2)**	**Dependence rate on external water resources (%) (4)**	**Self-sufficiency rate from local water resources (%) (5)**	**Unit productivity of irrigation water (kg/m3) (6)**
2000	0.03	4.04	4.07	0.82	99.18	0.09
2001	0.02	5.35	5.37	0.34	99.66	0.17
2002	0.02	16.69	16.71	0.09	99.91	0.15
2003	0.01	16.54	16.55	0.06	99.94	0.13
2004	0.02	13.64	13.66	0.16	99.84	0.12
2005	0.02	16.31	16.33	0.11	99.89	0.14
2006	0.02	14.03	14.05	0.14	99.86	0.15
2007	0.02	15.99	16.01	0.11	99.89	0.14
2008	34.48	14.60	49.08	70.25	29.75	0.09
2009	23.06	12.86	35.92	64.21	35.79	0.13
2010	9.53	14.12	23.65	40.29	59.71	0.19
2011	17.16	16.68	33.84	50.70	49.30	0.17
2012	13.95	17.61	31.56	44.20	55.80	0.17
2013	10.09	18.81	28.90	34.92	65.08	0.22
2014	4.84	21.72	26.56	18.22	81.78	0.23
2015	1.69	10.56	12.25	13.81	86.19	0.25
2016	0.54	9.42	9.96	5.42	94.58	0.32
2017	1.76	10.74	12.50	14.10	85.90	0.28
2018	6.90	8.04	14.94	46.21	53.79	0.27
2019	2.12	16.13	18.25	11.61	88.39	0.27
2020	3.74	21.85	25.59	14.62	85.38	0.29
2021	9.10	20.33	19.12	13.55	82.88	0.24
2022	7.66	19.90	11.55	12.30	83.77	0.21
Average	6.19	14.08	20.27	20.49	79.51	0.19

Source: Calculated by the researchers according to the following equations:
Column (1) External Water Footprint = Virtual amount of imported water.
Virtual amount of imported water = Amount of imports in tons * Water needs.
Column (2) Internal water footprint = Amount of water used in production - Amount of virtual water exported.
Amount of virtual water exported = Amount of exports in tons * Water needs.

Column (4) Dependence rate on external water resources = (External water footprint / Total water footprint) * 100.
Column (5) Self-sufficiency rate from local water resources = (Internal water footprint / Total water footprint) * 100.
Column (6) Productivity of irrigation water unit = Crop productivity per dunum / Water needs per crop dunum.

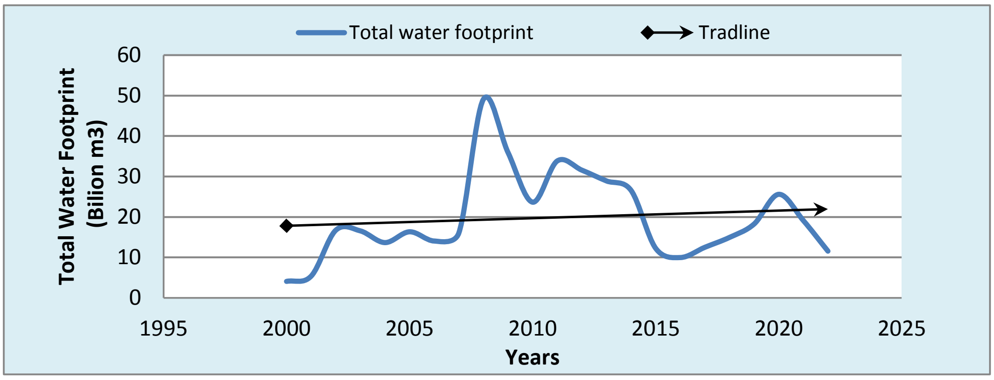

Figure 1. The total water footprint of the wheat crop in Iraq for the period 2000- 2022. Source: Prepared by the researchers based on the data in table 1.

3.1.2 Rice

By studying and reviewing the data of table 2 and figure 2, it found that the external water footprint of the rice crop reached its lowest in 2000, estimated at 0.01 billion cubic meters, and reached its maximum in 2001, when it was estimated at 25.23 billion cubic meters, the reason for this difference was the reliance on the cultivated area, with an average of about 9.90 billion cubic meters. It also found that the internal water footprint reached its lowest in 2018, estimated at 0.31 billion cubic meters, and reached its maximum in 2019 when it estimated at 7.34 billion cubic meters, with an average of about 3.99 billion cubic meters. The total water footprint of the rice crop ranged between a minimum of about 1.18 billion cubic meters in 2000, and a maximum of about 29.23 billion cubic meters in 2001, with an average of about 13.89 billion cubic meters. It was also found that the percentage of dependence on external water resources for the rice crop ranged between a minimum of about 0.85% in 2000, and a maximum of about 97.39 % in 2018 due to the dependence on imports in this year because the production was only 30 thousand tons, because of limiting the water quota and preventing its cultivation in the governorates of AL-Najaf and AL-Qadisiyah for this year, with an average of about 67.98% , and this percentage was high in most years of study, while the percentage of self- sufficiency of the local water resources for the rice crop ranged between a minimum of about 62.1% in 2018, and a maximum of about 99.15% in 2000, with an average of about 32.01%. This represents a great pressure on Iraqi water resources due to the high-water requirements for rice. The unit productivity of irrigation water ranged between a minimum of 0.05 kg/m3 in 2001 and a maximum of 0.15 kg/m3 in 2014, with an average of 0.10 kg/m3. Thus, we see that the productivity of the water unit considered low for the rice crop.

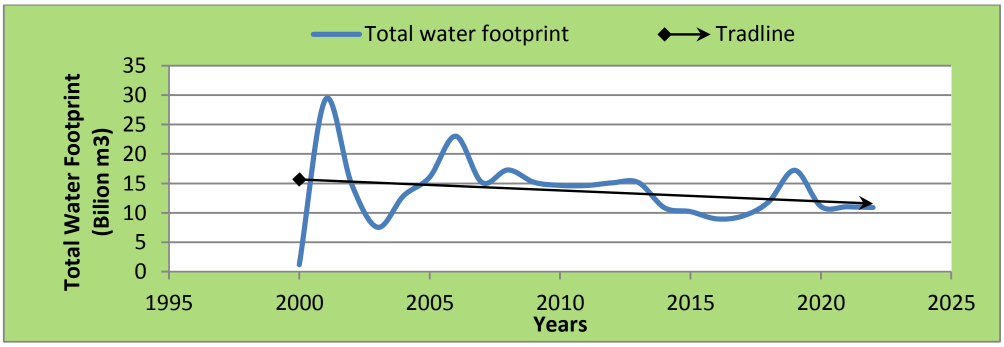

Figure 2. The total water footprint of the rice crop in Iraq for the period 2000-2022.Source: Prepared by the researchers based on the data in table 2.

Table 2. Water footprint and its indicators for the rice crop in Iraq during the period 2000-202

Years	External water footprint (1)	Internal water footprint (2)	Total water footprint (3) (1+2)	Dependence rate on external water resources (%) (4)	Self-sufficiency rate from local water resources (%) (5)	Unit productivity of irrigation water (kg/m3) (6)
2000	0.01	1.17	1.18	0.85	99.15	0.09
2001	25.23	4.00	29.23	86.32	13.68	0.05
2002	11.08	3.87	14.94	74.11	25.89	0.10
2003	5.62	1.92	7.54	74.54	25.46	0.08
2004	7.89	5.02	12.90	61.12	38.88	0.08
2005	9.92	6.15	16.06	61.73	38.27	0.08
2006	15.82	7.20	23.02	68.72	31.28	0.08
2007	8.02	7.14	15.16	52.90	47.10	0.09
2008	12.42	4.86	17.28	71.88	28.13	0.09
2009	12.04	3.15	15.19	79.26	20.74	0.09
2010	11.91	2.75	14.66	81.24	18.76	0.09
2011	10.84	3.79	14.63	74.09	25.91	0.10
2012	10.52	4.58	15.09	69.67	30.33	0.13
2013	9.64	5.51	15.15	63.63	36.37	0.14
2014	6.31	4.55	10.86	58.10	41.90	0.15
2015	8.62	1.58	10.20	84.51	15.49	0.11
2016	6.76	2.21	8.97	75.36	24.64	0.14
2017	6.26	3.19	9.45	66.24	33.76	0.14
2018	11.56	0.31	11.87	97.39	2.61	0.10
2019	9.88	7.34	17.22	57.38	42.62	0.13
2020	7.58	3.50	11.08	68.41	31.59	0.13
2021	7.44	3.10	11.02	65.66	22.15	0.12
2022	7.12	3.09	10.90	69.11	27.32	0.11
Average	9.90	3.99	13.89	67.98	32.01	0.10

Source: Calculated by the researchers according to the following equations:
Column (1) External Water Footprint = virtual amount of imported water.

- Virtual amount of imported water = Amount of imports in tons * Water needs.

Column (2) Internal water footprint = Amount of water used in production - Amount of virtual water exported.

- Amount of virtual water exported = Amount of exports in tons * Water needs.

Column (4) Dependence on external water resources = (External water footprint / Total water footprint) * 100.

Column (5) self-sufficiency rate from local water resources = (Internal water footprint / Total water footprint) * 100.
Column (6) Productivity of irrigation water unit = Crop productivity per dunum / Water needs per crop dunum.

3.2 Estimation of virtual water and its indicators for the study crops in Iraq for the period 2000-2022:
Virtual water is an innovative economic idea that searches for invisible water. People do not only consume water for drinking, bathing, etc., but there are other implicit aspects that were not previously appreciated, especially in the areas of food production. According to this concept, a cup of coffee consumes about 140 liters of water was used in irrigation, production and preparation of coffee tree, and producing one kilogram of rice consumes about 300 liters of water, and producing one kilogram of beef needs 15000 liters of water on average, so virtual water is the total amount of water used in the production of food, especially for imported and exported agricultural products. Therefore, the concept of virtual water has become an economic concept as long as it relates to quantities for an important aspect in foreign trade (exports and imports) [13].

3.2.1 Wheat
By studying and reviewing the data of table 3 and figures 3,4,5 and 6, it found that the water needs used in wheat production ranged between a minimum of about 3.08 m^3 / kg in 2016, and a higher limit of about 11.63 m3 / kg in 2008 because it was a year of scarce rain and therefore wheat production in it was less than usual, with an average of about 6.04 m3/kg. The amount of water used in wheat production ranged between a minimum of 4.04 billion cubic meters in 2000, and a maximum of 21.85 billion cubic meters in 2020, with an average of 14.23 billion cubic meters. While the amount of imported virtual water ranged between a minimum of 0.01 billion cubic meters in 2003, and a maximum of 34.48 billion cubic meters in 2008, with an average of 6.19 billion cubic meters. The value of imported virtual water ranged between a minimum of about 140 thousand dollars in 2016 and a maximum of about 14,460 thousand dollars in 2008, with an average of about 3820 thousand dollars.

Table 3. Virtual water and its indicators for wheat crop in Iraq for the period 2000-2022

Year	Water needs (m^3/kg) (1)	Amount of water used in local production (billion m^3) (2)	Imported virtual water quantity (billion m^3) (3)	Imported virtual water value (thousand dollars) (4)	Imported quantities of wheat (ton) (5)
2000	10.53	4.04	0.03	7880	3185
2001	6.00	5.42	0.02	5000	3000
2002	6.48	16.79	0.02	2950	2417
2003	7.49	17.45	0.01	1980	1276
2004	8.55	15.66	0.02	3510	2501
2005	7.32	16.31	0.02	3630	2535
2006	6.74	14.06	0.02	3920	2833
2007	7.26	15.99	0.02	5720	2423
2008	11.63	14.60	34.48	14460	2963320
2009	7.56	12.86	23.06	6020	3050409
2010	5.14	14.12	9.53	2400	1854525
2011	5.94	16.68	17.16	6800	2888833
2012	5.75	17.61	13.95	4730	2425381
2013	4.50	18.81	10.09	3660	2241683
2014	4.30	21.72	4.84	2420	1126009
2015	3.99	10.56	1.69	540	423744
2016	3.08	9.42	0.54	140	175087
2017	3.61	10.74	1.76	460	488187
2018	3.69	8.04	6.9	2000	1870612
2019	3.71	16.13	2.12	890	570646
2020	3.50	21.85	3.74	1060	1068000
2021	3.21	21.44	3.09	1022	1053000

2022	3.12	21.35	2.56	989	192800
Average	6.04	14.23	6.19	3820	1007933.8

Source: Calculated by the researchers according to the equations:
Column (1) Water needs = Water ration per unit area / Crop productivity.
Column (2) Amount of water used in production = Amount of production in tons*Water needs (total).
Column (3) Virtual amount of imported water = Amount of imports in tons * Water needs (total).
Column (4) Value of imported virtual water = Amount of imported virtual water * Price of the imported unit.

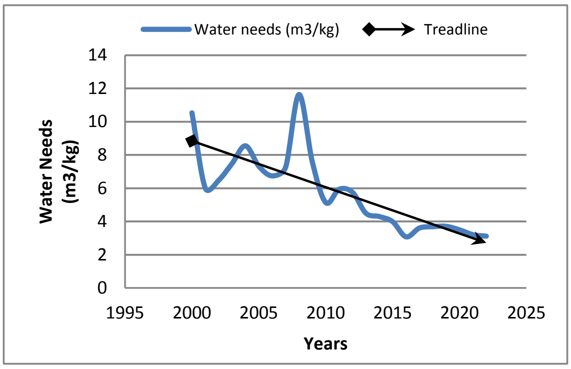

Figure 3. Water needs of wheat crop in Iraq for the period 2000-2022.
Source: Prepared by the researchers based on the data in table 3.

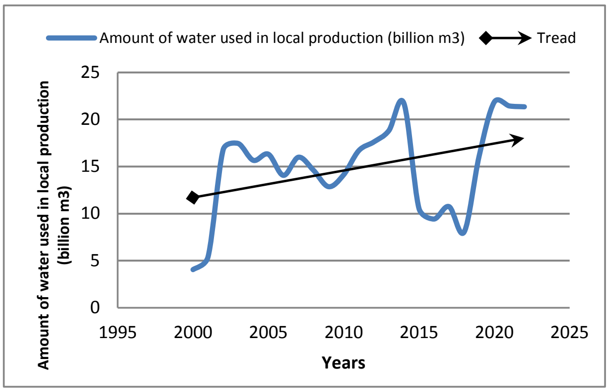

Figure 4. Amount of water used in the local production of wheat in Iraq for the period 2000-2022.
Source: Prepared by the researchers based on the data in table 3.

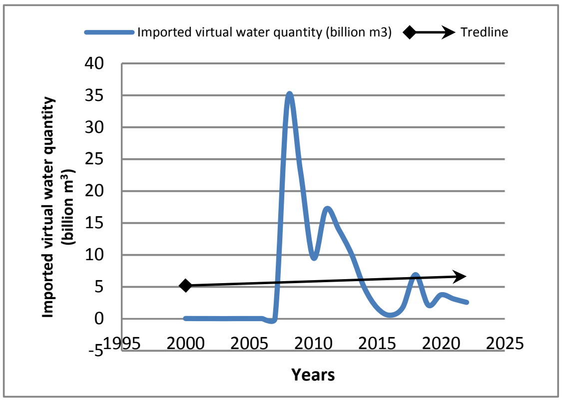

Figure 5. Amount of virtual water imported for the wheat crop in Iraq for the period 2000-2022.
Source: Prepared by the researchers based on the data in table 3.

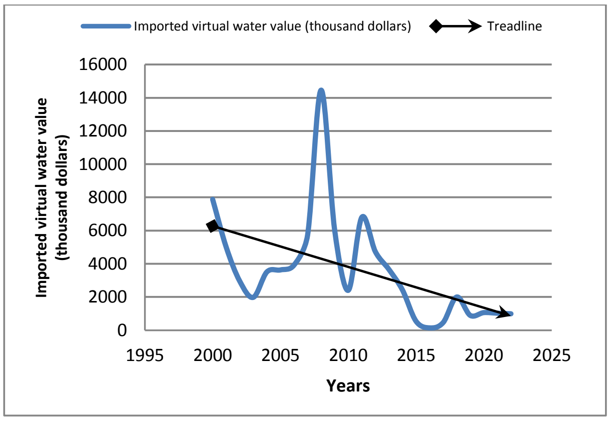

Figure 6. Value of the virtual water imported for the wheat crop in Iraq for the period 2000-2022.
Source: Prepared by the researchers based on the data in table 3.

3.2.2Rice

By studying and reviewing the data of table 4 and figures 7, 8, 9 and 10, it found that the water needs used in rice production ranged between a minimum of about 6.78 m3 / kg in 2014, and a higher limit of about 19.74 m3/kg in 2001, with an average of about 10.19 m3/kg. The amount of water used in rice production ranged between a minimum of 0.31 billion cubic meters in 2018, the year in which rice cultivation was determined in the governorates of AL-Najaf and AL-Qadisiyah due to water scarcity, and a maximum of 7.34 billion cubic meters in 2019, with an average of 4.01 billion cubic meters. While the amount of imported virtual water ranged between a minimum of 0.01 billion cubic meters in 2000, and a maximum of 25.23 billion cubic meters in 2001, with an average of 10.03 billion cubic meters. The value of imported virtual water ranged between a minimum of about 2060 thousand dollars in 2003, and a maximum of about 9690 thousand dollars in 2018, with an average of about 5293.3 thousand dollars, which is the highest study crop in terms of water needs and the amount of imported virtual water and its value.

Table 4. Virtual water and its indicators for rice crop in Iraq for the period 2000-2022

Year	**Water needs (m3/kg) (1)**	**Amount of water used in local production (billion m3) (2)**	**Imported virtual water quantity (billion m3) (3)**	**Imported Virtual water value (thousand dollars) (4)**	**Imported quantities of rice (ton) (5)**
2000	11.66	1.16	0.01	3560	1200
2001	19.74	4.21	25.23	6390	1278167
2002	9.53	3.97	11.08	3240	1162000
2003	12.96	1.94	5.62	2060	433512
2004	12.11	5.04	7.89	2100	651654
2005	11.94	6.15	9.92	3460	830645
2006	11.90	7.20	15.82	5540	1329113
2007	10.89	7.14	8.02	3320	736039
2008	11.76	4.86	12.42	6950	1056016
2009	10.92	3.15	12.04	6230	1102263
2010	10.60	2.75	11.91	6220	1123199
2011	9.66	3.79	10.84	6180	1122245
2012	7.60	4.58	10.52	7150	1384191
2013	7.31	5.51	9.64	7000	1317874
2014	6.78	4.55	6.31	3060	930487
2015	8.70	1.58	8.62	6430	991063
2016	7.32	2.21	6.76	4270	923484
2017	7.19	3.19	6.26	5110	870730
2018	10.27	0.31	11.56	9690	1126193
2019	7.66	7.34	9.88	7350	1290124
2020	7.54	3.50	7.58	5850	1004345
2021	7.34	3.10	6.55	4890	997100
2022	6.90	2.67	6.12	4769	878050
Average	10.19	4.01	10.03	5293.3	984025.9

Source: Calculated by the researchers according to the equations:
Column (1) Water needs = Water ration per unit area / Crop productivity.
Column (2) Amount of water used in production = Amount of production in tons*Water needs (total).
Column (3) Virtual amount of imported water = Amount of imports in tons * Water needs (total).
Column (4) Value of imported virtual water = Amount of imported virtual water * Price of the imported unit.

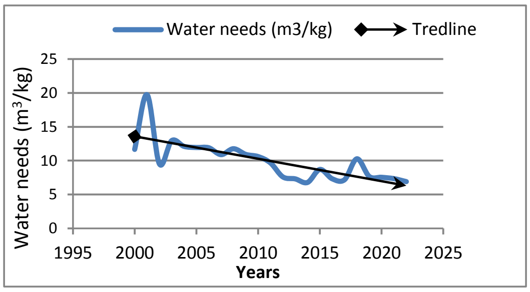

Figure 7. Water needs of rice crop in Iraq for the period 2000-2022.
Source: Prepared by the researchers based on the data in table 4.

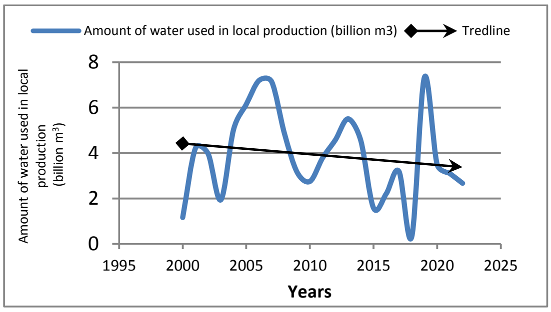

Figure 8. Amount of water used in the local production of rice in Iraq for the period 2000-2022.
Source: Prepared by the researchers based on the data in table 4.

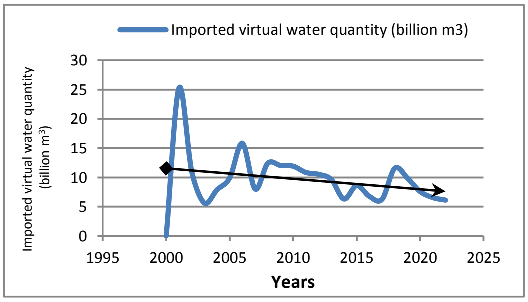

Figure 9. Amount of virtual water imported for the rice crop in Iraq for the period 2000-2022.
Source: Prepared by the researchers based on the data in table 4.

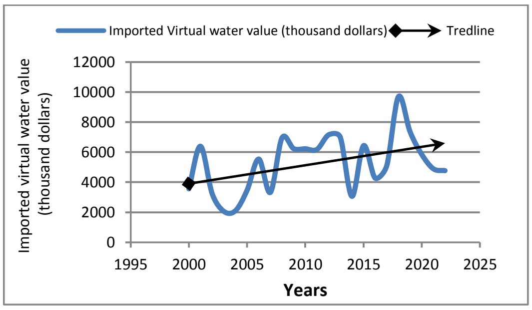

Figure 10. Value of the virtual water imported for the rice crop in Iraq for the period 2000-2022.
Source: Prepared by the researchers based on the data in table 4.

4. Conclusion

The studied cereal crops (wheat and rice) are water-consuming crops, and therefore their water footprint is high, and their virtual water content is also high, so they are consume high percentage of water share which allocated to within the agricultural plan especially rice, especially as they are widely used crops , and importing the crop from a humid country (with large water resources) is more economically and more efficient (cheaper) than importing the same crop from a dry country (which suffers from water scarcity) , and the water footprint of the rice crop was the largest, due to its high need for water and the large quantities imported from it during the study period , and high internal water footprint in water consuming crops such as rice puts great pressure on water resources in Iraq, rate of rice was higher in terms of virtual water indicators (water needs, amount of imported virtual water, value of imported virtual water) because it is a water-consuming crop and is widely used on the table of the Iraqi consumer as well as its considered within the vocabulary of the ration system . High population increase in Iraq leads to double caution, on the one hand, it increases the total water footprint of the study crops and at the same time leads to pressure on water resources and reduces the average share of the Iraqi individual from surface water resources. So the research recommended the following : The necessity of calculating the water footprint and the virtual water content of the crops to be imported especially high consumed water crops to saving water through import alone is not sufficient because the crop that must be imported should be determined after determining the production and irrigated plans, and importing products with high water content, and the necessity of calculating the water footprint of various crops to reach the percentage of self-sufficiency in the local water resources and the percentage of dependence on external water resources , and inclusion of the virtual water strategy within the comprehensive management of water resources and linking agricultural policy with water and economic policy to achieve water security and food security, encouraging farmers to replace part of the areas planted with rice with other alternative crops, by providing subsidies to producers , focusing on obligating farmers to water rations and supplementary irrigation through intensive efforts of agricultural extension agencies and the media in all its forms to publicize the extent of the problem, as the first basis for addressing it starts from the farmer, determining the current and future water needs and conducting a comprehensive survey of the water supply, adopting policies and programs regulating the import of agricultural commodities in a way that helps in regulating and stabilizing prices to protect local products. the necessity of reaching an agreement with the countries upstream of the Tigris and Euphrates rivers and their tributaries Turkey, Syria and Iran to divide the water, in order to ensure its continuous availability. By calculating the water footprint of the rice crop, we find that there is a need to use agricultural methods and modern technologies in growing the crop, including the intensive cultivation method (SRI), which has proven successful in reducing the water needs for rice cultivation in Iraq.

References

[1] Al-Aasar, K.M and W.H.A, Mohammed. 2016. The Water Footprint and Its Impact on The Foreign Trade of Egyptian Goods, *The Egyptian Journal of Agricultural Economics* - Volume 26 - Issue **2** :697-714
[2] Al-Naseeh, A. K. 2002. Reality of Water Use in Agriculture in Iraq - *Master's Thesis*- Department of Agricultural Economics/ College of Agriculture, University of Baghdad.
[3] Al-Badri, B.H, H.A.Alattabi and S.A.Al-Badawi, 2020, An Economic Study of The Relationship Between Agricultural Imports and Agricultural Product in Iraq for The Period 1991-2018 Using Toda-Yamamoto Causality, *Iraqi Journal of Agricultural Sciences* - **51**(3):789-796.
[4] Nassir, S.A and M.O, Farhan.2016. Economic Analysis for A Risk in The Cultivation of Wheat on of High Salinity Soils in Iraq, Using The Model (Motad) - Wasit Governorate an Applied Model, *The Iraqi Journal of Agricultural Sciences*-**47**(4):1013-1023.
[5] Mekonnen, M.M, A.Y. Hoekstra and M.M.Aldaya. 2011. The Water Footprint Assessment Manual. *First Published By Earth Scan. London.* Washington, DC, Https://Waterfootprint.Org .
[6] Al-Danasuri, F. M., F. M. Muhammad, A. A. Badir, and A. M. Ashraf. 2019. An Economic Study of The Water Footprint and Virtual Water Trade of The Most Important Cereal Crops in Egypt. *Journal of Sustainable Agricultural Sciences*.**45** (4).
[7] Al-Badri, B.H. and H.A.Alattabi. 2019. An Economic Analysis of The Most Important Factors Affecting Agricultural Growth in Iraq Using ARDL Model, *Iraqi Journal of Agricultural Sciences:* **50**(6): (1561-1570).
[8] Jbara, O.K and I.K, Mustafa.2018. Forecasting The Food Gap and Production of Wheat Crop in Iraq for The Period (2016-2025), *Iraqi Journal of Agricultural Sciences*: **49**(4):560- 568.
[9] Al-Badri, B.H. and R.A. Abdul Rahim. 2011. Measuring The Impact of Water Losses in Irrigated Agriculture on Water Scarcity in Iraq for The Agricultural Season (2009). *Journal of College of Administration and Economics.* Issue **87**:1-12
[10] Salam, O. M. 2017. The Egyptian Water Footprint: Is The Water and Food Security Are Index. Cairo, Www.Noor-Book.Com.
[11] Zidan, Tahseen Ali, and Others. 2002. The Effect of Groundwater and Sulfur Springs on The Water Quality of The Euphrates River From The Syrian Border to The Heet Region in Anbar Governorate. *Anbar University Journal of Pure Sciences*. Volume **1** Issue 1
[12] Rashid, A.J. 2017. Water Resources in Iraq. First Edition, Without Publishing House, Www.Merefa2000.Com.
[13] Bedewi, E. M. and H.N. Mohammed. 2016. Production and Trade of Some Agricultural Crops in Light of The Concept of Virtual Water. *Journal of Agricultural Economics and Social Sciences*, Mansoura University, Volume (**7**), Issue (4): 455-465.