أداة التحليل المكاني للبصمة المائية في العراق

Spatial Analysis tool for water footprint in Iraq

هبة عبدالكريم محمد
مدرس مساعد
د. خنساء عبدالاله احمد
مدرس
جامعة الموصل- مركز التحسس النائي

Hiba Abdulkareem M.
Assistant lecturer
Dr. Khansaa Abdulelah A.
lecturer
University of Mosul- Remote sensing center

hiba.abd@uomosul.edu.iq
khansaa.abd@uomosul.edu.iq

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الملخص

في هذه الدراسة تم استخدام اداة التحليل المكاني في .ARC GIS Pro لغرض تحليل بيانات البصمة المائية في العراق للفترة ما بين (١٩٩٥-٢٠٠٥) هذه البيانات التي تم الحصول عليها من شبكة البصمة المائية لجميع المحاصيل الغذائية وغير الغذائية للمحافظات العراقية. اظهرت النتائج ان بصمة المياه الزرقاء للمدة (١٩٩٥-٢٠٠٥) توزعت في محافظات الوسط والجنوب، في حين ان بصمة المياه الخضراء كانت في المحافظات الشمالية التي تعتمد على الامطار بشكل أساسي في عملية الزراعة، في حين توزعت البصمة الرمادية في عموم العراق بشكل متفاوت. تم إجراء مقارنة بين البصمة المائية لمحصولي القمح والشعير، حيث كانت بصمة المياه الزرقاء للقمح عالية وموزعة في جميع أنحاء العراق، وسجلت البصرة أعلى بصمة للمياه الزرقاء وأقلها في محافظة نينوى للمدة (٢٠١٩-٢٠٢٠). تزايدت البصمة المائية للشعير للمدة (١٩٩٥-٢٠٠٥) في جميع محافظات العراق، وكانت الأعلى في محافظة

المثنى والأدنى في محافظة نينوى نتيجة اعتماد الحفاظ على المياه الخضراء في إنتاج القمح والشعير. يشير استخدام بصمة المياه الخضراء إلى كفاءة استخدام المياه بشكل مستدام والحفاظ على المياه الزرقاء وخاصة في المناطق الوسطى والشمالية، اذ من الضروري اعتماد المياه الخضراء وحصادها وزيادة المساحة المزروعة التي تعتمد على مياه الأمطار، مما يجعل الاستخدام مستداما من أجل الحفاظ على الموارد المائية الموجودة في العراق.

Abstract

In this study spatial analysis tool in ARC GIS was used for the purpose of analyzing data for water foot print in Iraq, the data of agricultural crops for the period between (1995-2005) obtained from the water footprint network for all food and non-food crops of Iraqi governorates. The results showed that the blue water footprint for the period (1995-2005) was distributed in the central and southern governorates, while the green water footprint was in the northern governorates which is depend on the rain for agriculture process, while the gray footprint was distributed throughout Iraq unevenly. A comparison was made between the water footprint of wheat and barley crops, the blue water footprint of wheat was high and distributed throughout Iraq, Basra recorded the highest blue water footprint and the lowest in Nineveh Governorate for the period (2019-2020). The water footprint of barley increased for the period (1995-2005) in all governorates of Iraq, and it was the highest in Muthanna and the lowest in the province of Nineveh as a result of the dependence of green water preservation in the production of wheat and barley. The use of green water foot print refers to the efficiency of water use in a sustainable manner and the preservation of blue water, especially in the central and northern regions, it is necessary to adopt green water and harvest it and increase the cultivated area that depends on rainwater, which makes the use of sustainable in order to preserve existing water resources in Iraq.

Introduction

Water is the main environmental resource necessary for the requirements of life, as it is used for agricultural, domestic and industrial purposes, agriculture consumes globally 70% of fresh water, the demand for water for agricultural purposes has increased in order to secure food due to increased population growth and climate change from high temperatures and lack of rainfall. Water scarcity is one of the most important challenges facing the world and means that there is not enough water to meet the needs of the population to meet daily needs, (Hogeboom, 2020, P.218-222). The World Water Council (WWC) indicated that the global water crisis will face difficulty by 2025, represented by limited water, especially in the countries of the Middle East. (Alaskari and Ahmad et.al., 2013, P 223-241).

Drought, climate change and increasing population growth are among the most important indicators of water scarcity due to the increasing demand for this water, (Hoekstra,2009, P.1963-1974). This, in turn, is reflected in the degradation and pollution of natural ecosystems and soils, which makes the value of freshwater in the near future more than oil, as indicated by the World Bank, specialized institutes and the World Water Council, (Bekheet, 2021, p. 39-51). Iraq ranks first among the Arab countries that suffer from water scarcity due to the lack of water supply, high population growth, annual climate fluctuations and wars with upstream countries, (Ghorbani and Karimi et.al., 2018, P.1683-1697).

Agriculture is one of the most important products that consuming water in large quantities, as the global consumption responsible for agricultural activity is 70% of fresh water (United Nations (FAO), 2020, p. 210). The demand for food is increasing exacerbated, which requires more water for the purpose of agriculture, production and consumption, resulting in pollution of water bodies and the lack of availability of fresh water, Iraq is one of the most important countries in crop cultivation, as it occupies an area of about 26% of the cultivated area in Iraq, equivalent to 11.5 billion hectares. (Mekonnen and Hoekstra, 2011).

The total water used for agriculture is about 42.8% BCM/year comprehensively, 85% for agriculture, 7% for industry and 8% for other purposes. (Al-Ansari and, & Knutsson, 2011, P. 53-67). Iraq relies on the irrigation of crops mainly on the Tigris and Euphrates rivers and their tributaries, as the irrigation system was used in the Sumerian era 7500 years ago to irrigate wheat and barley in the areas between the Tigris and Euphrates rivers, which are dependent on the volume of water from upstream countries. (Haj, 1994. P. 126-163), (Khoshsirat, A. M., & Zolfaghari, M. (2015, P. 467-473). The irrigation systems consist of 25 dams and 275 pumping stations. (Al-Ansar and Ewaid, 2021, p. 012143). Due to climate change, rising temperatures and wars with the spring countries, the water level of the Tigris and Euphrates has fallen in recent years and is expected to decrease by 50% by 2025. (Alwash, 2018, P. 45). Therefore, it was necessary to know the distribution of water consumption for the agricultural sector is important and linked to the problems of water shortage through the spatial distribution of the water footprint.

The term water footprint refers to the estimated amount of water needed to produce a product and put it in the hands of consumers (Lovarelli, D, 2016, P.236-251), it helps to find the relationship between the great water challenges and the consumption of this water and is an indicator of direct and indirect use of water, water footprint has been defined by (Hoekstra and Mekonnen, 2012, P.3232-3237) as fresh water consumed in various agricultural, domestic and agricultural activities. (Abdul Hasan and Hanafiah, 2017) defined water footprint as an indicator of the use of fresh water by the producer or consumer, whether directly and indirectly, and defined by (Ewaid and Abed et.al., 2021, p. 12008) as a comprehensive measure of freshwater use that can be used to assess the impact on both water volume and the distribution of human and water consumption.

The WF (water footprint) is expressed in m^3/ton of product and includes the blue, green and gray footprint, the blue footprint refers to the use of surface water and groundwater (Hoekstra, 2009, P.1963-1974), which represents the volume of water consumed for irrigation during the crop growth period, the green footprint refers to the use of rainwater for crops and evaporation from the soil, while the gray footprint refers to the extent to which the water body absorbs pollutants (Hoekstra and Chapagain, 2011), which contains agricultural fertilizers and pesticides that cause water pollution. The water footprint depends on the amount of blue, gray and green water consumption as well as on crop productivity (Sun, & Wang.et., 2012, P. 1176-1187).

Study Area

Iraq is located in the eastern part of the Middle East and North Africa region at 33°13'23.5" N 43°40.757' E and is among the areas prone to water shortage (Elena and Esther, 2010) and has an area of 433,970 km2 inhabited by about 32 million people (Al-Ansari, N.A. 2013, P.667-684), the regions of Iraq are divided into mountainous areas in the northern region which occupy 5% of the total area, hills and plains in the central regions by 15% and 20% respectively, as well as the western plateau and the island by 60%. Fig. 1.

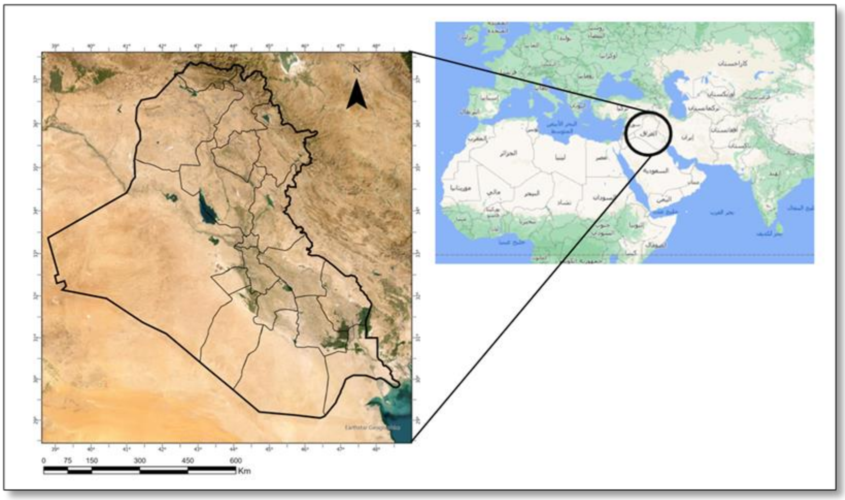

Fig. (1)

Iraq's position in the Middle East and North Africa

Iraq is rich in water resources, as surface water is represented by the presence of the Tigris and Euphrates and Shatt al-Arab rivers and their tributaries and branches, as indicated that most of the Tigris and Euphrates water comes from outside the borders of Iraq (World Bank, 2006, P 97.). Fig. 2. Groundwater is distributed in the northern and southern regions, which are important for crop irrigation and are expected to be adopted in light of current water challenges. Iraq's climate is characterized by being subtropical hot to very hot, the summer months extend from July and June, August and December, and the winter months are limited from October to May (AbdulHasan., & Hanafiah, 2017, P. 30-34). It is characterized by fluctuating rainfall in some areas, as the amount of precipitation in the northern region reaches more than 1000 mm, while in the southern regions it is less than 100mm (Sulaiman& Shiri, et al., 2018, P.1-11).

Temperatures in northern Iraq reach 0 degrees Celsius, while in the southern regions in the summer they reach 45 (Yaseen, Z., 2020, p.70-89.), high temperature rise and climate change have led to water scarcity and increased evaporation rates leading to increased demand for water (Mittler & Goloubinoff, 2012, P.118-125).

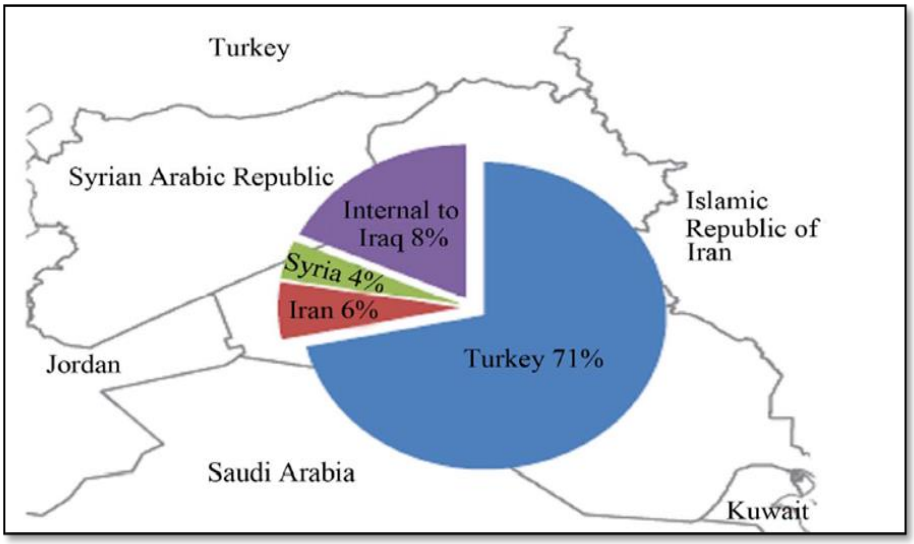

Fig. (2)

Water sources of the Tigris and Euphrates rivers (Al-Ansari, 2013)

Methodology

The water footprint requirements of CWR and the water consumption rate of ET need to be known in order to calculate the green and blue water footprints. The evaporation rate (ET0) multiplied by the quantity of Kc crop yields the crop's water requirements, which are determined by meteorological conditions like heat, humidity, wind, and sun bulbs. (Shrestha, S., 2013, P.5223-5243)

$CWR= Kc*ET_0$ ……..(1)

The blue and green CWU of the crop are used for calculating the water consumption rate by evaporation rate, which is derived from CROPWAT.80 and CLIMWAT2.0. The climatic conditions of crops and the quantity of water required for each crop are determined by these models in the following ways:

$CWUgreen = 10 \times \Sigma ETgreen$ …….(2)

$CWUblue = 10 \times \Sigma ETblue$………..(3)

Thus, the water footprint is calculated by dividing the CWU m3/ha by the productivity of the crop (Y ton/ha) as follows:

$\frac{\mathbf{CWUgreen}}{\mathbf{Y}} \dots \dots (\mathbf{4})WF_{green}=$

$WF_{blue}=\frac{\mathbf{CWUblue}}{\mathbf{Y}} \dots \dots . . (\mathbf{5})$

Data were obtained from the Water Footprint Network for the period between (199٥-2005) for agricultural crops for all Iraqi governorates, which included grains, vegetables, fruits and crops used for fodder, which included the blue, green and gray water footprint, Fig. 3, this data were injected into GIS-pro environment in order to classify the effect of green, blue and gray water foot print. Geospatial data describes any data relating to or containing information about a particular location(s) on the Earth's surface, including three-dimensional information. The Geographic Information System (GIS) is a framework that enables the ability to capture and analyze spatial and geographic data. Geospatial analysis describes the collection, display, processing and analysis of images, GPS, satellite imagery and historical data. Applications of geospatial analysis include: climate change modeling, weather monitoring, tracking of human and animal distributions, and planning of radiocommunication systems. GIS applications are used to predict, manage and gain knowledge about many different phenomena affecting the Earth, its systems and population. Geospatial analysis involves the collection, display and processing of images, GPS coordinates, imaging and satellite data (in real time or past), and making use of explicit geographic coordinates or identifiers used in geographic models. The spatial analysis played an important role in giving an indication of the volume of water use of agricultural crops for each Iraqi governorate. The data for each governorate were classified and crops were classified into cereals, oils, sugary crops, tubers, roots and fodder crops, in addition to vegetables and fruits using Excel and analyzed spatially to obtain a general assessment of the reality of the water footprint used for agriculture in Iraq. Spatial analysis tool in ARC GIS Pro. was used in order to study the spatial distribution of the green, blue and gray water footprint distribution in Iraqi governorates, these data vary from one governorate to another as a result of the variation in agricultural and productive activities for each governorate. Fig. 6.

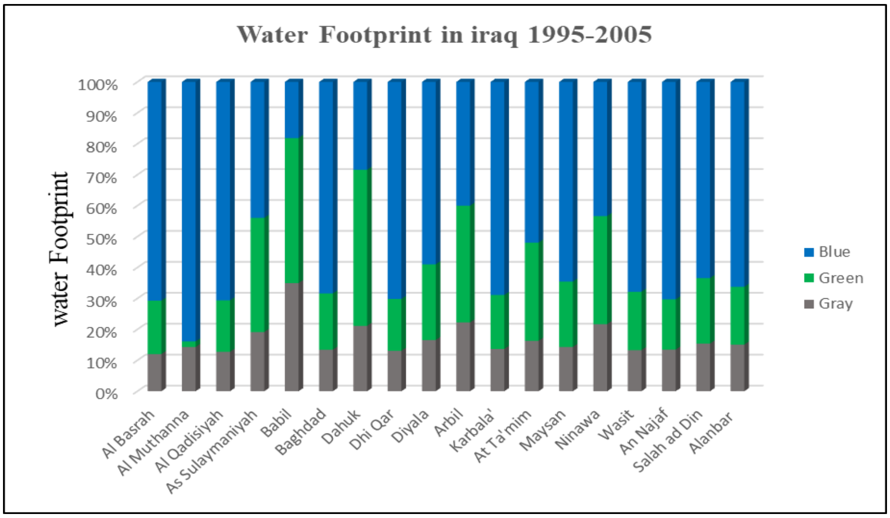

Fig. (3)

Water Foot print in Iraq 1995-2005

Table (1)

The comparison between the green and blue water footprint

1995-2005

Wheat	Green	Blue	Barly	Green	Blue
Al Anbar	24312	26167	Al Anbar	11073	15840
Al Basrah	26318	36032	Al Basrah	11136	18905
Al Muthanna	21153	35787	Al Muthanna	10913	21552
Al Qadisiyah	22525	33168	Al Qadisiyah	11730	18959
Babil	25198	28809	Babil	12916	15830
Baghdad	24271	27371	Baghdad	11897	15502
Dhi Qar	24554	35070	Dhi Qar	11746	21515
Diyala	27752	23029	Diyala	14053	12728
Karbala'	24047	20080	Karbala'	12186	16398
karkuk	30773	13153	karkuk	15804	7731
Maysan	28953	31868	Maysan	14004	18256
Ninawa	30937	6589	Ninawa	14999	5703
Wasit	26811	29323	Wasit	12898	16675
An Najaf	22433	31986	An Najaf	10529	19555
Salah ad Din	28354	21581	Salah ad Din	13580	11846

Tabe (2)

The comparison between the green and blue water footprint

2019-2020

Wheat	Green	Blue	Barly	Green	Blue
Al Anbar	469.415	410.34	Al Anbar	481.5	619.05
Al Basrah	413.805	488.305	Al Basrah	16451.5	17676
Al Muthanna	362.955	788.045	Al Muthanna	485.75	970.85
Al Qadisiyah	211.985	567.825	Al Qadisiyah	359.4	971.9
Babil	262.76	367.38	Babil	609.45	786.9
Baghdad	289.285	404.47	Baghdad	416.65	537.85
Dhi Qar	296.63	947.2	Dhi Qar	423.025	1363.5
Diyala	628.43	6.29	Diyala	1145.35	62.69
Karbala'	160.35	625.09	Karbala'	426.9	1448.4
karkuk	550.11	0	karkuk	959.35	0
Maysan	699.28	502.285	Maysan	1202.6	825.35
Ninawa	662.235	0	Ninawa	792.65	0
Wasit	282.93	524.1	Wasit	528.55	966.7
An Najaf	188.175	733.56	An Najaf	325.45	1104.15
Salah ad Din	577.155	0	Salah ad Din	915.45	0

Results, Discussion and Conclusion

The results of the spatial analysis distribution show that the consumption of the blue and green footprint is for the grain group throughout Iraq, while the gray footprint was highest in non-food crops, which cause pollution for water bodies and loss of biodiversity in them unless they are treated. The water footprint is a clear spatial and geographical indicator of the amount of water consumption for agricultural crops, which is the largest consumer in Iraq, and due to the scarcity of water and the low level of the Tigris and Euphrates rivers due to the construction of dams in neighboring countries, it is necessary to know the volume of water used for agricultural crops for the purpose of developing perfect management that achieves the preservation of non-renewable water resources and the trend towards optimal and sustainable use that is commensurate with climate change, increasing population and increasing water demand in light of current circumstances. The water footprint depends on several factors, including temperature, rainfall, and the difference in crop productivity per unit area, in addition to the percentage of cultivated area. The results show that the highest amount of green water footprint GWF for all crops throughout Iraq for the period (1995-2005) in the northern regions form (GREEN map) as shown in figure (6), this reflects the dependence of these areas on rain-fed agriculture to varying degrees, while the use of blue water for agricultural crops for the same period was concentrated in the southern governorates form (BLUE) due to the lack of rain and the conditions of drought and high temperatures enjoyed by these areas as shown in fig. 4.As for the gray footprint (GRAY), it was throughout Iraq to varying degrees, and this indicates the number of pollutants carried by puncture water in the northern regions and land washing in the southern regions, which are loaded with a large percentage of dissolved salts and toxic chemical fertilizers.

A comparison of the water footprint of wheat and barley crops in this study was conducted due to their importance in achieving self-sufficiency and food security, as well as to find out the percentage of water consumption for these two crops, figure (4 a&b). As the comparison was made based on spatial analysis for the period (1995-2005) and the period (2019-2020) as shown in figure 7, by data obtained from (Salim, A. H. (2022) for all Iraqi governorates except Kurdistan region. The blue water footprint of wheat was high and distributed throughout Iraq for the period (1995-2005) due to the expansion of cultivated areas and desertification conditions in that period, which required the consumption of large quantities of blue water to irrigate crops while it was concentrated in the southern governorates for the period (2019-2020). this is due to the availability of rainfall in sufficient quantities in this period, which made the northern central region to rely on rain-fed agriculture in wheat production as shown in the figures (green and blue) and when comparing the results for the period (1995-2005) and for the period (2019-2020) figure (5a&b), we find that the blue water footprint of wheat for the period (1995-2005) was higher than in the period (2019-2020). Basra recorded the highest blue water footprint and the lowest in Nineveh Governorate due to the expansion of cultivated areas, climate change, desertification conditions and varying high temperatures in the governorates, which led to the consumption of large quantities of surface and groundwater, while the blue water footprint of barley increased for the period (1995-2005) in all Iraqi governorates, the highest was in Muthanna Governorate and the lowest in Nineveh Governorate due to the governorate's dependence on green water in the production of wheat and barley as shown in the figure. 8. blue and green footprint of wheat and barley for the two periods. The use of green water indicates the efficiency of water use in a sustainable manner and the preservation of blue water, especially in the central and northern regions, so it is necessary to adopt green water and harvest it and increase the cultivated area dependent on rainwater, which would reduce the use of glaucoma and create a policy for water management for crop production by improving modern irrigation methods instead of the waste that occurs as a result of flood irrigation. In addition to reducing the production of crops that consume large amounts of water and have little production by importing them instead of consuming large amounts of water in vain, either in terms of reducing the gray footprint, it is done by reducing fertilizers and pesticides and relying on biotreatments in agricultural pest control, use of bioremediation such as the use of biofertilizers and phytoremediation. And the need to commit to the treatment and recycling of agricultural water to preserve surface and groundwater from pollution, and it is necessary to find agreements with neighboring countries about water to preserve water resources from drought coinciding with climate change.

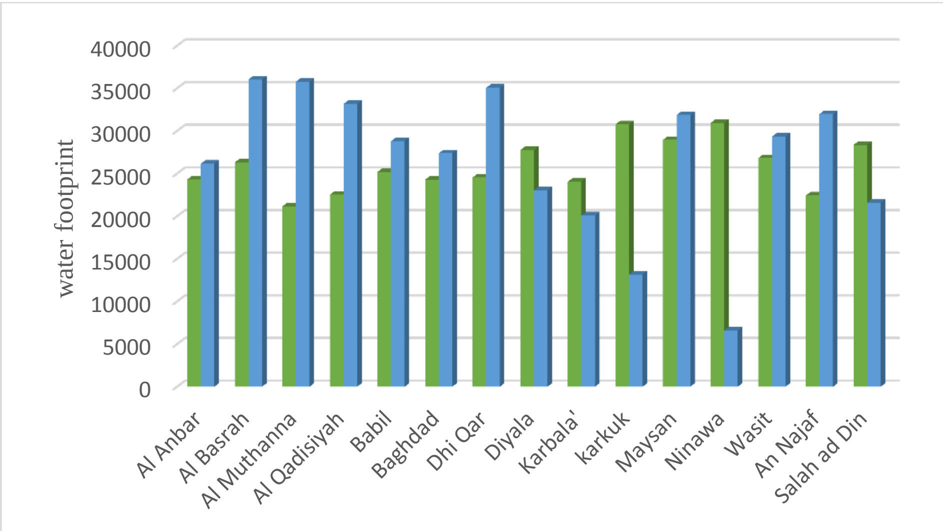

Fig.(4)

a. The green and blue eater footprint for wheat 1995-2005

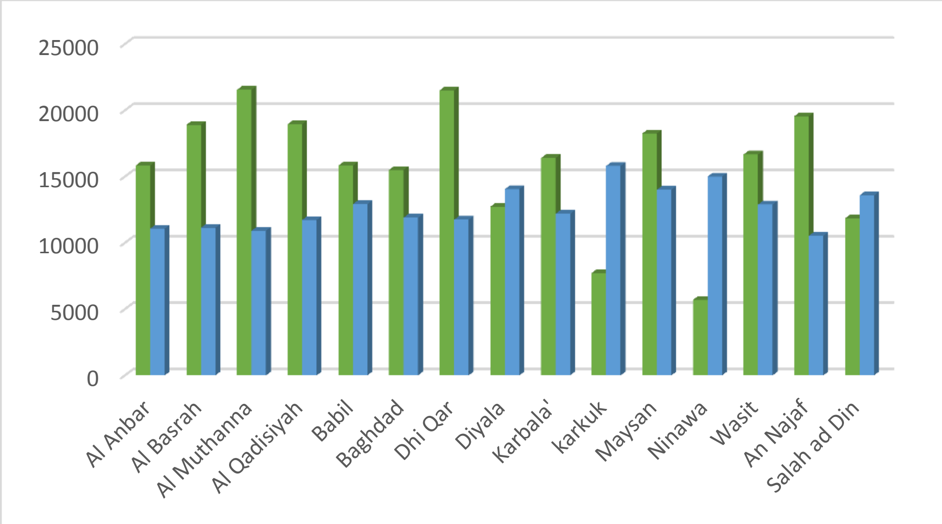

Fig.(4)

b. The green and blue eater footprint for barly 1995-2005

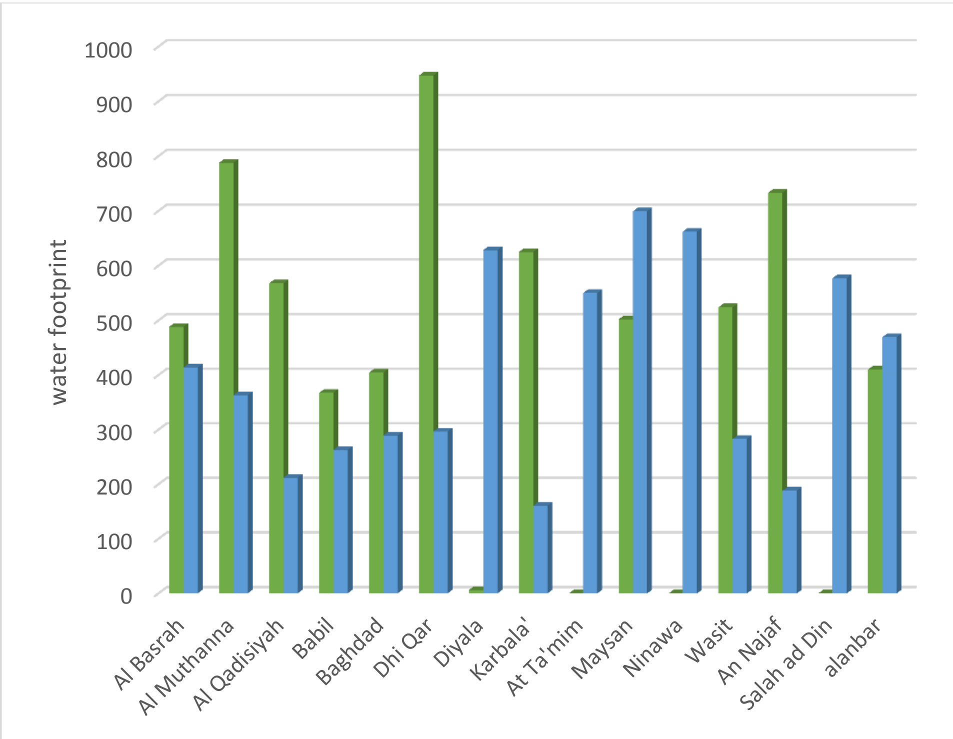

Fig.(5)

a. The green and blue eater footprint for wheat 2019-2020

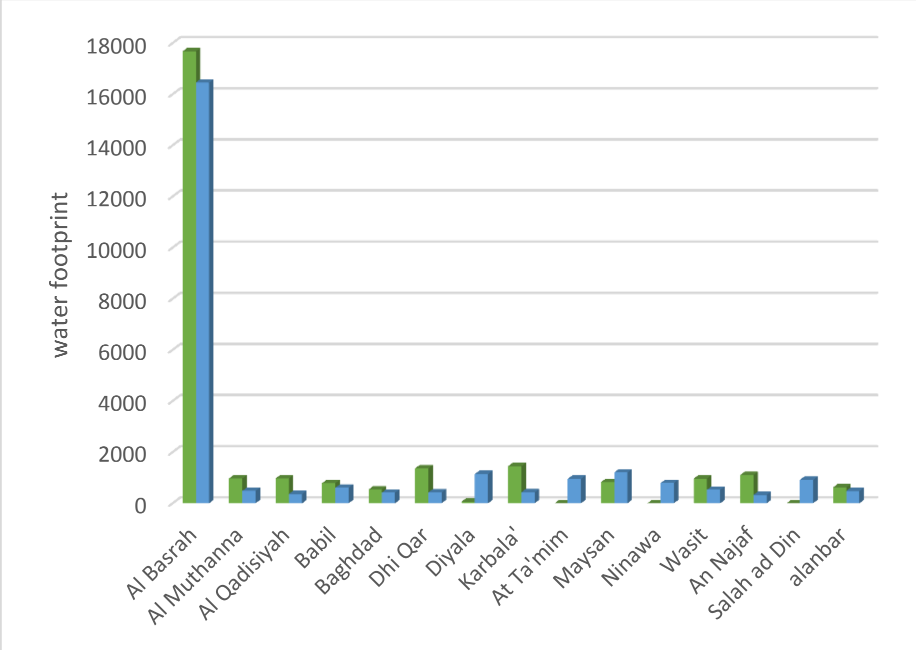

Fig.(5)

b. The green and blue eater footprint for barly 2019-2020

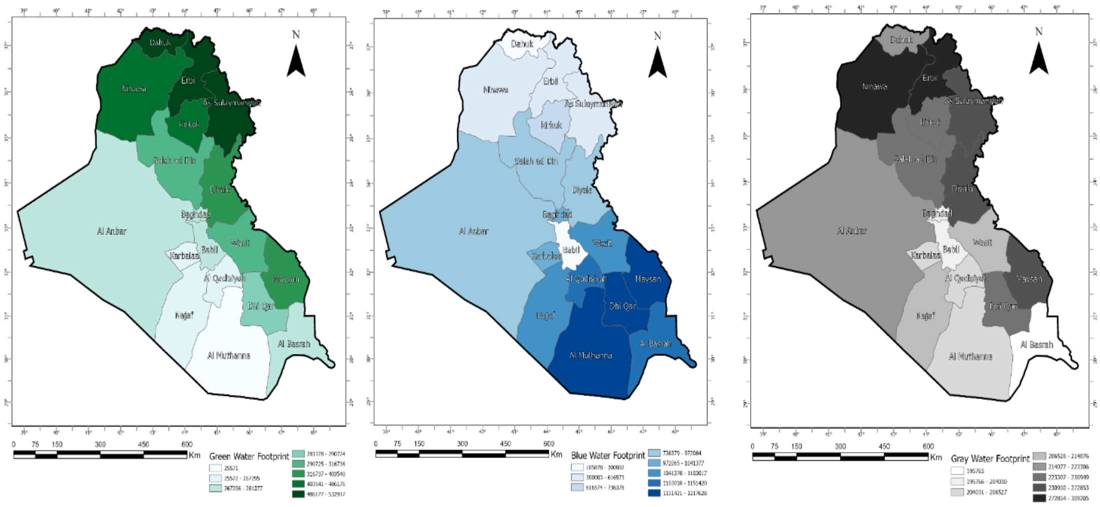

Fig. (6)

Spatial distribution of green, blue and gray water footprint in Iraq

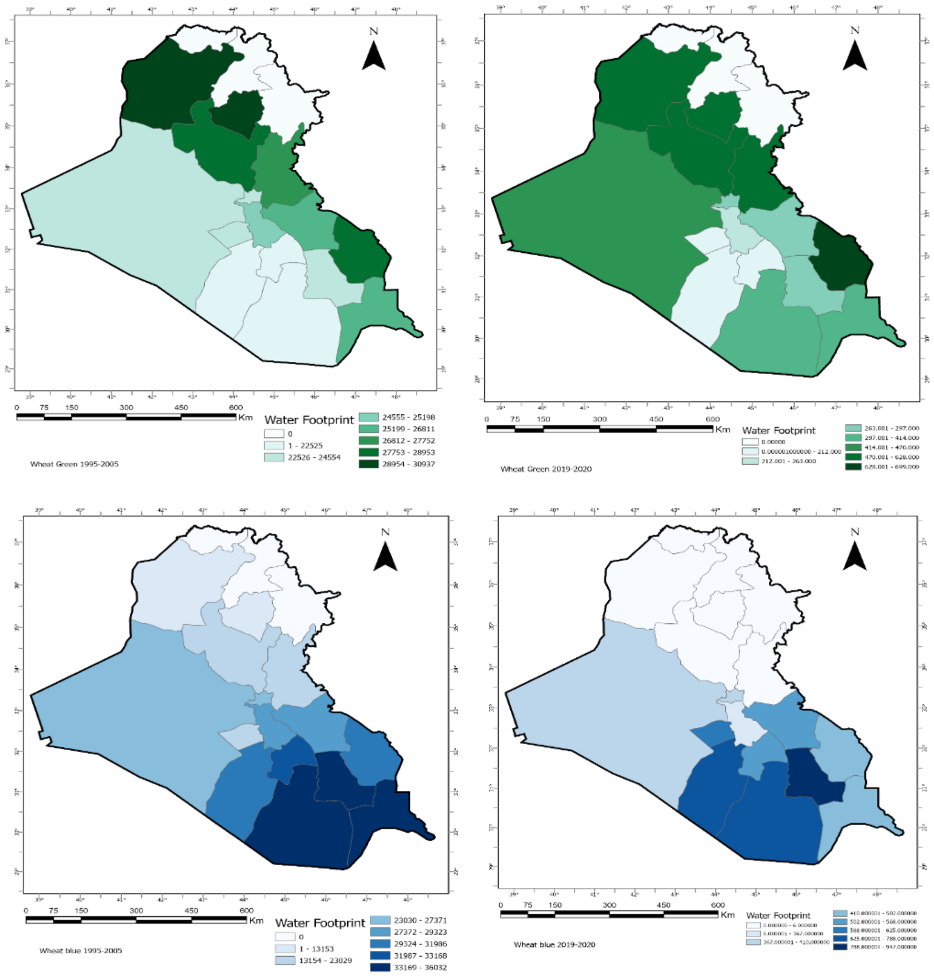

Fig. (7)

Spatial distribution of green, blue water footprint for wheat (1995-2005), (2019-2020)

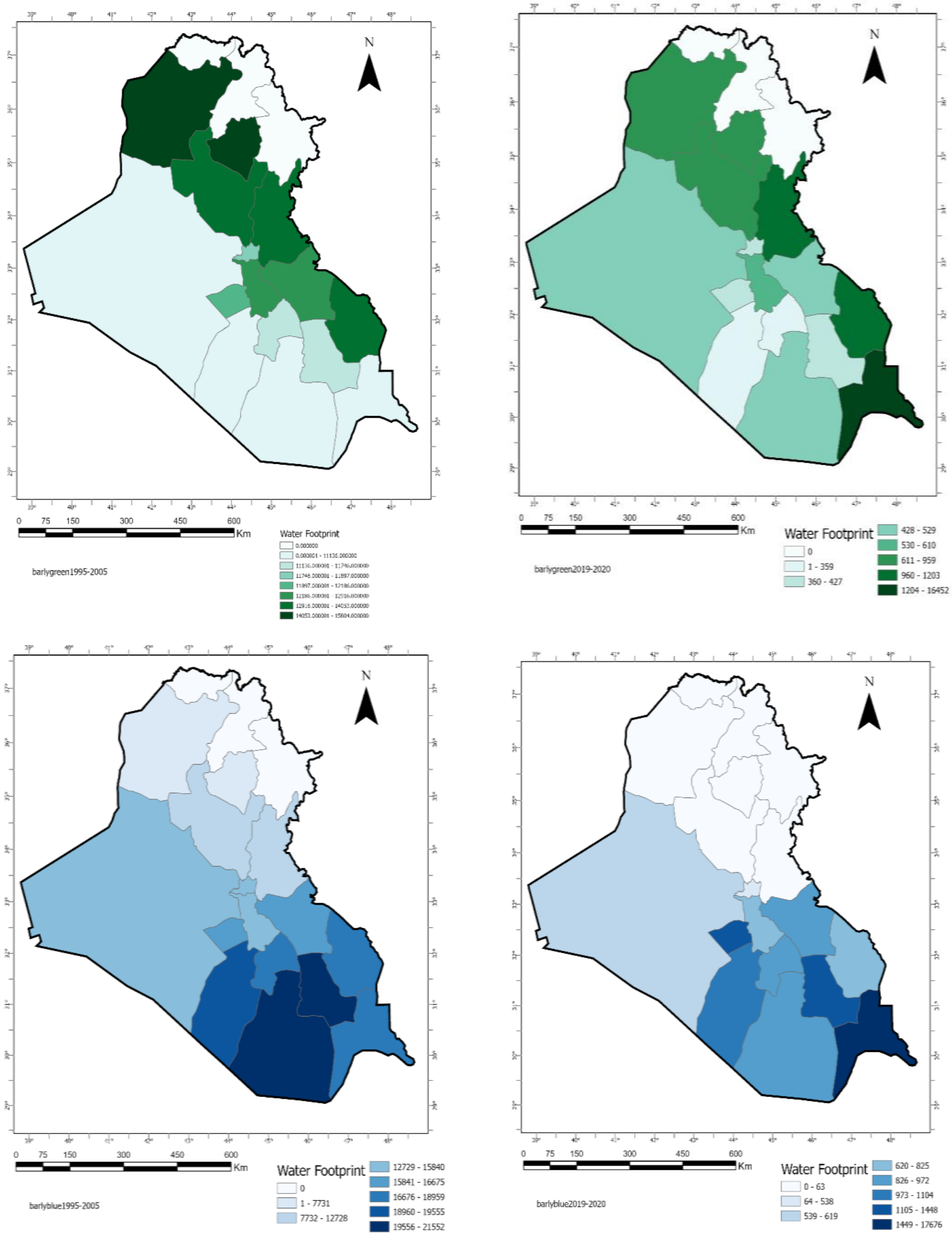

Fig. 8. Spatial distribution of green, blue water footprint for barley (1995-2005), (2019-2020)

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