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The water poverty rates and water sustainability rates for Some Arab countries for the period (2000-2023)

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Abstract
The aim of the study is to identify the concept of water poverty and water sustainability 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 in Arab countries, as the water resource is the main obstacle to economic development and food production in these countries and the main goal is to benefit from it. Therefore, the study aims to calculating the water poverty and water sustainability indicators for Iraq, Algeria, Egypt, Saudi Arabia, and Tunisia for the period (2000 - 2023). The study assumes that the water poverty index is high in the study countries, but the water sustainability index is low in them. The water sustainability was determined, where it found that Tunisia is one of the sample countries that is somewhat conservative in managing its water resources, followed by Egypt, then Iraq, Saudi Arabia and Algeria. By calculating the water poverty index (average per capita share), it was found that all sample countries suffer from serious scarcity, increased competition and water stress, and thus some sample countries have moved beyond the stage of water scarcity to water poverty.
Key words: water Poverty, water sustainability, water crises, water resource.

Introduction

Because of continued economic growth and population expansion, the demand for fresh water is increasing worldwide, with domestic fresh water shortages occurring more frequently than ever. Nearly one billion people in the developing world do not have access to clean, safe drinking water. Many regions of the world face serious water scarcity, particularly water used in agricultural production. More than 80% of the population in developing countries suffers from water stress and around 50% suffers from water shortage. Demand and dependence on water continue to increase while available resources remain relatively constant. Water poverty is a critical and complex challenge facing many regions around the world, characterized by insufficient access to safe and clean water for drinking, sanitation and agricultural purposes. This condition is a central concern because water is essential for human health, economic development and environmental sustainability. Water poverty not only affects the immediate health and well-being of individuals, but also has far-reaching implications for educational opportunities and economic empowerment. Water sustainability is also closely linked to poverty and development (1). Access to clean and safe water is a basic human need and a critical component of social and economic development. Therefore, it is important to study water poverty rates and sustainability rates. In general, sustainable water management is a priority for agriculture in the world, especially in areas facing water scarcity (2). Water sustainability includes different dimensions that need to be clearly addressed through appropriate indicators. Therefore, developing appropriate tools to help assess water scarcity is a major requirement. Hence, the agricultural water poverty index was developed to measure the water situation at the farm level. The main function is to measure the level of water poverty as the most important factor. Although there is no specific definition of water poverty agreed upon by countries, it could said that it means the state of not obtaining sufficient quantities of water and of appropriate quality to meet basic needs (3). The United Nations Water Organization defined it as "the ability of the population to ensure sustainable access to sufficient quantities of water of acceptable quality to maintain human life and well-being, achieve sustainable economic and social development, and ensure protection against water pollution and water-related disasters." The water poverty index is a composite index of several sub-indicators to measure the extent of a country's progress in managing the water sector and meeting its needs. This study will address this in more detail through specific case studies, data-driven insights, and recommendations for improving agricultural practices and integrated water management. However, water scarcity affects more than 40% of the world's population, a number that expected to rise. Sustainable water management is critical to poverty reduction, because water insecurity can exacerbate the hardships faced by the poor, limiting their access to food, health and economic opportunities. Sustainable management of this vital resource is critical to achieving poverty reduction goals and ensuring a secure and prosperous future for all individuals regardless of their socio-economic status (4). According to what was proposed by the Swedish scientist (Vulcan Mark) to determine the use of water per person annually on the basis of the amount of (1000) cubic meters per person annually as a unit of water stability and (500) cubic meters per person for semi-arid regions such as the Middle East, however, with the presence of an amount of (1000) cubic meters, the possibility of the emergence or appearance of pressure on stability cannot be ruled out. Therefore, the United Nations programs went to determine the amount of (1000) cubic meters per person as a minimum for the use of water resources. Countries that provide their individuals with an amount of more than (1700) cubic meters of water do not have a crisis called a water crisis (5). However, providing a share per person between (1000-1700) cubic meters annually means the presence of water stress or poverty for water (6). As for less than (1000) cubic meters per person annually, the description confirms the presence of water scarcity in that country. Accordingly, we find that about (700) million people suffer from water crises in (43) countries worldwide, noting that the share per person annually of the amount of water, if it is less than (500) cubic meters in any place or country, is called (absolute water scarcity) (7). The problem of the study is the critical scarcity of water resources in the Arab countries under study. Therefore, exports and imports must arranged according to their water needs from virtual water.

Material and Methods

First: Water Poverty Rate: The Water Poverty Index (WPI) is an innovative tool designed to measure and analyze water scarcity by integrating different dimensions of water availability, access, and use with socio-economic factors and environmental considerations. The WPI provides a comprehensive framework for assessing water stress and its impacts on communities, with the aim of informing policy-making and decision-making processes to improve water management and accessibility (8). Water poverty is a condition in which communities face a severe shortage of clean, accessible water. A deep-rooted issue intersects with environmental, economic, and social factors at multiple levels. To understand the nuances of water poverty, it is essential to explore its underlying causes, the breadth of its impacts on communities, and the strategies needed to mitigate and resolve it (9). Water poverty accounts serve as a critical measure in assessing the accessibility and affordability of clean water resources for communities around the world. Sustainability rates in water management measure the feasibility of water conservation efforts and the equitable

distribution of water resources in the long term according to the international indicator, which stipulates that the per capita share of fresh water should not be less than (1000) cubic meters per year. Iraq is one of the countries that fall within water stress, as the average per capita share reached (1549.86) cubic meters in 2000 and decreased to (1365.67) cubic meters in 2023. The Arab Republic of Egypt and the Kingdom of Saudi Arabia are among the countries that suffer from chronic water shortages, as we note that the Egyptian per capita share was (877) cubic meters in 2000 and decreased to (825) cubic meters in 2023, while the Saudi per capita share reached (894) cubic meters in 2000 and decreased to (774) cubic meters in 2023. As for what we notice in Tunisia It suffers from absolute water scarcity, as the Tunisian individual's share of fresh water was (443) cubic meters in 2000 and decreased to (396) cubic meters in 2023. As for the Algerian individual, he falls under water scarcity, as the average individual share was (316) cubic meters in 2000, but it increased to (506) cubic meters in 2023, as shown in Table (1)

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Table (1) Water stress rates and fresh water

Water stress rate	Annual renewable fresh water (cubic meters/year)
Absolute water scarcity	less than 500
Chronic water shortage	500-1000
Regular water stress	1000-1700
Episodic or local water stress	greater than 1700

Source: Sofi, 2016, 21.

Strategies to address water poverty

The strategies to address water poverty are as follows (12):

1. Sustainable agricultural practices: Implementing water-saving irrigation methods, such as drip irrigation, and encouraging the cultivation of drought-resistant crop varieties can significantly reduce water use in agriculture.
2. Water reuse and recycling: Technological advances can enable the reuse of wastewater and agricultural runoff for agricultural and industrial purposes, reducing demand for freshwater resources.
3. Rainwater harvesting: Collecting and storing rainwater provides an additional source of water, especially in areas with seasonal rainfall, which helps alleviate water scarcity.
4. Integrated Water Resources Management (IWRM): Integrated water resources management approaches include managing water resources in a comprehensive manner that balances social, economic and environmental needs, ensuring that water used sustainably.
5. Community education and engagement: Educating communities about water conservation techniques and involving them in water management decisions can lead to more sustainable water use practices.
6. International cooperation and assistance: International support, in terms of funding and expertise, is critical to developing water infrastructure and building capacity in water-scarce regions. We note that addressing water poverty requires a multi-faceted approach (strategic approach) that includes technological innovation, sustainable resource management, policy reform, and international cooperation. By addressing the root causes of water scarcity and implementing forward-thinking solutions, it is possible to mitigate the effects of water poverty and move towards a more equitable and sustainable future for all.

Table No. (2) Water poverty rates in the sample countries during the period from (2000-2023) (M^3)

Year	Iraqi per capita share	Algerian per capita	Saudi per capita	Egyptian per capita	Tunisian per capita
2000	1549.86	316	894	877	443
2001	1228.79	320	891	886	439
2002	2069.62	325	808	896	435
2003	2774.86	329	933	909	430
2004	2393.60	334	860	884	428
2005	1954.36	345	631	874	439
2006	2169.03	351	732	864	444
2007	1900.81	358	596	877	447
2008	1025.23	365	623	875	448
2009	1019.77	372	651	854	453
2010	1542.93	380	654	839	450
2011	1426.60	387	699	825	449
2012	1435.33	395	739	812	447
2013	1588.50	403	768	810	444
2014	1033.28	411	781	798	439
2015	989.69	419	806	788	429
2016	1512.06	427	785	796	408
2017	1091.27	434	731	844	366
2018	864.80	441	758	820	375
2019	2388.82	449	758	832	383
2020	1235.11	500	744	832	400
2021	1496.24	448	751	840	392
2022	1399.50	400	744	833	399
2023	1365.67	506	774	825	396

Source: World Bank - Years of Study.

Based on these numbers, we call for the importance of governments and specialized organizations in the sample countries assuming responsibility for practicing and developing specialized and sound approaches to water resources management to avoid chronic crises that hinder development and progress.

Second: Water Sustainability Index: Measuring the level of water security by estimating the per capita share of available water resources alone is not enough because measuring this index is constantly decreasing in almost all countries of the world because of population growth. Therefore, the water sustainability index was estimated, as the water sustainability index (water scarcity) is measured by dividing the water consumed or used by the amount of water obtained annually from water sources multiplied by (100) (10). Countries classified according to the water scarcity index (water sustainability) into three cases: 1- Countries in which the index value is less than (10%) are countries that do not suffer from major problems in managing their water resources. 2- Countries in which the index value exceeds (20%) are countries that suffer from water scarcity and increased competition for its use between different sectors. 3- Countries in which the index value exceeds (40%) are countries that suffer from serious water scarcity (11).

Water Sustainability Strategies (8):

The most important water sustainability strategies are:

1. Water conservation: Promoting water conservation practices, such as reducing water waste, repairing leaks, and implementing water-efficient technologies, can help reduce water demand and ease pressure on water resources.
2. Infrastructure investment: Investing in water infrastructure, such as water treatment plants, wastewater recycling facilities, and irrigation systems, can improve water quality, increase water supply reliability, and reduce losses in distribution networks.
3. Integrated water management: Adopting integrated water management approaches that take into account the interconnectedness of water resources, land use, and ecosystems can help balance competing demands for water and promote sustainable water use.
4. Policy and governance: Implementing effective water management frameworks, policies, and regulations can support equitable allocation of water resources, encourage sustainable water management practices, and enhance collaboration among stakeholders.
5. Community engagement: Engaging local communities in water management and decision-making processes can increase ownership, awareness, and participation in sustainable water practices, leading to more effective water resource management.

6. Research and innovation: Investing in research and innovation can help develop new water technologies, improve water efficiency, and enhance water quality monitoring to address emerging water challenges and support long-term water sustainability.

Finally, addressing water scarcity requires a multifaceted approach (integrated management) that integrates water conservation, infrastructure development, governance, and community engagement. By implementing sustainable water management practices and policies, we can work to ensure equitable access to clean water for current and future generations while protecting the health of ecosystems and the environment.

Calculating the Water Sustainability Index in Iraq for the period (2000-2023): The water sustainability index shows the water poverty that the country is going through, as the index rose in Iraq in 2008 and reached (156.36%), and the reason for this was the lack of water supply, amounting to (32.7) billion cubic meters relative to demand, due to the policies followed by the upstream countries due to the construction and operation of dozens of dams on the sources of the Tigris and Euphrates rivers in Turkey and Iran and the lack of rain. The sustainability index was at its lowest value in 2019 and reached (60.08%) due to the abundance of water supply relative to the rest of the years, amounting to (93.47) billion cubic meters, with an average of (103.08%).

Table (3) Water Sustainability Index in Iraq for the period (2000-2023)

Years	Water demand (billion m3) (1)	Water supply (billion m3) (2)	Water Sustainability Index (%) (3)
2000	47.03	37.33	90.15
2001	46.13	30.49	103.75
2002	62.27	52.91	87.76
2003	60.42	73.09	93.92
2004	58.56	64.96	156.36
2005	56.70	54.65	152.59
2006	54.84	62.49	87.83
2007	52.99	56.42	95.79
2008	51.13	32.70	88.98
2009	49.27	32.29	75.05
2010	44.03	50.13	107.47
2011	45.56	47.56	137.73
2012	43.69	49.10	70.42
2013	41.84	55.75	106.24
2014	39.98	37.20	101.79
2015	48.00	34.85	60.08
2016	38.51	54.69	104.98
2017	43.06	40.53	80.81
2018	33.56	32.97	91.58
2019	56.16	93.47	90.15
2020	52.06	49.59	103.75
2021	47.41	58.67	87.76

2022	49.73	54.30	93.92
2023	50.23	55.20	91.12

Source:(1) & (2): World Bank- Years of study. (3) Calculated by the researchers according to the following formula: Water sustainability rate = quantity of water required ÷ quantity of water supplied *100.

Calculating the Water Sustainability Index in Algeria for the period (2000-2023): The sustainability index confirms the water poverty that Algeria is going through, as the index was high in 2000 and reached a value of (177.44%) due to the low supply of water, amounting to (5.63) billion cubic meters, due to the low expected rainfall and high temperatures as well as drought. The lowest value of the sustainability index was in 2009, amounting to (85.44%), due to a slight increase in the quantities of water offered relative to the rest of the years, amounting to (7.28) billion cubic meters, while there were higher increases in the rest of the years, but increasing demand, and therefore sustainability did not appear less despite the higher water supply, and there was less demand for water in 2009, amounting to (6.22) billion cubic meters, due to the pricing of water requirements by the state.

Table (4) Water Sustainability Index in Algeria for the period (2000-2023)

Years	Water demand (billion m3) (1)	Water supply (billion m3) (2)	Water Sustainability Index (%) (3)
2000	9.99	5.63	177.44
2001	5.80	5.81	99.83
2002	8.04	6.04	133.11
2003	7.42	6.22	119.29
2004	8.39	6.39	131.30
2005	6.77	6.57	103.04
2006	6.95	6.75	102.96
2007	6.99	6.92	101.01
2008	6.11	7.10	86.06
2009	6.22	7.28	85.44
2010	9.99	7.45	134.09
2011	8.63	7.63	113.11
2012	7.88	7.80	101.03
2013	9.18	8.18	112.22
2014	8.26	8.57	96.38
2015	10.90	8.95	121.79
2016	8.55	9.23	92.63
2017	9.43	9.70	97.22
2018	9.88	9.80	100.82
2019	9.89	9.80	100.92
2020	10.90	9.80	111.22
2021	10.22	9.80	104.29
2022	10.06	9.88	101.82
2023	10.43	9.12	114.36

Source: (1) & (2): World Bank- Years of study. (3) Calculated by the researchers according to the following formula: Water sustainability rate = quantity of water required ÷ quantity of water supplied *100.

Calculating the Sustainability Index in Saudi Arabia for the period (2000-2022): The sustainability index shows the water poverty that Saudi Arabia is going through, as the index rose in 2007 and reached (153.31%) due to the lack of water supply in that year compared to the rest of the years, which amounted to (14.65) billion cubic meters due to the lack of rain in that year, while the lowest sustainability index was in 2015 and reached (91.71%) due to the increase in the supply of water imports in that year as a result of the increase in rain, which led to an increase in the groundwater level, which amounted to (24.83) billion cubic meters.

Table (5) Water Sustainability Index in Sudia Arabia for the period (2000-2023)

Years	Water demand (billion m3) (1)	Water supply (billion m3) (2)	Water Sustainability Index (%) (3)
2000	19.67	20.10	97.86
2001	19.98	20.12	99.30
2002	20.34	20.15	100.94
2003	20.59	20.54	100.24
2004	20.88	19.40	107.63
2005	21.47	14.66	146.45
2006	22.64	17.51	129.30
2007	22.46	14.65	153.31
2008	22.29	15.73	141.70
2009	22.12	16.89	130.97
2010	21.94	17.44	125.80
2011	21.77	19.19	113.44
2012	21.60	20.88	103.45
2013	21.46	22.36	95.97

2014	21.47	23.41	91.71
2015	22.77	24.83	91.70
2016	29.31	23.93	122.48
2017	22.94	23.35	98.24
2018	23.38	23.82	98.15
2019	23.38	15.39	151.92
2020	23.38	24.53	95.31
2021	23.30	24.54	94.95
2022	23.34	24.64	94.72
2023	23.89	25.12	95.10

Source :(1) & (2): World Bank- Years of study. (3) Calculated by the researchers according to the following formula: Water sustainability rate = quantity of water required ÷ quantity of water supplied *100.

Calculating the Water Sustainability Index in Egypt for the period (2000-2023): The sustainability index shows the water poverty that Egypt is going through, as the index rose in 2022 and reached a value of (111.80%) due to the lack of water supply from the Nile River for that year due to the construction of the Ethiopian Renaissance Dam, as Egypt is a downstream country and not a source country, as the amount of water offered reached (72.9) billion cubic meters, and the lowest index recorded in 2016, where its value reached (71.19%) due to the increase in the amount of water supply, which amounted to (85.20) billion cubic meters, over the demand for it, which amounted to (60.65) billion cubic meters.

Table (6) Water Sustainability Index in Egypt for the period (2000-2023)

Years	Water demand (billion m3) (1)	Water supply (billion m3) (2)	Water Sustainability Index (%) (3)
2000	55.94	55.51	100.77
2001	58.70	61.88	94.86
2002	60.38	68.26	88.46
2003	62.06	68.76	90.26
2004	63.73	68.76	92.68
2005	65.41	69.56	94.03
2006	67.09	69.96	95.90
2007	68.76	72.36	95.02
2008	70.44	73.60	95.71
2009	72.12	73.35	98.32
2010	75.98	73.75	103.02
2011	71.65	74.16	96.62
2012	72.03	75.40	95.53
2013	73.00	76.00	96.05
2014	60.07	76.40	78.63
2015	77.99	76.25	102.28
2016	60.65	85.20	71.19
2017	77.05	80.25	96.01
2018	77.05	80.40	95.83
2019	77.07	75.10	102.62
2020	82.99	80.10	103.61
2021	80.02	79.70	100.40
2022	81.50	72.90	111.80
2023	82.11	73.00	112.47

Source: (1) & (2): World Bank- Years of study. (3) Calculated by the researchers according to the following formula: Water sustainability rate = quantity of water required ÷ quantity of water supplied *100.

Calculating the Water Sustainability Index in Tunisia for the period (2000-2023): The sustainability index shows the water poverty that Tunisia is going through, as the index rose in 2015 and reached (138.77%) due to the lack of rain in this year compared to other years, as the amount of water offered in that year reached (6.81) billion cubic meters, which is the lowest amount for the study period, while the lowest water sustainability index was in 2011, as its value reached (8.52%), as the quantities of water offered were greater than the demand for it, and for this reason it appeared in this year that it is one of the countries that does not suffer from major problems in managing its water resources, and this is what it aspires to in the rest of the years and the rest of the countries.

Table (7) Water Sustainability Index in Tunisia for the period (2000-2023)

Years	Water demand (billion m3) (1)	Water supply (billion m3) (2)	Water Sustainability Index (%) (3)
2000	9.99	10.48	95.32
2001	2.80	9.22	30.37
2002	2.82	10.11	27.89
2003	2.83	12.12	23.35
2004	2.85	13.16	21.66
2005	2.86	24.69	11.58

2006	2.88	25.26	11.40
2007	2.89	25.62	11.28
2008	2.91	25.98	11.20
2009	3.01	26.90	11.19
2010	9.99	27.55	36.26
2011	3.21	37.64	8.53
2012	3.31	12.57	26.33
2013	3.42	16.40	20.85
2014	3.52	20.83	16.90
2015	9.45	6.81	138.77
2016	3.72	8.30	44.82
2017	3.52	9.63	36.55
2018	3.78	23.56	16.04
2019	3.79	7.90	47.97
2020	9.19	8.10	113.46
2021	6.76	6.80	99.41
2022	7.97	7.60	104.87
2023	8.11	7.00	115.85

Source :(1) & (2): World Bank- Years of study. (3) Calculated by the researchers according to the following formula: Water sustainability rate = quantity of water required ÷ quantity of water supplied *100.

Conclusions

1- The water sustainability and water poverty index (per capita share of total water) was determined, where it was found that Tunisia is one of the sample countries that is somewhat conservative in managing its water resources, followed by Egypt, then Iraq, Saudi Arabia and Algeria.

2- By calculating the water poverty index (average per capita share), it was found that all sample countries suffer from serious scarcity, increased competition and water stress, and thus some sample countries have moved beyond the stage of water scarcity to water poverty.

3- Significant reductions in the average per capita consumption of water occurred following the implementation of major measures to reduce demand in the form of pricing programs, where Egypt began pricing water by raising the land tax, and Algeria also began pricing agricultural water (irrigation), and pricing was also implemented in both Saudi Arabia and Tunisia, where the policy followed in them was to include all costs of providing water for operation and maintenance, and the state provided water resources to encourage more water-efficient irrigation, while the issue of pricing irrigation water is still a subject of research and controversy in Iraq.

Recommendations

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

2- Imposing agricultural policies that improve water management and use, which is imposing the application of the water footprint concept for products grown in the country in order to correct its economic decisions related to the production of agricultural crops.

3- Determine water needs (current and future demand) and conduct comprehensive and adequate studies on the quantities of water offered and required.

4-Adopting agricultural policies that improve water management and use, and different policies must adopted in the dependence of some countries on others in achieving water security and then food, as well as adopting integrated water resources management in order to achieve the greatest benefit from water resources to achieve a high percentage of water security.

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