Journal of Sustainable Development in Social and Environmental Sciences
http://jsdses .journals.ekb.eg/

P-ISSN: 2812-6335 E-ISSN:2812-6343

Demand Management for Water Resources in the Irrigation and Population Sectors in Jordan

Dr. Ibrahim Abdul Salam Ali Mohammed Algalaly*

* Holder of PhD in Economics, Department of Political and Economic Systems, Institute of Asian Studies and Research, Zagzig University, Egypt; elgalaly2016@gmail.com

doi: 10.21608/jsdses.2023.202739.1016

This is an open access article licensed under the terms of the Creative Commons Attribution International License (CC BY 4.0).
http://creativecommons.org/licenses/by/4.0/

ABSTRACT

The Jordanian irrigation sector is one of the largest sectors consuming water. In view of the water crisis in Jordan, Jordan is considered one of the leading countries in the use of treated water for agriculture, while water harvesting is a complementary source for water needs in agriculture. As for managing the demand for drinking water, water wastage is considered one of the most economically feasible measures, but it is not exploited. It is possible to activate demand management through a gradual water tariff for large consumers, and provide incentives to reduce water consumption. Adopting innovations, unconventional entrepreneurial ideas, and modern technology (smart meters, leak detection devices, and aquaculture) is one of the measures that will activate the water demand management approach. Adopting a water demand management approach requires combining different solutions, measures, and methods, which in turn requires concerted efforts to recognize the real need for the required and available water. Accordingly, there is a clear vision regarding demand management, which helps in attracting the required investments, and achieving a balance between the supply and demand departments.

Keywords: Demand management, water resources, water pricing, uses of water resources, Jordan.

Introduction

Most of the Arab countries are located in arid and semi-arid regions, where there is unexpected little rain in most countries. The region is characterized by negative traditional and cultural practices related to the use of water, especially in irrigation, as surface irrigation is the dominant method. Besides, the efficiency of water use for drinking purposes and for industrial purposes is, in fact, totally insufficient. This is mainly due to the fact that at least a third of the quantity is lost due to misuse during leakage from networks, and many industries use quantities of water that are much more than the quantities they need. Besides, the region is also characterized by having one of the highest population growth rates in the world, which increases pressure from one year to another on limited water resources, by nature. It is expected in the near future that the water deficit

problem will increase.

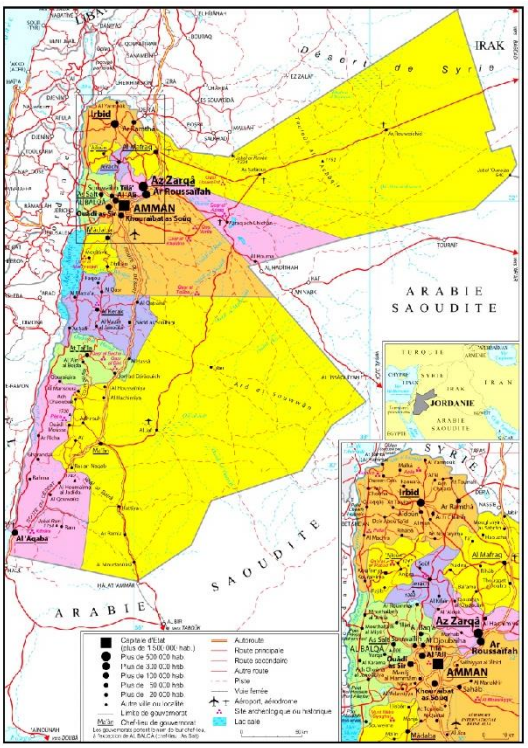
Population growth, rapid urbanization, pollution and the expansion of economic activities have put enormous pressures on water resources in many countries. The increasing demand for water has been met through programs to increase supply, such as new infrastructure for storage, desalination and recycling. However, increasing water supplies face increasing environmental and financial costs. As a result, policy makers' attention has increasingly shifted to demand management. Appropriate water pricing policies can improve water use efficiency, increase revenues, and thus improve services, in addition to enhancing and expanding the operation and maintenance of piped water supply systems. Designing an appropriate pricing policy, effective planning and management of water supply requires understanding the determinants of water demand across different categories of users (https://www.monash. edu/ data/assets).

One of the most important challenges facing Jordan today is the acute shortage of water, which constitutes a challenge in terms of providing water for the large numbers of the population and meeting their basic needs, and the lack of water security. Jordan is witnessing a severe and unparalleled deficit in terms of water resources, to the extent that the amount of water available has made it the poorest country in the world in terms of the availability of water resources.

This situation is getting worse as a result of climate changes and their repercussions on the effect on dry weather, and thus all sectors will be negatively affected as a result of this deficit. Therefore, the importance of water resources cannot be denied in relation to economic and social development and the achievement of its security and stability, and accordingly it was necessary to improve and develop demand management for the water in Jordan.

Water demand management is defined as "maximum utilization of available water, limiting its waste, preserving its sources, minimizing waste, and promoting the principles of its use with the highest levels of efficiency". Water scarcity can be faced through managing both demand and water supply. Jordan should shed light on water demand management because it plays an important role in preserving the limited sources of demand, as it is more flexible, less expensive, and capable of redistributing water in an effective manner.

Jordan is located in the southwestern part of Asia, with an area of 89.318 km^2, and is bordered by Saudi Arabia to the south and east, Syria to the north, Iraq to the east, and Palestine and Israel to the west. Jordan has access to the Red Sea through the port of Aqaba, which is located at the northern end of the Gulf of Aqaba. It consists of 12 governorates, and the largest governorate is Ma'an in terms of area (Figure 1). The total population of Jordan is 11.1 million in 2021, and the capital Amman ranks first with a population of 4.6 million (Jordanian General Statistics Department, 2021).



Source: https://www.worldmaps.info/Jordan/

Figure 1: General Characteristics of Jordan

The study aims to identify the traditional water resources and water pricing methods as a tool for

managing the demand for water resources in the irrigation and population sectors in Jordan. It also aims at identifying the current and future uses of water resources in the various sectors in Jordan, and attempting to identify the most important problems of their exploitation.

To achieve the aim of the study, this research is divided into the following topics:

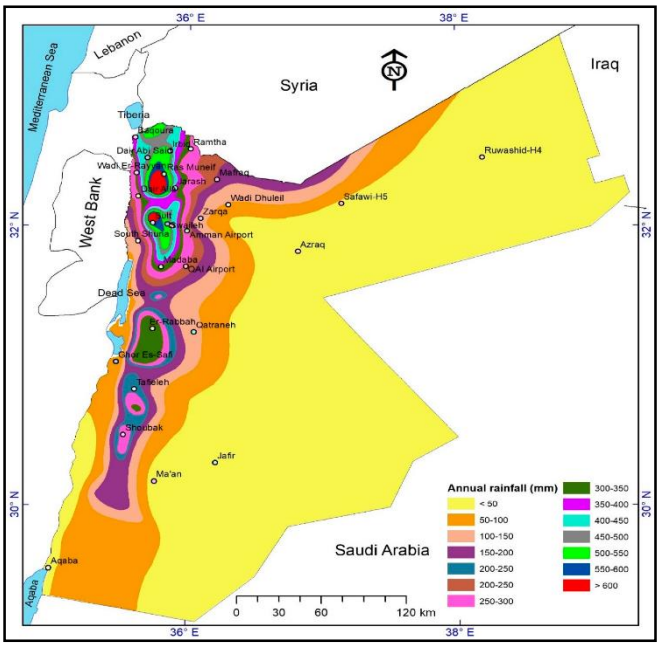
First: Water Resources in Jordan

Water resources play the main role in achieving economic development in various sectors as well as providing food for the population of the international community. Hence, the importance of these resources and their great role in the continuity and sustainability of life on the surface of the planet arises. The following is an explanation of water resources in Jordan.

1- Rain:

The annual amount of rainwater in Jordan is eight thousand million cubic meters, and in rainy years this figure rises to 12 thousand million cubic meters. However, this amount, in years of scarcity, decreases to six thousand million cubic meters, and this rain is distributed over the area of Jordan with great disparity. On the other hand, the northwestern regions in the heights of Ajloun and Al Balqa have rates of about 500 mm/year, and the eastern and southern regions have annual rainfall rates of less than 50 mm/year. Rainwater is distributed over the area of Jordan as follows: 1.3% of the area of Jordan receives annual rainfall rates of more than 500 mm, 1.8% receives between 300-500 mm, 3.8% receives between 200-300 mm, 12.5% receives between 100-200 mm, and the rest which is about 80.6% of the area receives less than 100 mm (Jordanian Economic and Social Council, 2021).

Figure 2 shows a discrepancy in the annual amounts of rain falling on Jordan during the year 2018/2019, as it is clear that the amount of rain increases in the north of Jordan, reaching more than 600 mm/year, and decreases as we moved towards the south, reaching 150 mm/year. It decreases to 50 mm/year towards the east.



Source: Aladaileh et al., 2019.

Figure 2: The Annual Amount of Rainfall (mm/year) in Jordan in (1979/2017)

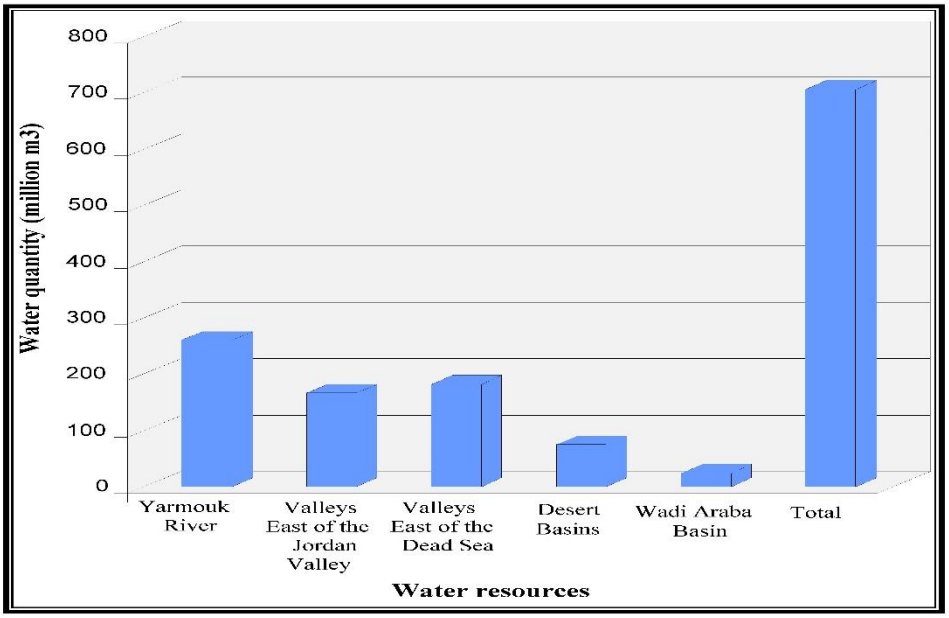
2- Surface water:

The total surface runoff in Jordan is estimated at about 706 million cubic meters annually, distributed as shown in Table 1 and Figure 3, which shows the sources of surface water in Jordan.

Table 1: Sources of Surface Water in Jordan

No.	source/resource	Water quantity (million m^3)
1	Yarmouk River	260
2	Valleys east of the Jordan Valley	166
3	Valleys east of the Dead Sea	182
4	Desert basins	74
5	Wadi Araba Basin	24
Total		**706**

Source: Ashram, 2008.



Source: Table 1.

Figure 3: Sources of surface water in Jordan

It is clear from the analysis of Table 1 and Figure 3 that there is variation in the amount of water from different sources, as the Yarmouk River contains the largest amount of water, which is estimated at 260 million m^3. The valleys east of the Dead Sea come in second place with a water quantity of 182 million m^3, the valleys east of Jordan valley come in the third place with about 166 million m^3, the desert basin ranks fourth with an amount of 74 million m^3, and the Wadi Araba basin comes in fifth place with a water quantity of 24 million m^3.

3- Groundwater:

The groundwater in Jordan is represented by what is known as the deep water system consisting of three underground systems. The exploitation of this system is uneconomical, in addition to the boiling of siliceous limestone systems whose waters are exploited for their quality and limited depth, as well as the basaltic rock system in eastern Jordan that is fed by rain falling on Jabal Al-Arab in Syria which is an almost fully exploited system. Besides, the system of sediments of valleys and rivers in the streams of valleys and rivers such as the Jordan Valley and Wadi Araba.

Groundwater resources in Jordan suffer from depletion resulting from excessive pumping, as the safe pumping of groundwater is estimated at about 275 million m^3, while the quantities extracted in 2014 exceed the safe limit by about 160 million m^3. It has been recently shown through the use of remote sensing techniques and satellite images provided by NASA that the quantities actually extracted from aquifers are more than what is recorded by about 220 million m^3, and these quantities are illegally pumped by both licensed and unlicensed wells (Jordanian Ministry of Water and Irrigation, 2019).

Second: Water pricing in Jordan:

Water pricing policies play an effective role in the areas of rationalizing water uses. The water tariff structure must be determined based on knowledge of the costs of water production and distribution on the one hand, and the economic and social conditions of water consumers on the other hand. In the field of industrial use, the principle of "who pollutes pays" must be applied as in developed countries (Al-Ashram, 2008).

The pricing mechanism depends on a number of factors, such as the type of sector used, the level

of support provided, the ability to pay, fairness among consuming groups, and incentives to rationalize water use. As for water pricing policies, they are classified according to pricing according to the amount of water consumed, progressive pricing, market pricing for water, and non-quantitative pricing.

1- Irrigation sector:

Since 1994, the Jordanian government has implemented a plan to install meters on agricultural wells, where the rate of installation of meters on agricultural wells has reached about 94% in various regions of the Kingdom. The cost of pumping a cubic meter of groundwater has been calculated within the range of 80-120 penny per cubic meter (1.13-1.69). $/m^3$) according to the depth of the water surface and the type of energy used to operate the pumps (Al-Hadidi, 2002). Table 2 shows the prices of irrigation water according to the stratum system.

Table 2: Irrigation water prices according to the stratum system

No.	The amount of water consumed (m3/agricultural unit/month)	Price (penny/m^3)	Price ($/$m^3$)
1	0-2500	8	0.11
2	More than 2500-3500	15	0.21
3	More than 3500 - 4500	20	0.28
4	More than 4500	35	0.49

Source: Al-Hamwi, 2016.

It is clear from Table 2 that water prices increase as consumption increases. In the case of consumption up to 2500 m^3/agricultural unit/month, the price reaches 8 penny/m^3, equivalent to $0.11/$m^3$, and the consumption price reached 15 penny/m^3 in the case of consuming an amount of water. Water is estimated at 2500-3500 m^3/agricultural unit/month, and if the amount of water consumed reaches 3500-4500 m^3/agricultural unit/month, the price reaches 20 penny/m^3, and the water price rises to 35 penny/m^3, which is equivalent to $0.49/ m^3 when the amount of water consumed rises to more than 4500 m^3/agricultural unit/month.

2- The population sector:

The population increase in Jordan represents a huge burden on the Jordanian water resources at a time when the per capita share of water is less than the international rates, which is estimated at 500 m^3 per person.

Table 3 shows the evolution of water value in the population sector in Jordan during the period from 2008 to 2013.

Table 3: Evolution of Water Value in the Population Sector in Jordan (2008-2013)

The years / Statement	2008	2009	2010	2011	2012	2013
Water revenues (JD/m^3)	0.547	0.505	0.521	0.585	0.675	0.724
Non-residential water price (JD/m^3)	1.00	1.00	1.00	1.00	1.300	1.300
Opportunity cost (JD/m^3)	0.453	0.495	0.479	0.415	0.625	0.576
Total water cost (JD/m^3)	0.820	0.960	0.830	0.930	1.230	1.350
Water value (JD/m^3)	1.273	1.455	1.309	1.345	1.855	1.926
Total value of water (million JD)	244.9	284.1	261.2	270.5	338.3	376.7

Source: Tabieh, ,et.al, 2022.

Table 3 indicates an increase in water revenues from 0.547 JD/m^3 in 2008 to 0.724 JD/m^3 in 2013. In addition, the price of non-residential bottled water for outside use increased from 1,000 JD/m^3 in 2008 to 1,300 JD/m^3 in 2013, and the total cost of water increased from 0.820 JD/m^3 in 2008 to reach 1.350 JD/m^3 in 2013. The value of water was estimated at 1.273 JD/m^3 in 2008 and reached 1.926 JD/m^3 in 2013. Total water value in 2008 was 244.9 million Jordanian dinars that increased to 376.7 million Jordanian dinars, an increase of 65%.

It is clear from the foregoing that the real water price is much higher than what consumers pay, due to the support provided by the Jordanian government to the water sector, as well as for many other reasons.

Water prices are an important and essential part and a necessary tool of water demand management tools, to control and raise the efficiency of water uses in all sectors whatever the source of that water is. Therefore, the Jordanian Ministry of Water and Irrigation has recently adopted a policy of energy efficiency and renewable energy in the water sector, with the aim of reducing the consumption of traditional energy and reliance on alternative energy in the water supply systems. This, in turn, helps reduce operating and maintenance expenses, recover costs and reduce losses in the water sector. Reducing the electric energy consumption bill will contribute to reducing the cost of water. (Jordanian Ministry of Water and Irrigation, 2016).

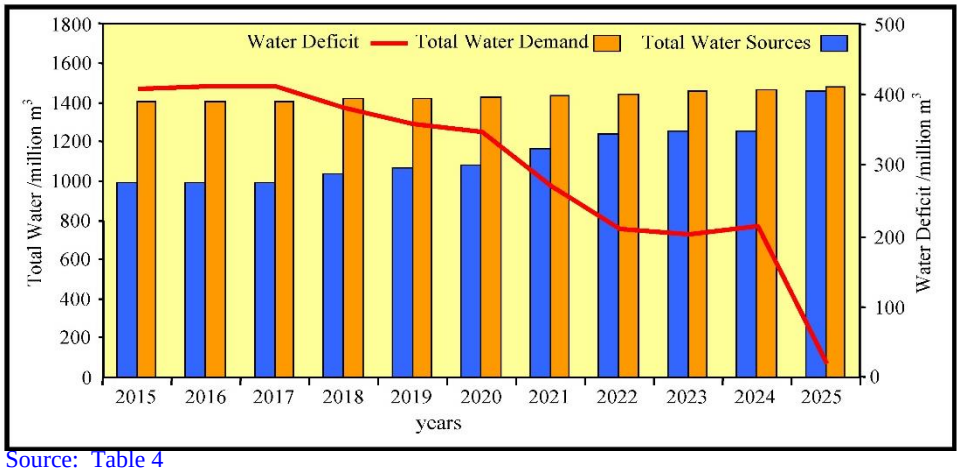
Third: Current and future uses of water resources in various sectors in Jordan from 2015 to 2025

Rapid population growth, economic development, high standards of living, and weak implementation mechanisms of international agreements lead to an increase in demand for scarce water resources. Projections indicate that the population of Jordan will be doubled by 2025, and thus the percentage of water used for domestic purposes will increase. Table 4 and Figure 4 show water resources in Jordan, and current and future uses during the period from 2015 to 2025.

Table 4: Water Resources in Jordan, and Current and Future Uses (million m^3) from 2015 to 2025

The years / Statement	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Groundwater (safe extraction)	275	275	275	275	275	275	275	275	275	275	275
Non-renewable Groundwater	144	145	145	147	178	189	174	240	241	242	243
Groundwater Overextraction	160	156	156	148	144	140	136	131	127	122	118
Surface Water (local + from Lake Tiberias)	263	265	265	269	271	276	284	293	306	311	329
Treated Wastewater	140	140	140	176.6	176.6	181.6	191	191	195	195	235
dditional Sources (Mubadala + Desalination)	10	11	11	18	19	20	106	107	108	109	260
Total sources	992	992	992	1033.6	1063.6	1081.6	1166	1237	1252	1254	1460
Demand for water in the (domestic, industrial, and tourist) sectors	701	703	703	717	723	730	737	746	755	766	778
Demand for water in the irrigation sector	700	700	700	700	700	700	700	700	700	700	700
Total water demand	1401	1403	1403	1417	1423	1430	1437	1446	1455	1466	1478
water deficit	409	411	411	383.4	359.4	348.4	271	209	203	212	18

Source:
-The Jordanian Ministry of Water and Irrigation, The National Water Strategy in Jordan 2016-2025.
-The Jordanian Ministry of Water and Irrigation, Summary of the National Strategic Plan for Water in Jordan 2022-2025.



Source: Table 4

Figure 4: Water Resources in Jordan, and Current and Future Uses (million m^3) from 2015 to 2025

It is clear from the analysis of Table 4 and Figure 4 that the total Jordanian water resources amounted to 992 million m^3 in 2015, and reached 1081.6 million m^3 in 2020. It is expected that the total Jordanian water resources will increase to 1460 million m^3 in 2025. The total demand for water for the domestic, industrial and tourism sectors was 701 million m^3 in 2015, and increased to 730 million m^3 in 2020, and it is expected to reach 778 million m^3 in 2025. The table shows the stability of the demand for water for the irrigation sector during the period from 2015 to 2025, and the total uses of the Jordanian economic sectors amounted to 1401 million m^3 in 2015, and reached 1430 million m^3 in 2020. It is expected that the total uses will reach 1478 million m^3 in 2025. The water deficit in Jordan was 409 million m^3 in 2015, and it decreased to 348.4 million m^3, and it is expected to reach 18 million m^3 in 2025.

It also appears from Table 5 that the total water used in the domestic sector amounted to 514.23 million m^3, and the highest participation rate was 52.6% for groundwater sources in uses in the various economic sectors. The amount of water used in the industrial sector reached 33.54 million m^3, and the total water used in the irrigation sector amounted to 565.95 million m^3, while the total water used in the animal sector amounted to 10.01 million m^3, and the total water used in the Jordanian economic sectors reached 1128.63 million m^3 in 2020.

It is clear from the previous analysis that the Jordanian agricultural sector is the most water consuming sector due to the expansion of the agricultural area through the reclamation of semi-desert lands, and the domestic sector comes in second place due to the high population growth rate, then the industrial sector and then the animal sector.

Table 5: Jordanian Water Resources and Uses in Different Sectors (million m^3) 2020

Uses / Water Resources	Domestic	Industrial	Irrigation	Animal	Total water use	Water Resource Participation %
Surface water	147.78	6.18	200.52	8.5	362.98	32.3
Groundwater	366.45	24	199.68	1.51	591.64	52.6
Treated wastewater	0.00	3.36	165.75	0.00	169.11	15.1
Total water used	514.23	33.54	565.95	10.01	1123.73	100

Source: Academy of Strategic Management Journal Volume 21, Special Issue 6, 2022.

Results and Recommendations:

First: Results

1. Population growth, rapid urbanization, pollution and expansion of economic activities have placed enormous pressures on water resources.
2. The Jordanian agricultural sector is the most water-consuming sector due to the expansion of the agricultural area through the reclamation of semi-desert lands.
3. The annual amount of rain water in Jordan is eight thousand million m^3.
4. The total surface runoff in Jordan is estimated at about 706 million m^3 annually.
5. The groundwater resources in Jordan suffer from depletion resulting from excessive pumping, as the safe pumping of groundwater is estimated at about 275 million m^3.
6. Economic controls, particularly water price policies, play an effective role in rationalizing water uses.
7. Water prices are an important and essential part and a necessary tool for water demand management.
8. The water resources currently available are not sufficient to meet the demand.

Second: Recommendations

9. Desalination of sufficient quantities of sea water in Aqaba so as to solve the problem of water shortage and reduce over-exploitation of groundwater reservoirs.
10. Social justice in the distribution of water to meet actual requirements only as well as obliging users at various levels to practice the most appropriate means in order to rationalize consumption and introduce modern irrigation techniques.
11. Adopting appropriate pricing mechanisms for water for each of the Jordanian economic sectors.
12. Reducing water losses for all uses, for optimal use and maximum benefit.
13. Achieving a balance between the expected benefits of water use and the cost of water supply to meet the growing needs.
14. Conducting awareness programs for citizens about the importance of preserving water resources and preventing pollution.
15. Expanding the reuse of treated wastewater in agricultural production, and providing the necessary water for industrial and other economic purposes.
16. Setting a price that guarantees the interest of all parties (supplier and consumer).
17. The price of water should be commensurate with the yield and revenue for each sector.
18. The tariff should be encouraging and incentivizing the optimal use of water, taking into consideration the social and economic aspects as well as consumers with limited incomes.
19. Reading the meters periodically during a specific period of time, including the actual amount of water consumption in the bill, and issuing it immediately after reading the meter, to provide the consumer with accurate information about the amount of consumption and the cost.
20. Incorporating treated or mixed wastewater into the replacement and reuse policy. It is important to set a reasonable price for it that guarantees cost recovery, taking into account the application of cost-saving innovations.

References:

Aladaileh, H., Al Qinna, M., Al-Karablieh, E., & Rakonczai, J. (2019). An investigation into the spatial and temporal variability of the meteorological drought in Jordan, *Climate*, 7, 82; doi: 10.3390/cli7060082, https://www.mdpi.com/journal/climate.

Al-Hamwi, B. A. (2016). An Overview of Countries' Experiences in Water Pricing, Al-Baath University, College of Civil Engineering, Department of Water Resources Engineering and Management.

Jordanian Ministry of Water and Irrigation, Water Authority, Summary of the Strategic Plan 2015-2019

Jordan Economic and Social Council, Country Status Report 2021.

Al-Hadidi, K. (2002). Estimating the economic value of irrigation water (the situation in the

Hashemite Kingdom of Jordan). A report presented to the Water Demand Affairs Management Forum: Estimating the Economic Value of Water, Lebanon.

Al-Ashram, M. (2008). Water Economics in the Arab World and the World, Center for Arab Unity Studies, Lebanon.

Mukhaimer, S., & Hijazi, K. (1996). Water crisis in the Arab Region: Facts and possible alternatives. *World of Knowledge Series*, No. 209, Kuwait.

Summary of the National Water Strategic Plan in Jordan 2022-2025

Tabieh, et.al. (2022). An estimate of the economic value of domestic water services: case study in Jordan. *Academy of Strategic Management Journal*, *21*, Special Issue 6.

.

The Jordanian General Statistics Department, Population and Social Statistics, Jordan in Numbers, 2020.

The Jordanian General Statistics Department, Population and Social Statistics, Jordan in Numbers, 2021.

The Jordanian Ministry of Water and Irrigation, Water Yearbook 2018/2019

The Jordanian Ministry of Water and Irrigation, Water Yearbook 2018/2019

The Jordanian Ministry of Water and Irrigation, 2016.

The National Water Strategy in Jordan 2016-2025

Websites

https://www.worldmaps.info/Jordan.

https://www.monash.edu/data/assets