Water supply and water use statistics in Jordan

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1. Introduction

The scarcity of water resources is one of the main challenges for Jordan and a limiting factor for economic development especially for agriculture. The demand on water resources is increasing with time for both agriculture and non-agricultural purposes.

Jordan receives rainfall of about 6,000 million cubic meters (MCM), and the Syrian catchment of the Yarmouk River Basin receives an additional 2,065 MCM. High evaporation and infiltration results in a relatively small annual stream flow of about 878 MCM, excluding Jordan River flow. The potential for further development of surface water resources rests principally with the construction of the proposed Al Wehdeh Dam on the Yarmouk River. This dam would provide an annual safe yield of about 105 MCM, of which 55 MCM for manufacturing and industrial uses in Irbid region. The remaining 50 MCM would be used to intensify agricultural production in the Jordan Valley.

In addition to the overall constraints of this resource, there are other problems which limit its large scale usage for irrigation purposes. One of the most significant problems is the exceeding of the safety limits which leads to the depletion of fresh water resources and an increased salinity of water. Other problems include the growing costs of water pollution and excessive pumping of groundwater especially in the highlands e.g. the Dheleil and Azraq basins.

Jordan is considered among the poorest countries in the world in terms of water resources. The climate is generally arid, with more than 90% of Jordan's total area receiving less than 200 millimeters rainfall per year and more than 70% of the country receiving less than 100 millimeters of precipitation on a year. Only around 2% of the land area, located in the north-western highlands, has an annual precipitation exceeding 300 millimeters. The northern highlands may receive as much as 600 millimeters. About 5.5% of Jordan's area is considered dry land with annual rainfall ranging from 200 to 300 millimeters. The pattern of rainfall is characterized by an uneven distribution over the various regions, and strong fluctuation from year to year in terms of quantity and timing.

Jordan is characterized by a pronounced scarcity of renewable fresh water resources, which averages at about 680 MCM per year, or approximately 135 m^3 per capita for all uses. Thus, Jordan's water resources are, on a per capita basis, among the lowest in the world.

The water resources of Jordan consist of groundwater and fossil water which are found in aquifers at different depths throughout Jordan. Other sources of water include surface water flows from precipitation in the Jordan River Basin, increasing treated waste water as well as non-conventional water resources such as brackish water.

2. Water supply

2.1- Surface water supply

The main supplier of water in Jordan is the public sector. The public sector provides the agriculture holders in Jordan valley with surface water for irrigation purposes. The Jordan Valley Authority (JVA) is the government agency in the Jordan Valley, and has established an irrigation network system to serve more than 31,174 ha of fertile valley land on Jordan's western border, an area which makes a significant contribution to the total tonnage of fruit and vegetables produced in Jordan.

The annual supply of surface water is 214.69 MCM, with the Jordan Rift Valley contributing 108 MCM. Springs account for 57.2 MCM and base flows and floods account for 49.4 MCM. Most of the surface water (73.5%) is allocated for agricultural activity, with about 152 MCM allocated for the purpose of irrigation. Most surface water used for irrigation is used in the Jordan Valley.

In addition, all treated waste water for irrigation purposes is mixed with fresh water to ensure dilution of pollutants from the treated water. The total quantity of treated water is 75.4 MCM.

The government also supplies water for municipal use (this includes households and some economic activities like service activities). The total quantity of surface water allocated for this purpose is 54.4 MCM, with industrial activity using about 2.5 MCM

Table 1: Quantity (MCM) of surface water use by water resource 2004.*

Source	Livestock	Irrigation	Industrial	Municipal	Total
1. Surface Water	**6.00**	**151.85**	**2.48**	**54.37**	**214.69**
- Jordan Rift Valley	0.00	67.35	2.14	38.61	108.09
- Springs	0.00	41.10	0.34	15.76	57.20
- Base & Flood	6.00	43.40	0.00	0.00	49.40
2. Treated Waste Water	**0.00**	**75.40**	**0.00**	**0.00**	**75.40**
- Registered	0.00	67.40	0.00	0.00	67.40
- Not Registered	0.00	8.00	0.00	0.00	8.00
Total	**6.00**	**226.25**	**2.48**	**54.37**	**289.09**

**Source: M.O.W.I-Water Authority*

Treated water contributes more than one fourth of what is contributed by surface water (Table 1). This contribution is quite high and can be attributed to the scarcity of water resources in Jordan. It is very important to make sure there is quality control of treated water before it is used for irrigation purposes.

2.2- Ground water supply

Ground water is abstracted by both public and private sectors. Most agriculture holders abstract water for their own use directly which is considered self–supply. The government is trying to monitor the quantity of ground water abstracted by the private sector including agriculture. The government abstracts ground water for purposes other than agriculture. The mining industry also abstracts ground water for their own use.

The total quantity of ground water is 520 MCM. The agricultural sector uses about 54% of ground water. The municipal sector uses about 40% of ground water, and the remaining (6%) is used for industrial activity.

Table 2: 2004 Ground water use in MCM.*

Source	Livestock	Irrigation	Industrial	Municipal	Total
2. Ground Water	**0.64**	**278.7**	**33.27**	**207.45**	**520.1**
- Renewable	0.64	210.25	29.20	192.74	432.83
- Non-Renewable	0.00	68.45	4.07	14.71	87.22

**Source: M.O.W.I-Water Authority*

It is important to note that the current use of ground water exceeds available renewable supplies, and non-renewable water is being abstracted. Jordan covers the increasing deficit through over drafting of highland aquifers and exploitation of non-renewable groundwater. In 2004, the over drafting of groundwater resources exceeded 230 MCM.

The depletion of ground water varies from one ground water basin to another. In some basins the over pumping of ground water exceeds by 3 times the safe yield, on the other hand the abstraction of water from other basins can be much less than the safe yield. This situation reflects the geographical distribution of water resources between ground water basins and the distribution of users. To reduce the immediate cost of transferring water and the cost of establishing infrastructure to do this, people increase water abstraction from the nearest basin which leads to an unsustainable dependence on the resource.

The table below shows ground water availability and ground water abstraction from each ground water basin.

Table 3: Ground water resources and use 2004.

Ground Water Basin	Safe Yield (M.C.M)	Water usage (M.C.M)					Balance	% Safe Yield
		Municipal	Industry	Agriculture	Distance Regions	Total Use		
Yarmouk	40.0	0.5	0.1	35.0	0.0	43.3	-3.3	108.0
Side Valleys	15.0	0.0	0.0	3.3	0.0	25.9	-10.9	172.0
Jordan Valley	21.0	0.0	0.2	19.6	0.0	27.9	-6.9	133.0
Amman-Zarqa	87.5	3.7	5.7	54.7	0.0	138.7	-51.2	158.0
Dead Sea	57.0	2.1	12.5	30.1	0.2	89.3	-32.3	157.0
Desi and Mudawrah	(1)125	0.0	4.1	68.4	0.0	82.1	42.9	66.0
North Araba Valley	3.5	0.0	3.3	2.8	0.0	6.7	-3.2	193.0
Red Sea\ South Araba Valley	5.5	0.0	0.4	15.9	0.0	17.4	-11.9	316.0
Jafer	9.0 (1)18	0.4	6.8	10.7	0.0	24.8	-15.8	276.0
Azraq	24.0	0.1	0.2	34.4	0.1	59.3	-35.3	247.0
Serhan	5.0	0.0	0.0	3.6	0.2	3.8	1.2	76.0
Hammad	8.0	0.0	0.0	0.0	0.2	0.9	7.1	11.0
Total	**275.5**	**6.9**	**33.3**	**278.7**	**0.6**	**520.1**	(2)**-170.8**	

Source: Ministry of Water and Irrigation

(1) Nonrenewable Ground Water

(2) Sum of Renewable Ground Water

Total water use in Jordan increased by more than 27%, from 639 MCM in 1985 to 810 MCM in 2004. Strong yearly fluctuations can be observed due to high variation in rainfall.

Water for municipal uses showed the highest increase in average annual water consumption (153-262 MCM) and accounts for more than 32% of total water use, and accounts for about 36% of fresh water use. Municipal users also registered the highest increase in share of total water use.

Table 4: Quantity of Municipal water Used (M^3) by Governorate, 1997 to 2002.

Governorate	2002		2001		2000		1999		1998		1997	
	Qty	%	Qty	%	Qty	%	Qty	%	Qty	%	Qty	%
Amman	94.1	38.3	93.6	39.2	91.34	38.8	88.18	37.2	85.21	35.3	88.78	37
Balqa	18.3	7.4	15.25	6.4	16.33	6.9	17.92	7.5	19.15	7.9	18.87	7.9
Zarqa	34.4	14	32.73	13.7	31.76	13.5	31.81	13.4	32.37	13.4	31.46	13.1
Madaba(1)	6.1	2.5	5.94	2.5	5.58	2.4	8.75	3.7	11.74	4.9	11.98	5
Irbid	31.3	12.7	30.9	12.9	30.09	12.8	30.06	12.7	30.53	12.6	29.64	12.4
Mafraq	16.9	6.9	18.91	7.9	18.51	7.9	19.02	8	19.21	8	18.42	7.7
Jarash(2)	4.2	1.7	3.94	1.7	3.16	1.3	3.56	1.5	4.55	1.9	4.15	1.7
Ajlun(2)	3.5	1.4	3.05	1.3	4.24	1.8	3.03	1.3	3.95	1.6	3.71	1.5
Karak	11.2	4.6	9.41	3.9	9.21	3.9	9.17	3.9	9.33	3.9	8.73	3.6
Tafiela	3	1.2	2.62	1.1	2.41	1	2.21	0.9	2.29	0.9	2.3	1
Ma'an	8	3.3	7.73	3.2	7.55	3.2	7.15	3	6.84	2.8	6.77	2.8
Aqaba(3)	14.7	6	14.95	6.2	15.16	6.4	16.49	6.9	16.34	6.8	15.08	6.3
Total	**245.7**	**100**	**239.03**	**100**	**235.35**	**100**	**237.35**	**100**	**241.5**	**100**	**239.87**	**100**

Source: Water Authority Report

Irrigation water for agriculture makes up the largest part of total average water used accounted for 62 % during 2004. The share of irrigation water percentage is declining with time. Its share of use was more than two thirds of water use but has recently decreased due to increasing municipal use and the priorities of government on water allocation.

Water use for livestock production constitutes only 0.8% of total water use during 2004. It has to be noted that the annual water use for the agricultural sector varies considerably due to climatic variations.

The industrial sector accounts for 4.4% of total water use, the main consumer being mining and quarrying.

The table below shows the quantity of water use by economic activity. Obviously the main use of the water is Mining and Quarrying, and it is worth noting that most of the water used in this activity is self–supply. Also the results of this survey registers a slight difference between the quantity estimated by Ministry of water for water used and the survey estimation. Detailed information has been acquired using a sample survey.

Table 5 Water use by economic activity in industrial sector 2002.

Economic Activity	Quantity of Used Water CM
Extraction of Crude Petroleum and Natural Gas	1,888.0
Mining and Quarrying	21,611,863.3
Manufacturing of Food Products and Beverages	5,247,409.0
Tanning and Dressing of Leather, Manufacturing of Luggage Handbags Saddlery, Harness and Footwear	26,052.4
Manufacturing of Paper, and Paper Products	216,387.0
Publishing, Printing and Reproduction of Recorded Media	66,646.6
Manufacturing of Coke, Refined Petroleum Products and Nuclear Fuel	17,413.0
Manufacturing of Other Non-Metalic Mineral Products	4,720,370.4
Manufacturing of Basic Metals	342,110.3
Manufacturing of Fabricated Metal Products, Except Machinery & Equipments	179,495.7
Manufacturing of Machinery and Equipments N.E.C.	69,569.5
Manufacturing of Electrical Machinery & Apparatus N.E.C.	63,762.0
Manufacturing of Motor Vehicles, Trailers & Semi–Trailers	13,795.0
Manufacturing of Furniture, & of Other Products N.E.C.	99,868.5
Electricity, Gases, Steam and Hot Water Supply	493,161.0
Total	**33,169,791.6**

The survey on chemical manufacturing provided more details of water use by economic activity (ISIC 4 Digit). This data indicated the quantity of water use for each activity by supply.

Table 6: Quantity of Used Water in Manufacturing of Chemical Products,Rubber and Plastic Products by Water Source, 2002 (M^3)

Economic Activity	Used Water CM				
	Distilled Water	Well	Tank	Public System	Total
Manufacturing of Vegetable & Animal Oil & Fat	0	0	100130	14724	114854
Manufacturing of Basic Chemicals	80	2288983	146447	12229	2447739
Manufacturing of Fertilizers & Nitrogen Compounds	0	3608141	10606	68950	3687697
Manufacturing of Plastics in Primary Forms & Synthetic Rubber	0	7400	20057	16551	44008
Manufacturing of Pesticides	0	0	3990	665	4655
Manufacturing of Paints, Varnishes, Similar Coating, Printing Link & Mastics	0	0	56086	9264	65350
Manufacturing of Pharmaceuticals Medicinal Chemicals & Botanical Products	30	50006	55128	97697	202861
Manufacturing of Soap & Detergant & Cleaning Polishing Preparations Perfumes & Toilet Preparation	3	90500	88057	41834.8	220395
Manufacturing of Other Chemical Products N.E.C.	0	0		2317	13241
Manufacturing of Rubber Tiers & Tubes	0	0	905	895	1800
Manufacturing of Other Products	0	0	234	1012	1246
Manufacturing of Plastic Products	0	18000	83960.3	46908.2	148869
Manufacturing of Accumulatores Primary Cells & Primary Battaries	0	30300	1680	10667	42647
Total	**113**	**6093330**	**578204.3**	**323714**	**6995361**

3. Sources of Data

Two main methods were applied to estimate water supply and water use in Jordan

3.1- Administrative records

The Ministry of Water provides data regarding water abstraction, water supply and water use for different sectors and activities in Jordan. By monitoring pilot wells the ministry can estimate the quantity of water and the changes in quantity, in each aquifer layer, which then allows an estimation of what quantity of water has been abstracted and how much water has infiltrated into aquifers over a calendar year.

In general, most fresh water abstracted for public, houses, small enterprises and other similar activities is abstracted by public sector.

3.2- Survey

The department of statistics conducts an annual survey to collect data related to water use by Jordan's main economic activities.

Sample design

1-The frame

The economic enterprises census was conducted in 1999 and covered all economic enterprises in Jordan. It provides good benchmark and frame for this survey. It includes information about paid capital, total revenue, and total number of employees for each enterprise as well as identification data like the detailed activity (ISIC 6digit) and other useful information needed to make the sample design.

2–Stratification

All enterprises are stratified by total revenue into 3 classes classified by paid capital, total number of employees, and activity (4 digit level) at the region level.

3–Sample design

All enterprises classified as big enterprises were surveyed by complete coverage. (Revenue 200000 JD and above, or paid capital 200000 JD and above, or number of employees 20 people or more).

All enterprises with a small number (less than 10 enterprises in the frame) at the same stratum were also surveyed by complete coverage.

Remaining enterprises were divided into middle and small size (middle when revenue between 60 thousand and less than 200 thousand, and small when revenue less than 60 thousand J.D.). After that, sample units were selected from each stratum and each size of enterprise.

4-Sample allocation

The Nyman allocation was applied to allocate sample units between stratums after calculating the sample size based on 1999 results. The coefficient of variation (C.V.) is around 5% at the regional level for each activity ISIC[1] 4 digits.

5-Method of drawing sample

The systematic method was applied after ordering all sampling units in each stratum ascending by total revenue, to provide implicit stratification to increase the efficiency of the design.

4. Difficulties and Problems

1. Availability of data
    - There are many gaps in the administrative records like water supply by sector, external inflow, out flow, and water losses.
    - The data for water supply is only available for the total of public and private sectors, with no disaggregating between both.
    - Some data is available but it is difficult to access to it.
2. The quality of data
    - The data isn't comparable between different sources of data.
3. The classification of the available data
    - The ISIC classification isn't used in the data base, also the SNA system is not used.
4. The cost of collecting of data by survey is very high.
5. The wide range of activities covered in the survey means there is a huge need for good frames and other supporting facilities.
6. This work needs skills in both statistics and water science, a combination of skills which are not available.

[1] International Standard Industry Classification