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IMPACT OF IRRIGATION WATER SCARCITY ON THE SOCIO-ECONOMICS OF AGRICULTURAL SECTOR AND FOOD SECURITY IN JORDAN

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SUMMARY – After many years of absorbing warnings about dire days to come, Jordan today stands face to face with the reality of potentially frightening water shortages. In the short run water shortages may threaten domestic progress and health standards; in the long run they could become a growing source of regional tension. For Jordan, water has become an issue of national strategic importance that can only be properly addressed in a regional context. The main aim of this paper is to address the impact of irrigation water scarcity on the socio-economics of agricultural sector and the Jordanian food security. The self-sufficiency degree of food in 2003/2004 amount to 2.2 % for wheat products, 131.4% for vegetables, and 94% for fruits. 0.0% for sugar as well as 16% for fats The rapid increase in Jordan population from approximately 4.4 million in 1996 to 5.1 million in 2000 and the expected increase to 7.0 million in 2010 to 9.3 million in 2020, have placed unprecedented demand on water sources. The main findings of this paper were that decreasing water supply by 20% will be followed by a reduction in the total cultivated area by about 14%. This will lead to a decrease in the total net income generated by 15%. As a matter of fact, the reduction in employment will be accompanied by a direct and indirect loss in income too. As a policy implication of this paper, it is suggested that irrigated land base must be maintained in good order to sustain relatively low food prices. New strategies for water development and management are urgently needed and to continue searching means and methods to increase water supply by increasing the investment in the irrigation sector, which can increase water supply and irrigation use efficiency.

Keywords: water shortages, socio-economic, agriculture, food security, Jordan

INTRODUCTION

Population and economic growth in developing countries posed serious challenges for humanity in simultaneously meeting food requirements and water demands. Competition for limited water resources increasingly occurs between different stakeholders and at different levels: between farmers within an irrigation system; between irrigation systems in the same river basin; between the agricultural sector and other rural uses, such as fisheries or domestic water supply and drinking water; and more and more between agricultural and urban and industrial users and uses; and environmental uses. Agriculture still accounts for the majority of global water withdrawals, and is often responsible for 65% or more of total withdrawals for consumptive uses in Jordan.

Jordan is a small Arab country with inadequate supplies of water and other natural resources such as oil. Debt, poverty, and unemployment are fundamental problems. In an attempt to get the food demand in line with the available agricultural resources the authors in this paper estimated the impact of irrigation water scarcity of the socio-economics of the agricultural sector and food security in Jordan.

AGRICULTURAL PRODUCTION AND FOOD SECURITY

Over the past decade food supplies have been adequate in aggregate, and at least until mid-1995 there were historically low food prices. Even with the recent run-up in cereal prices, real prices remain well below the levels of the mid-1980s. Currently low food prices may not continue indefinitely, for on the supply side there are some important food production systems that are not sustainable. There are also worrying signs that the various actions necessary to maintain a supply growth on the remaining high potential and other farms.

Agriculture contributed substantially to the economy from the time of Jordan's independence. However, in the last two decades, industrial and other sectors have expanded and the contribution from agriculture as a percentage of the GDP has decreased from 8.10% in 1990 to 3.5% in 1998. The Jordanian employment in the field of agriculture is only 5.5% of the active labour force; however, a substantial number of the workers are non-Jordanians.

The agricultural land in Jordan has increased from 1173 thousand ha in 1993 to 1178 thousand ha in 1999.This came as a result of implementing several agricultural policies in the late 1980s. The strategy was to increase the total cultivated area by increasing irrigated arid desert area for the cultivation of cereal crops. This was achieved by harnessing of water resources, the country's most pressing need. The irrigated area has increased from 71 thousand ha in 1993 to 75 thousand ha in 1997.

The total production of cereals has increased in 2001 to reach 65,300 Mt. Wheat, barely, maize and sorghum are the mostly cropped in the rain-fed areas. Total production remains insufficient to meet domestic demands. In the Jordan Valley, fruits and vegetables including tomato, cucumber, potato, eggplants, citrus fruits and melons are often produced in surplus amounts. However, in the mountain areas, olives are produced in sufficient amounts.

As a result of implementing several agricultural development policies, Jordan has improved its position regarding food security in the last two decades. During the period 1980 to 1996 the per capita food production increased by 13%. Food imports have decreased from 26.4% in 1974-1976 to 16.7% in 1996-1998. .However, food imports remained necessary to meet the needs of high population growth rate.

TRENDS IN ENERGY REQUIREMENTS AND ENERGY SUPPLIES

The population has more than doubled (increased by 202.6%) between the years 1965 and 1995. Over the last 3 decades (from 1965 to 1997), the average daily per capita energy supply has increased by 29.6%.

There is a decline in carbohydrate share of the dietary energy supply (DES) from around 71% in 1965 to 64% in 1997. This is accompanied with an increase in energy supply from fat from 18.7 to 25%. The protein share in energy supply has been fluctuating around 10.5% of DES which is equivalent to a daily protein supply sufficient for covering the recommended dietary allowances of adults. The relatively high carbohydrate share in daily energy supply is a characteristic of developing countries. However, the increasing fat share and the decreasing carbohydrate share of DES reflect, together with the increased proportion of urban population, the trend of urbanization in the country. The economic stability reflected in the increase in DES till the end of the eighties has been followed by a setback in the nineties after the Gulf crisis and the repatriation of hundreds of thousands of Jordanians working in Gulf areas.

MAJOR FOOD IMPORTS AND EXPORTS

In the last 3 decades, food imports were mainly cereals, sweetener, and vegetable oils that have generally increased in contribution to dietary energy supply. This is due to the increased consumption of these foods and the introduction of non-traditional vegetable oils in the local diet, particularly soybean oil and corn oil (United Nations, 2001).

Jordan has been less competitive in the world food markets. Most of the food consumed is imported. There has been an increase in food exports between the years 1964-66 and 1979-81, mainly in vegetables, vegetable oils and fruit. Export of vegetable oils has increased in 1998-2002 to cover 15.9% of DES, though it has been below 1% in previous years. This is explained by the fact that some imported raw vegetable oil is exported and with the reduction in cereal exports the percent oil exported increased. Also, olive oil production has increased in the last 3 decades. The liberalization of world market has led to reduced competition of Jordanian exports especially the traditional fruit and vegetables.

Table 1 shows, the self-sufficiency degree of food in 2003/2004 amount to 2.2 % for wheat products, 131.4% for vegetables, and 94% for fruits. 0.0% for sugar as well as 16% for fats.

Table 1. Food supply for selected food groups 2003 in Jordan

Items	Production	Import	Export	Supply	Self-sufficiency degree %
Wheat products	42,600	1,943,294	14,741	1,971,153	2.2
Vegetables	1,142,011	122,594	395,499	869,106	131.4
Fruits	275,409	62,769	45,458	292,720	94
Sugar	0.0	206,057	9,420	196,637	0.0
Fats	23,592	197,837	74,125	147,304	16

Source: http://www.dos.gov.jo

TRENDS IN FOOD AVAILABILITY

Food availability depends on amounts of food produced, food imported and that used for seeds or taken away for processing losses. This is particularly important for cereals. The main cereal used in Jordan is wheat. The second most important cereal is rice, which is entirely imported. There has been an increase in the supply of cereals (mainly wheat) from 131-176 kg/capita/ year, between 1964-1966 and 1998-2002. This increase is mainly due to an increase in wheat imports and a result of state subsidy for a long period of time ending in 1996. In the same time there has been a net reduction in the availability of fruit and vegetables (from 290 to 136 kg/capita/year). There also has been an increase in the supply of milk and eggs (from 50 to 74 kg/capita/year), sweeteners (from 28 to 33 kg/capita/year), and meat and offals (from 10 to 34 kg/capita/ year). This is largely due to the increased imports with liberalization of economy and the affluence of people particularly in the period 1975 to 1990.

About 6% of the population was undernourished in the period 1999-2001. The average energy intake was about kcal 2700 /capita/day in the same period. 21% of the population lives in rural areas. About 11% of them are involved actively in the agricultural production. The average self-sufficiency degree of food in the last ten years amounts to 0% of rice and sugar, 9% of wheat, 15% of legumes, 36% of red meat and 50% of milk equivalents. On the other hand, Jordan is self-sufficient in eggs, white meat, fruits and vegetables.

Energy supply has been on an increase from (1965-1985) then levelled off in the following 15 years until 2002. However, all throughout this period (34 years) there has been no significant change in the share of cereals in the DES. This represents 1505 kcal/capita/day, which is equivalent to 53 % of the total energy.

FOOD CONSUPTION BASED ON FAMILY INCOME AND EXPENDITURE SURVEYS

In Jordan, food consumption surveys are rarely conducted due to their cost. The Department of Statistics in Jordan (DOS) conducts national household expenditure and income sample surveys every five years. The data on household food expenditure is analyzed by sectors (urban and rural) and as a total presented for the whole country.

Fluctuation in the budget has been observed over the last 3 decades, although there has not been a significant change in the share of household expenditure on different food groups. The household expenditure on foods and beverages has slightly increased from 40.6% in 1992 to 44.3% in 1997. Household expenditure on cereals has increased from 3.4% in 1992 to 6.0% in 1997 of total expenditure on foods, and was slightly decreased from 4.6% in 1992 to 3.8% in 1997 for milk products. Poor households spend more on food, particularly cereals and other staple cereals, mainly wheat and rice, constitute the highest amount of food consumed (210 kg/capita/year) . Rice and bread intake has decreased by 1% each between 1992-1997. This slight decrease due to the phasing out of bread price subsidies in 1996 and rice, sugar and powdered milk price subsidies in 1997.

Fruit and vegetables constitute the next largest volume of food consumed (183.6 kg/capita/year). The consumption of at least two to three vegetables and fruit a day is common. The type of fruit and vegetable consumed varies with the availability and price. For example, tomato, potato and cucumber were the most available and consumed vegetables in 1992 and 1997. In 1997 their consumption was 40.1 kg for tomato, 18.7 kg for potato, and 10.9 kg for cucumber. In 1997 the highest consumed fruit were citrus fruits, melons and apples (18.5, 15.9 and 8.0 kg respectively).

In Jordan, the poultry intake is higher than that of meat and fish, which is partly due to costs. Poultry consumption has increased from 29.3 kg/capita/year in 1992 to 31.02 kg/capita/year in 1997. The consumption of milk and its products was maintained at 4.5% between 1992 and 1997. The contribution of fresh milk from the total consumed milk products was only 0.11% in 1997, while 12.9% was from yogurt.

WATER AND FOOD PRODUCTION IN JORDAN

Together with labour and capital, water and land constitute the aggregate resource base for agricultural production. Their association with appropriate types and levels of labour, capital and technology enhances their productivity in agriculture. Thus, their availability is central to development of the irrigated agricultural sector.

The agricultural sector in Jordan consumes about 65% of the total available water supply, where municipal, industrial and rural sectors consumption was 28.9%, 4.7% and 1.4% respectively, in 1999 (MWI, 2000). Total irrigated area in Jordan is estimated to be about 713 thousand dunums in 2003. Jordan Valley forms 38% of the total irrigated area.

Jordan's water resources consist primarily of surface and ground water. Renewable water resources are estimated at about 780 million cubic meters (MCM) per annum, including ground water (275 MCM/year distributed among 11 basins) and usable surface water (505 MCM/year distributed among 15 catchments basins). An additional 143 MCM/year of ground water is estimated to be available from fossil aquifers. Brackish aquifers are not yet fully explored, but at least 50 MCM/year is expected to be available for urban uses after desalination. Treated wastewater is being used on an increasing scale for irrigation, primarily in the Jordan Valley, and can provide at least an additional 80 MCM/year until the year 2010 (MWI, 2002 and El-Naser, 1999).

Demand for irrigation water can be regarded as a derived demand for food. The contribution of surface and groundwater irrigation development to today's aggregate food supply is sometimes overlooked as evaluations of policies and projects focus on identifying problems rather than benefits. Despite the problem focus of the irrigation literature the generally accepted estimates of the contribution of irrigation to global food production are in the range of 25 to 50 percent (e.g. Swaminathan, 1994; FAO, 1994).

DOS estimates show that land increased over the period of 1986 to 1998 with a growth rate of 3.63%. This growth rate is accompanied with a growth rate of irrigated water of 1.18% (Table 2), which is lower than the growth rate of land. This can be attributed to use of water saving, conservation and harvesting techniques such as drip irrigation system and to the increase in irrigation use efficiency in areas like Jordan Valley and Mafraq, where water transfer system have be changed from open channel systems to pressurized pipe systems. Moreover, water requirements per dunum ensure this fact despite the previous drought period. It has been decreased from 1100 m^3/du as an average for the period of 1986-1990 to an average of 850 m^3/du for the period of 1994-1998.

In general, the irrigated area of Jordan Valley has increased at a rate of about 2.93%, while the general agricultural production increased at about 3.85%. This has happened mainly due to satisfying the increased demand of agricultural products. DOS figures in show that the area and agricultural production in the Jordan Valley increased. Area of fruit trees increased by 3.32% annually, while fruits production increased by 3.07% annually. Accordingly the yield of fruit trees registered a reduction at about 0.25% annually. This could be attributed to the scarcity of water. Area and production of field crops, which are tolerant to water stress, increased by about 1.89% and 3.01%, respectively. Consequently, the yield increased at the rate of 1.89% annually. However, vegetables production increased at the rate of 4.47%, while the area increased at 3.11%. This implied an annual increase in

the yield by about 1.36% for the same period (1986-1998). It can be noticed that there is a general increase in the yield of most crop types accompanied with lower water used per unit area, because of the use of improved seed varieties against drought and diseases and salinity.

Table 2. Development of production (x 1000 ton.), area (x 1000 dunum) and yield (ton/du) of fruit trees, field crops and vegetables during the period 1986-1998 in the Jordan Valley

Year	Fruit Trees			Field Crops			Vegetables			Total	
	Production	Area	Yield	Production	Area	Yield	Production	Area	Yield	Production	Area
1986	102.0	63.8	1.596	18.4	33.5	0.551	162.8	92.3	1.763	283.2	189.6
1987	133.6	69.4	1.925	31.2	49.7	0.628	236.1	84.7	2.789	400.9	203.8
1988	138.3	71.8	1.925	13.9	50.7	0.274	211.1	98.0	2.155	363.3	220.5
1989	183.0	74.0	2.473	6.1	28.5	0.214	194.2	89.6	2.168	383.3	192.1
1990	185.0	75.2	2.459	14.9	45.4	0.328	379.0	129.1	2.935	578.9	249.7
1991	187.0	76.4	2.448	12.9	47.2	0.272	313.5	130.0	2.412	513.4	253.6
1992	182.3	77.7	2.347	17.8	26.8	0.663	229.0	111.0	2.065	429.1	215.5
1993	146.0	78.2	1.868	15.5	52.4	0.296	284.0	114.2	2.487	445.5	244.8
1994	179.5	80.5	2.229	18.1	43.6	0.415	175.0	111.0	1.577	372.6	235.1
1995	143.6	82.8	1.734	22.6	49.5	0.457	241.3	97.3	2.48	407.5	229.6
1996	165.3	87.3	1.894	16.5	34.0	0.486	287.6	102.0	2.822	469.4	223.3
1997	197.8	100.0	1.979	27.1	66.5	0.407	408.7	155.7	2.624	633.6	322.2
1998	196.6	104.3	1.886	21.8	45.9	0.474	384.0	143.2	2.681	602.4	293.4
Average	164.6	80.1	2.059	18.2	44.1	0.420	269.7	112.1	2.381	452.5	236.3

Source: http://www.dos.gov.jo

In Jordan, additional food will be required if the full potential of irrigation is not realized. Population will increase on hillsides, desert fringes and fragile lands with erratic rainfall and we can anticipate that there will be increased rural-urban migration and thus growing population pressures on urban areas that are already giving cause for concern. It has been estimated that "… every 0.1 percent of yield increase in the period 2010 to 2025 'substitutes' for about 25 million hectares of rainfed cropland" (Feder and Keck, 1993). In Jordan Irrigated land has a higher yield and a higher yield potential than rainfed land. Every dunum of irrigated land 'saves' the development of 6–8 dunums of less productive rainfed land (under the Low rainfall conditions of Jordan).

As shown in Table 3, the plant production amounts to about 1479 thousand metric tons, from which about 36% produced in the Jordan Valley.

Table 3. Irrigated area (dunum) and cropping patterns (M T) in Jordan and in Jordan Valley

	Jordan Valley		Jordan	
Product	Area (dunum)	Production (tons)	Area (dunum)	Production (tons)
Tree crops	90,847	186,690	331,982	683,550
Field crops	20,162	8,327	57,196	24,022
Vegetables	139,067	334,594	323,992	771,425
Total	250,076	529,611	713,170	1,478,997

Source: http://www.dos.gov.jo

One dunum = 0.1 hectare, One metric ton = 1000 kg

As Table 4 shows the production of vegetables consumes 37% of the total water demand, while fruit trees and field crops consume 54% and 9% respectively. The share of the above mentioned groups from the optimum water demand (408 MCM) is estimated to be150 MCM for vegetables, 220 MCM for fruit trees as well as 38 MCM for field crops.

Table 4. Expected production of selected food items based on the proposed optimum water demand

Product	Water distribution of the total demand (%)	Optimum water demand (MCM)	Expected production (x 1000) tons
Vegetables	37	150	540,000
Fruits	54	220	792,000
Field crops	9	38	13,600

Based on the optimum water demand (Table 5) average yield given in Table 6 of these product categories (2.381 ton/dunum for vegetables, 2.059 t/dunum for fruit trees, and 0.420 t/dunum for field crops), and under consideration of the average water use (964 CM/dunum), the expected production will be found out from the following equation:

$$\text{Expected Production} = \frac{\text{Yield} * \text{Share of optimum water use}}{\text{Cubic meter of water per dunum}} \quad (1)$$

Table 5. The optimal water demand (MCM.) of main crop groups grown in Jordan

	Water Demand (MCM)	%
Vegetables	150	37
Fruit Trees	220	54
Field Crops	38	9
Jordan	408	100

By using the optimum water demand according to equation (1) under consideration of the other above mentioned variables the proposed production will be as shown in the Table 6.

Table 6. Comparison of the current agricultural production patterns with the proposed one in Jordan 2003

Crops	Irrigated Area (dunum)	Yield (tons)	Production (tons)	Proposed Patterns (tons)
Fruit trees	331,982	2.059	683,550	792,000
Field crops	57,196	0.420	24,022	13,600
Vegetables	323,992	2.381	771,425	540,000

Source: http://www.dos.gov.jo

The average gross water requirement in Jordan Valley over the last 10 years is 964 CM/dunum. The net available water supply is equal 63% of the gross requirement (63% of 964 CM/dunum) = 607.3 CM/dunum.

Table 7. Comparison of water use and revenue in the current and optimum water use

Crops	Current net water use (MCM)*	Current water use (MCM/dunum)	Revenue of the use of current CM (Mill.JD)**)	Optimum water use (MCM)	Revenue of optimum water use (Million JD)
Vegetables	229	463	63.8	150	41.9
Fruits	235	663	65.6	220	61.4
Field crops	40	664	11.2	38	10.0
Total	504		140.6	408	113.3

* = Area times net water requirement (607.3 CM/dunum)
** = Current net water use times revenue of one CM water (JD 0.279)

The proposed cropping patterns save 96 MCM for other purposes; the opportunity returns are about JD33.6 million (Table 7), while the opportunity costs are JD27.3 million. The implementation of the proposed patterns increase the fruit production of 108 450 tons with a value of about JD62.2 million, while the value of imports of vegetables, fruits, and cereals in 2003 amounted to JD 24 million, JD 36 million, an JD 211 million respectively.

The revenue of the additional fruit production of about 231 tons would compensate the cost of the actual fruit imports (62,800) tons with a value of JD 36 million on one hand and put about JD 26.6 million available to contribute to covering the cost of wheat imports on the other hand. Production of cereals has no significant role in the Jordanian agriculture.

It is worthwhile mentioning that the cost of supplying water for household and industrial uses is also increasing rapidly. In Amman, Jordan, the average incremental cost of water from groundwater has been US$0.41 per cubic meter. However, with shortages of groundwater, the city has begun to rely on surface water, pumped with a lift of 1,200 meters from a site 40 km from the city, at an average incremental cost of US$1.33 per cubic meter. Future schemes are estimated to cost US$1.50 per cubic meter (World Bank, 2001).

IMPACT IF DECREASING WATER SUPPLY ON CULTIVATED AREA,INCOME AND LABOR

In the Northern part of the Jordan Valley, Abu-Thallam, 2003, has estimated the impact of water shortage on the planted area, income and labour at the regional level, and it has been found that, by decreasing the irrigation water quantity, the cropping intensity decreased thus, the cultivated area decreased. This has resulted as a reduction in total net income and consequently a reduction in labour used in the area.

For instance decreasing water supply by 20% will be followed by a reduction in the total cultivated area by about 14%. This will lead to a decrease in the total net income generated by 15%. As a matter of fact, the reduction in employment will be accompanied by a direct and indirect loss in income too (Abu-Thallam, 2003).

Labour is considered as an important factor in the production process of the agricultural sector, the use of labour depends on the size of cultivated land and type of production whether crops or livestock production. Further more, for each production type, the use of labour differ according to the technology used and on the intensity of production. The Jordan Valley plays a big role in the agricultural development, it absorbs about 26%of the total agricultural labour, and as a matter of fact irrigated areas employ more labour than rainfed areas in Jordan.

The main objective of addressing the labour issue in this case study is to determine the main socio-economic impacts of irrigation reduction on the main communities located in the Northern Jordan Valley, as the expansion of the cultivated area leads to a significant increase in production intensity and efficiency thus, the result will create a better production opportunities, more jobs requires more labour, which means increasing the capability of the people to satisfy their needs and to enjoy a better quality of life.

The reduction in the decrease in water supply decreased the cultivated area accordingly; the direct impact of this reduction will have adverse affects on the growth in new jobs in the NJV communities, which may pull workers and their families out of their communities, either those permanent or temporary residents. When this occurs the outgoing population affects the social environment in various ways including lower demand for housing and social services (e.g., health care, education, recreational facilities). However, a more severe impact will take place in cases of 50% reduction which correspond to the maximum level of reduction in irrigation water supply.

The loss in hired and family labour is about 33% respectively, increasing the amount of water supply will encourage the investment in irrigated agriculture that would accelerate the growth rate of the agricultural sector and reduce the unemployment percentage in the area, and new jobs will be open and available. On the other hand, an increase of 20% in water supply the hired labour increased by about 18 % (Ibid).

One of the important consequences to the reduction of water supply is that due to fact that number of hired workers hours is higher than the family workers. Thus decreasing the water supply, would affect the number of hired labour rather than family labour, this reflects the need to reduce the cost of production, by having most of the work to be done by the family labour instead of the hired labour thus, due to the reduction in income. Incidence of water scarcity would affect the number of hired workers negatively and would threaten their socio-economic situation. This will finally address additional threat to the food security in Jordan.

CONCLUSIONS AND POLICY IMPLICATIONS

The irrigated land base must be maintained in good order to sustain relatively low food prices. Meaningful food security with high food prices is impossible because this would affect income of the poor people negatively.

New strategies for water development and management are urgently needed to avert severe national, regional, and local water scarcities that will depress agricultural production, damage the environment, and escalate water-related health problems.

Continue searching means and methods to increase water supply by implementing irrigation and water supply projects will require balanced development approaches acceptable to diverse constituencies. Certainly the full social, economic, and environmental costs of development are going to have to be considered, but so must the costs of failure to develop new water sources.

With its low and rapidly decreasing per capita water availability, less fresh water will be available for agriculture in Jordan. The rehabilitation and expansion of conventional sewerage and wastewater-treatment systems will be another solution to solve partially the problem of water scarcity in Jordan.

Institutional reform will be even more important in meeting new water demands if these are to be met by reallocating water from existing schemes. Improved conservation of water in existing uses will only be achieved through comprehensive reform of water policy and demand management.

Proper water demand management should be accompanied with proper pricing of scarce water resources. This can ensure a more optimal allocation to its most efficient uses. Water pricing could be a powerful tool for improving the low efficiency levels of water use in most areas of Jordan. However, water prices are mostly subsidized and it is politically impossible to introduce the cost recovery level of water prices for agriculture. This can be recommended under the condition that producers are working under efficient economic conditions, otherwise subsidy remains recommended.

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