Water Management in the Disi Basin in Jordan

Jordan Component of the Sustainable Development of Drylands Project

Report# 6

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College of Agriculture

Department of Agricultural Economics and Agricultural Business

and

The Badia Research and Development Center

By

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Introduction

Jordan is well known as one of the most arid regions in the world, with much of the country receiving less than 200 mm of annual rainfall (Figure 1). The arid nature of the country, with limited ground water reserves, and increasing water demands from growing domestic and industrial uses poses a challenge to the Jordanian government as

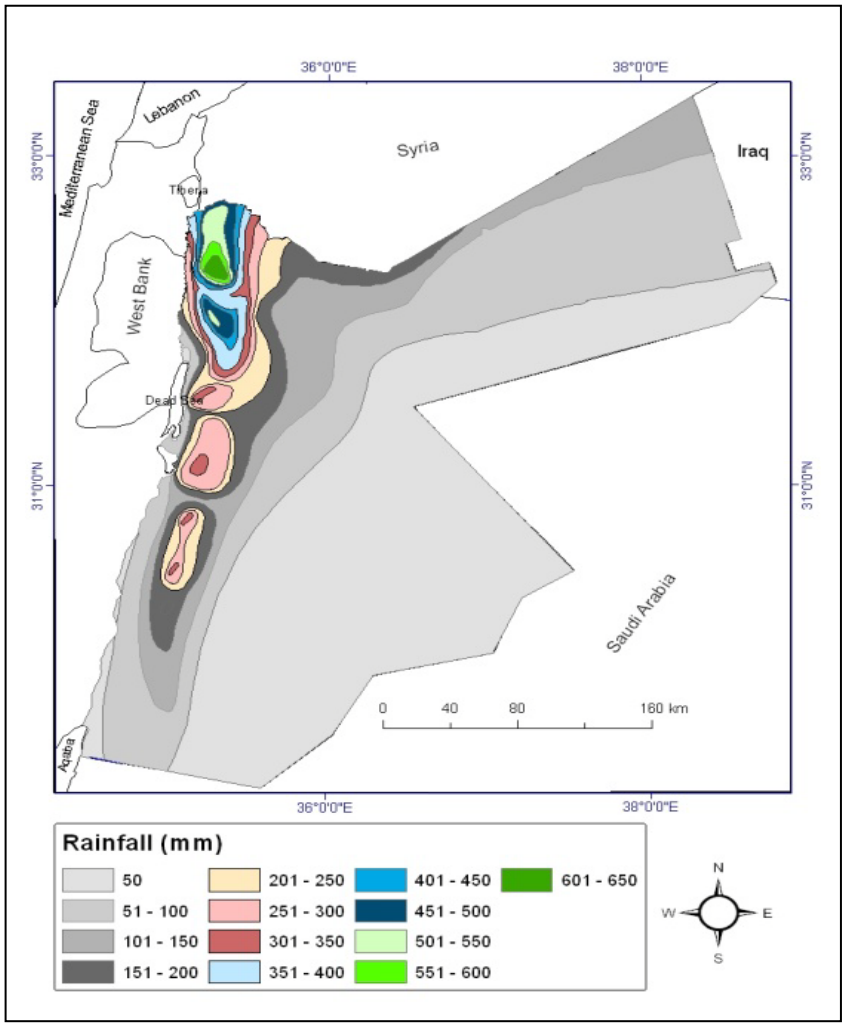
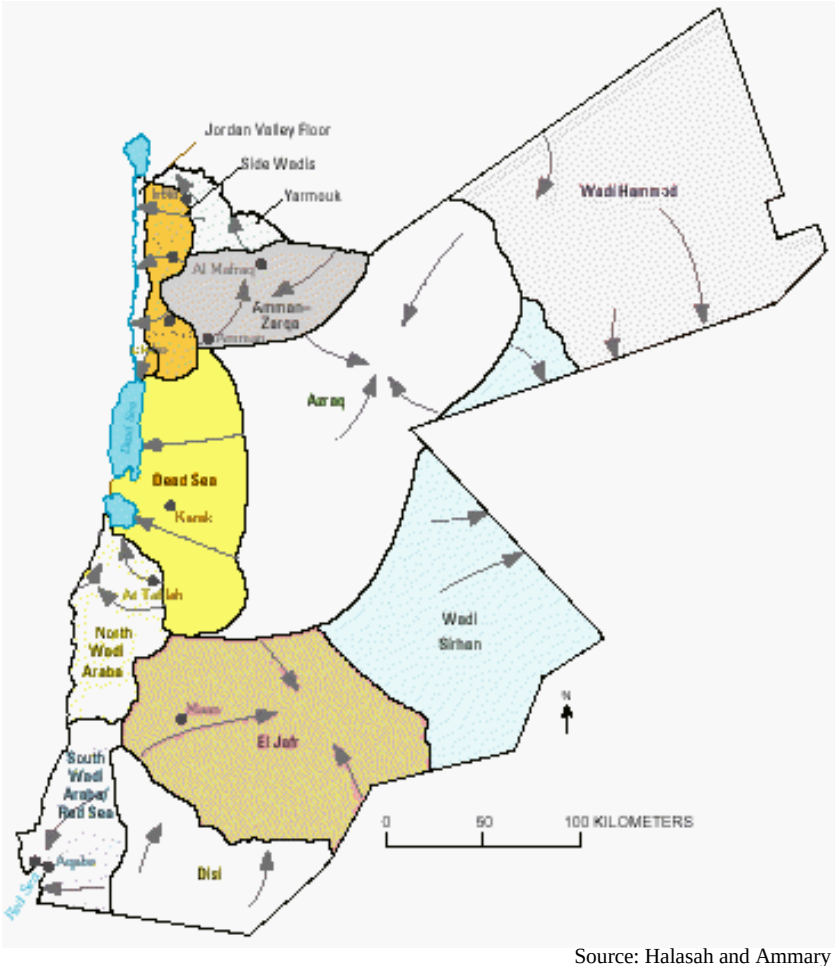


Figure 1. Annual Rainfall in Jordan

leaders attempt to balance water demands between agriculture and other important uses.

Groundwater basins in Jordan come from three main aquifer systems that run vertically through the country. One of the most important non-renewable groundwater sources is the Disi aquifer (Halasah and Ammary). The Disi aquifer, located in the south of the country (Figure 2) supplies water to both the city of Aqaba and to farms in the Disi region. This research explores current technologies and water uses among farmers in the Disi basin. By better understanding current agricultural water use and irrigation practices, government officials can better understand opportunities to encourage conservation. Increased conservation may allow for increased water use outside of agriculture while still maintaining a viable agricultural sector.



Source: Halasah and Ammary

Figure 2. Jordan's Groundwater Basins.

Problem Statement and Research Objective

Although only 3% of Jordanian GNP comes from the agriculture sector, it uses approximately 70% of the available water, mostly from groundwater sources (Philippi, 2004). In comparison, population, industry as well as the tourist sectors are expanding rapidly and facing increases in demand for water to survive. Supplies of renewable water are limited while demand is rapidly rising largely due to a high population growth rate and the growth of the industrial and tourism sectors. The current water demands in the Deci Basin exceed the long run recharge rate and thus currents uses are not sustainable in the future. It may be necessary to reduce the amount of water used by agriculture in the basin.

Productivity, in terms of cubic meters of water needed per unit of output, in the agriculture sector is low and in many cases production costs are higher than returns. The main purpose of this project is to offer suggestions and recommendations to farmers and Jordanian policy makers relative to efficient use of water in the agricultural sector. The results from this project will help farmers in their decision making processes such as selection of the right crop in terms of water-use efficiency and to improve the productivity of water devoted to agriculture.

Survey Methodology

In order to better understand water and irrigation issues in the Disi basin region, researchers from the Badia Research & Development Centre (BRDC) and NMSU teamed up to collaboratively collect information. A written survey questionnaire guide was developed in the summer of 2005 by researchers at the BRDC and NMSU. BRDC staff translated the questionnaire into Arabic and pre-tested the survey instrument with local farmers. Minor adjustments to the survey instrument were made (clarification of some questions). Upon

completion of the pre-test, local high school and undergraduate students (approximately ten) were trained to administer the survey.

Surveys were administered in the summer of 2006. Survey administrators approached farmers on their farm or place of residence, and assisted farmers in completing the survey. On average, each survey took two hours to complete. Responses from 170 were obtained representing 1,478 family members. This represents approximately 36% of all the Disi Basin population.

Survey Results

Results from the survey were reviewed and summarized. The following areas were examined: 1) farmers' educational level, 2) farm management practices, 3) regional dependence of agriculture, 4) technology use in farming operations, and 5) water used in crop production relative to recommended water use by experts. In addition, researchers examined differences in important policy-relevant characteristics between farmers living on-farm and those living off-farm, between farmers who receive a majority of their income from farm activities and those that didn't, and between older farmers and their younger counterparts.

Farmers' Education Level

The education level of farmers surveyed was low, slightly more than half have completed elementary school, and about a fifth have completed high school with only a few farmers had attended a technical school or obtained a university degree (Figure 3). Since the majority of the farmers in the Disi basin have limited education levels, those farmers are expected to face difficulties and barriers if they were to transfer their labor resources to pursuits other than low input, traditional farming. Although the effect of education level on the average amount of water

used at the farm was not significantly different, it is an interesting variable as it can help ascertain what proportion of farmers might be able to make a satisfactory income outside of agriculture, if needed. However, farmers with limited formal education could be trained in using irrigation systems which can be expected to help them use each cubic meter of water in a more efficient way.

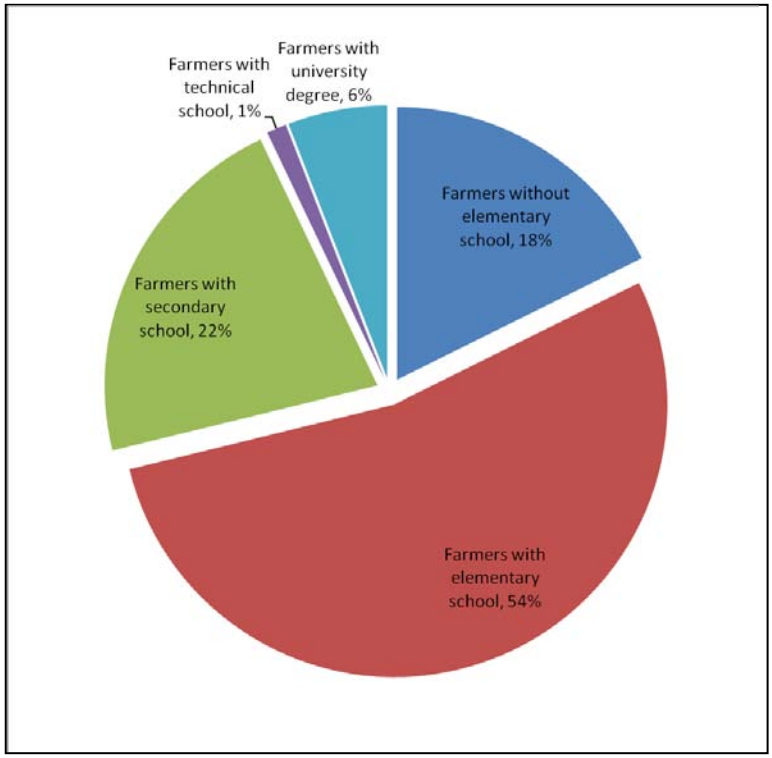


Figure 3. Farmer Education Level.

Farm Management

Most Disi farmers rely on their own experience for making farm management decisions such as fertilizer selection and application, crop selection, irrigation methods, business and marketing (Table 1)[1]. These management and marketing decisions can be very challenging and may lead to inefficient and unproductive farming operations.

Table 1. Farm Management in the Disi Basin

Description	No. of Farmers	Percentages
Farms managed by the farmers themselves	151	89%
Farms managed by agent	7	4%
Self-crop selection	167	98%
Self-business/market decision	167	98%
Self-irrigation management	168	99%
Self fertilizer selection	166	98%
Farmers attended irrigation training	7	4%

[1] Input suppliers (for seed, fertilizer, and crop protection chemicals) often finance farmers through the growing season and are likely sources of information for farm management decision.

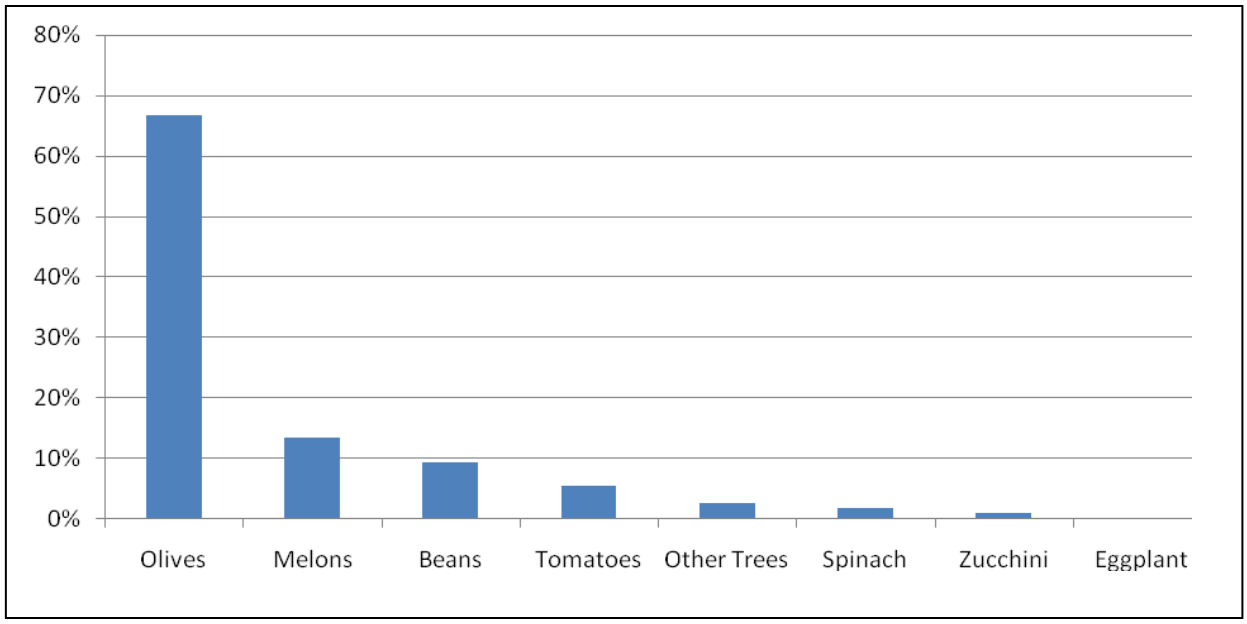


Figure 4. Crops Grown in Disi Basin, 2005.

Approximately 67% of the tillable area in the Disi basin is devoted to olive trees and 98% of all farmers in the survey reported growing some olives (Figure 4). Some crops not grown currently, e.g., onions and potatoes have excellent potential as highly productivity crops that also have high market demand.

The large percentage of farmers relying on their own knowledge for management decisions (as opposed to use of professional assistance) suggests a possible role for extension type programs, e.g., only seven farmers indicated that they had attended irrigation training.

Regional Dependence on Agriculture

A total of 1,478 family members were supported by 170 farms as shown in Table 2. This reflects approximately 36% of all the Disi Basin population (Ma'an Governorate, 2007). In addition to family members supported by these farms, there were 34 permanent farm workers and 314 temporary farm workers associated with the surveyed farms. The high percentage of families associated with farming suggests the agricultural sector has a large impact on the Disi basin economy.

Table 2. Dependency on Agriculture

Description	Total number
Disi basin population	4,100
Family members supported from farm income	1,478
Permanent workers	34
Days workers	314

Technology in Farming Operation

The majority of the farmers in the Disi basin, according to the survey, do not use the Internet in either in their general life or their farming operation (Table 3). Only 7% of the farmers surveyed used the internet in their general life and less than one percent used the internet in the farming practices. If the Internet was used more widely, the farmers could obtain up-to-date information about marketing, fertilizing, cropping, farming, watering, and other important information. Information was not collected as the percentage of farms with access to the Internet.

Table 3. Internet Usage by Farmers in the Disi Basin

Description	No of Farmers	Farmers by percentage
Farmers use Internet in general life	12	7 %
Farmers use Internet in business	4	2.4
Farmers use Internet in marketing	2	1.2
Farmers use Internet in farming	1	0.6

Water Used Versus Water Recommended

When the total irrigation water used by farmers in the survey is compared with water use recommendations the differences are quite startling. The total water used for all purposes including crops, livestock and households for the 170 surveyed farms and farm households is estimated to equal 4.4 million cubic meters of water annually (BRDC & Aqaba Water Authority, 2007). Researchers estimate that approximately 2.7 million of this total water use is dedicated to crop production. Data provided by agronomic researchers suggest that crops being grown in

the region (under similar growing conditions and same geographic area) should use approximately 900,000 cubic meters for agricultural purposes (Alawayda, M., Aledwan, E., & Alkarakee, M., 2005). Based on these estimations and recommendations, the 170 surveyed farms in the Disi basin are using 1.8 million cubic meters of water annually for agricultural (crop irrigation) purposes in excess of recommended water use. That is, farmers are using approximately three times the recommended water for their crops. On a per day basis, this translates into 32 cubic meters of water per day, per farm of water use in excess of the amount needed for all purposes.

Irrigation System

Approximately 35% of the farmers in the Disi basin use a flood system for irrigation which can be a highly inefficient method of irrigating (Figure 5). Conversely, 65% of the farmers use a more advanced, water saving method known as the irrigation drip system which is a recommended system of irrigation when water is in short supply.

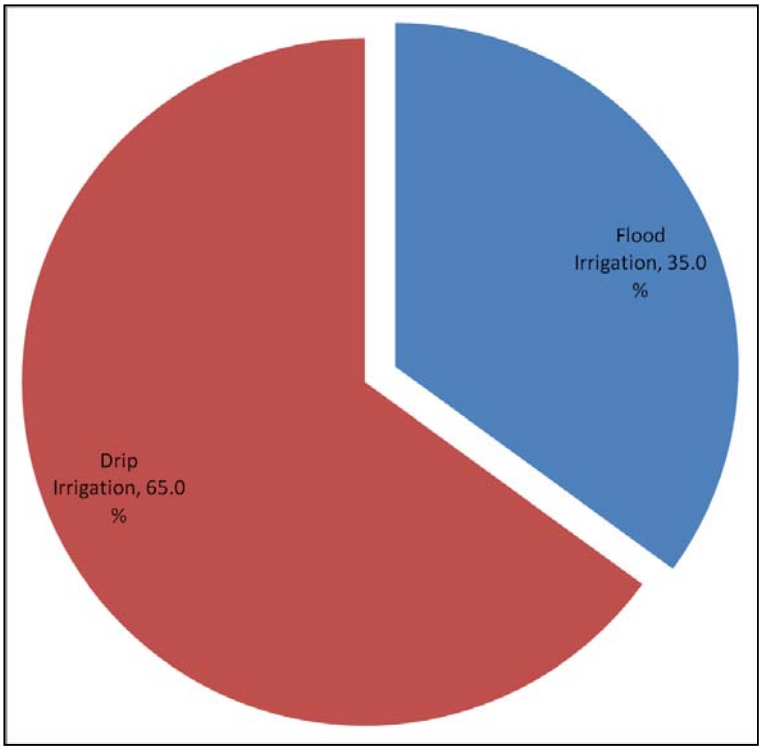


Figure 5. Irrigation Technologies Used in Disi Basin.

Comparisons of Survey Results by Operator Location and Primary Source of Income

In order to better understand factors influencing water use and farm productivity, researchers decided to examine production differences between selected groups of farmers. Two-way comparisons examined included (1) differences between farmers who live on-farm and those that live off-farm, and (2) differences between farmers who receive a majority of their income from farm activities and those that primarily on off farms income. In order to facilitate the analysis, only observations where all survey questions were answered were used. Information provided by 94 farmers, representing approximately 47% of all Disi basin farmers, fit this requirement and was used in the analysis. This subgroup of farmers planted only olive trees. The total area planted by these farmers was 755 donum and total water used was approximately 1,364,942 cubic meters (on an annual basis).

On-Farm and Off-Farm Influences on Production Behavior

Fifty-five percent of the farmers identified above lived on the farm while the remaining 45% reported living off-farm. Farmers who reported living on-farm were more likely to rely on farming as their primary income for family support. These farmers pumped an average 1,480 m^3 of water per donum from the aquifer each year. They use this water to irrigate 418 donum devoted to olives. Based on survey responses these farmers harvested on, on average 1,616 kilograms of olives per donum. Individuals not residing on the farm irrigated 337 donum and used an average 2,036 m^3 per donum of the water annually. These farmers produced an average of 916 kg of olives per donum (Table 4).

Table 4. Production Characteristics by Farmers' Place of Residence

	On-Farm		Off-Farm	
Description	Total	Average	Total	Average
Donum in production	418	8	337	8
Water used (m^3)	618,710	1,480 [a]	686,262	2,036 [a]
Water recommended (m^3)	167,000	400 [a]	134,880	400 [a]
Production (kg)	675,616	1,616 [a]	308,738	916 [a]
Output per m^3 used		1.09 [b]		0.44 [b]

[a] per donum
[b] kg per m^3

Farmers' Income Source

An issue of interest explored in the survey was the degree of farmer dependency on agriculture (and therefore on the pumping of water from the Disi Aquifer) for their sustenance. Table 5 shows that approximately 23% of the respondents indicated that they derive the majority (50% or more) of their income from farming. Seventy-seven percent indicated that they earned a majority (75% or more) of their income from other sources.

Farmers who derived the majority of their income from their farming operations farmed a total of 266 donum (an average of 12 donum/farm). These farmers used an average 1.680 m^3 of water per donum (pumped from the aquifer each year) and had a total olive output 2,496 kg of olives per donum. This compared to 1,755m^3 of water per donum and an average output of 655 kg per donum for farmers that earned a majority of their income from other sources. These farmers farmed a total of 489 donum.

Table 5. Farmers' Income Source

	Farming main source of income (22 Farmers)		Farming is not main source of income (72 Farmers)	
Description	Total	Average	Total	Average
Size (Donum)	266	12	489	7
Water used (m^3)	446,357	1,680	858,585	1,755
Rec water (m^3)	106,400	400	195,600	400
Output (kg olives)	663,887	2,496	320,477	655
Output / m^3 water		1.4kg		0.37kg

In terms of water efficiency (output per unit of water used), farmers who do not depend on farming as their primary source of income, generated only 0.37 kilograms of olives per cubic meter of water used compared to 1.4 kilograms for those who consider farming their main source of income. In addition, these farmers (consider farming their main source of income) use less water per donum than their non-farm income counterparts.

Table 6 breaks down the information presented in Tables 4 and 5 into greater detail by examining a cross tabulation between location (living on- or off-farm) and income (farming is primary source of income or farming is not primary source of income). The table confirms the conclusions presented in the previous discussion. The most inefficient users of water are individuals who live off-farm and who did not report their farm income as their primary family income. These individuals produced 0.40 kg of olives for every cube meter of water used, compared to 2.45 kg for individuals that received their primary income from farming and lived on the farm. Similarly, individuals that live off-farm and do not consider farming their primary source of income were less efficient in their production relative to the land use. These individuals reported and average of 654 kg of olives per donum whereas farmers that reported

their primary income was from the farm and that lived on the farm reported a per donum production nearly four times that (2,567 kg / donum).

Table 6. Production and Water Use by Location and Income Source

	Live On-farm	Live Off-Farm	Totals
Farming not main source of income	N = 38 Total Donums= 208 Total Water Use = 398,822 M^3 Total Olive Prod = 136,603 kg Ave Donums = 5.47 Ave Prod / M3 water = 0.34 kg Average Prod / Donum = 656.8	N = 34 Total Donums= 281 Total Water Use = 459,763 M^3 Total Olive Prod = 183,874 kg Ave Donums = 8.26 Ave Prod / M3 water = 0.40 kg Average Prod / Donum = 654.4	N = 72 Total Donums= 489 Total Water Use = 858,585 M^3 Total Olive Prod = 320,477 kg Ave Donums = 6.79 Ave Prod / M3 water = 0.37 kg Average Prod / Donum = 655.4
Farming is main source of income	N = 14 Total Donums= 210 Total Water Use = 219,888 M^3 Total Olive Prod = 539,013 kg Ave Donums = 15.00 Ave Prod / M3 water = 2.45 kg Average Prod / Donum = 2,566.7	N = 8 Total Donums= 56 Total Water Use = 226,469 M^3 Total Olive Prod = 124,864 kg Ave Donums = 7.00 Ave Prod / M3 water = 0.55 kg Average Prod / Donum = 2,229.7	N = 22 Total Donums= 266 Total Water Use = 446,357 M^3 Total Olive Prod = 663,877 kg Ave Donums = 12.09 Ave Prod / M3 water = 1.49 kg Average Prod / Donum = 2,495.8
Totals	N = 52 Total Donums= 418 Total Water Use = 618,710 M^3 Total Olive Prod = 675,616 kg Ave Donums = 8.04 Ave Prod / M3 water = 1.09 kg Average Prod / Donum = 1,616.3	N = 42 Total Donums= 337 Total Water Use = 686,232 M^3 Total Olive Prod = 308,738 kg Ave Donums = 8.02 Ave Prod / M3 water = 0.45 kg Average Prod / Donum = 916.1	N=94 Total Donums= 755 Total Water Use = 1,304,942 M^3 Total Olive Prod = 984,354 kg Ave Donums = 8.03 Ave Prod / M3 water = 0.75 kg Average Prod / Donum = 1,303.8

Ages' Effects Analysis

The effect of the age of the farmer or farm manager was evaluated to determine if there was difference in water use and productivity per unit of water related to age. Age differences, if any, might be a measure of management behavior related to educational levels and /or farming experience. Figure 6 shows the distribution of farmers by age.

Forty-four percent of farmers surveyed were young (ages between 20 and 39). Figure 7 shows that these farmers generate more output per unit of water used than older farmers (ages between 40 and 60). These farmers also generated more output per Donum as well (Figure 8).

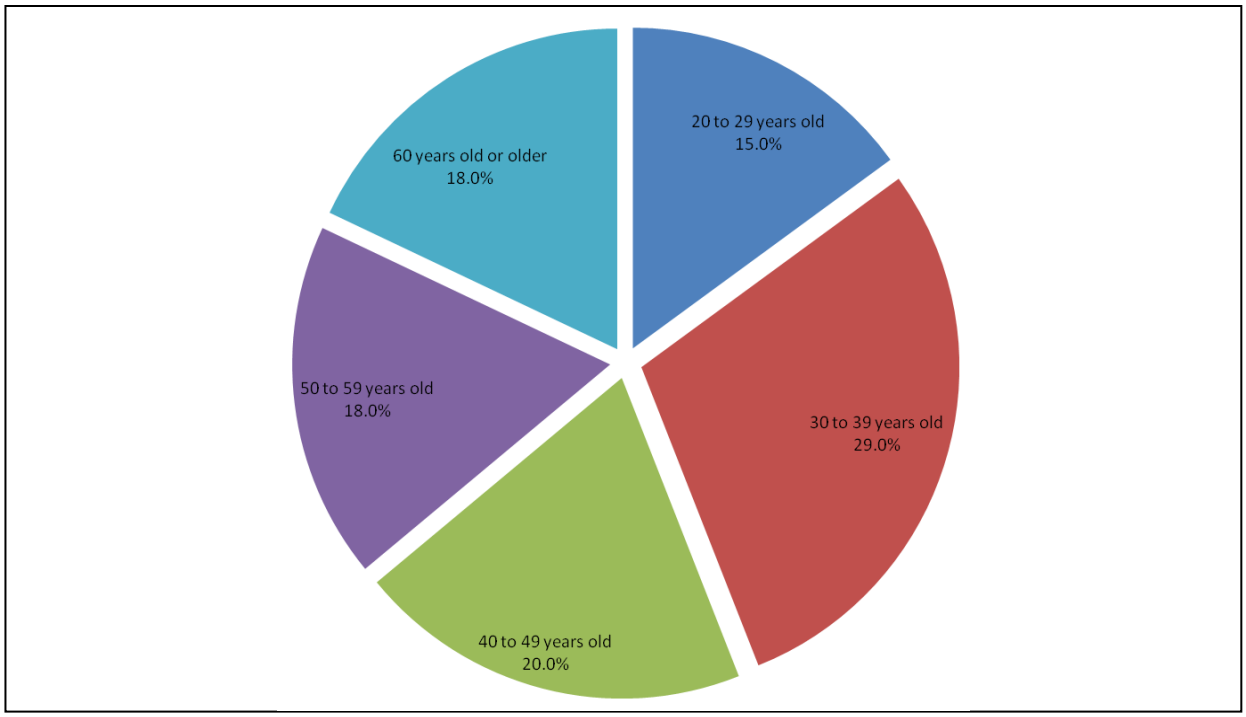


Figure 6. Farmer Age Distribution.

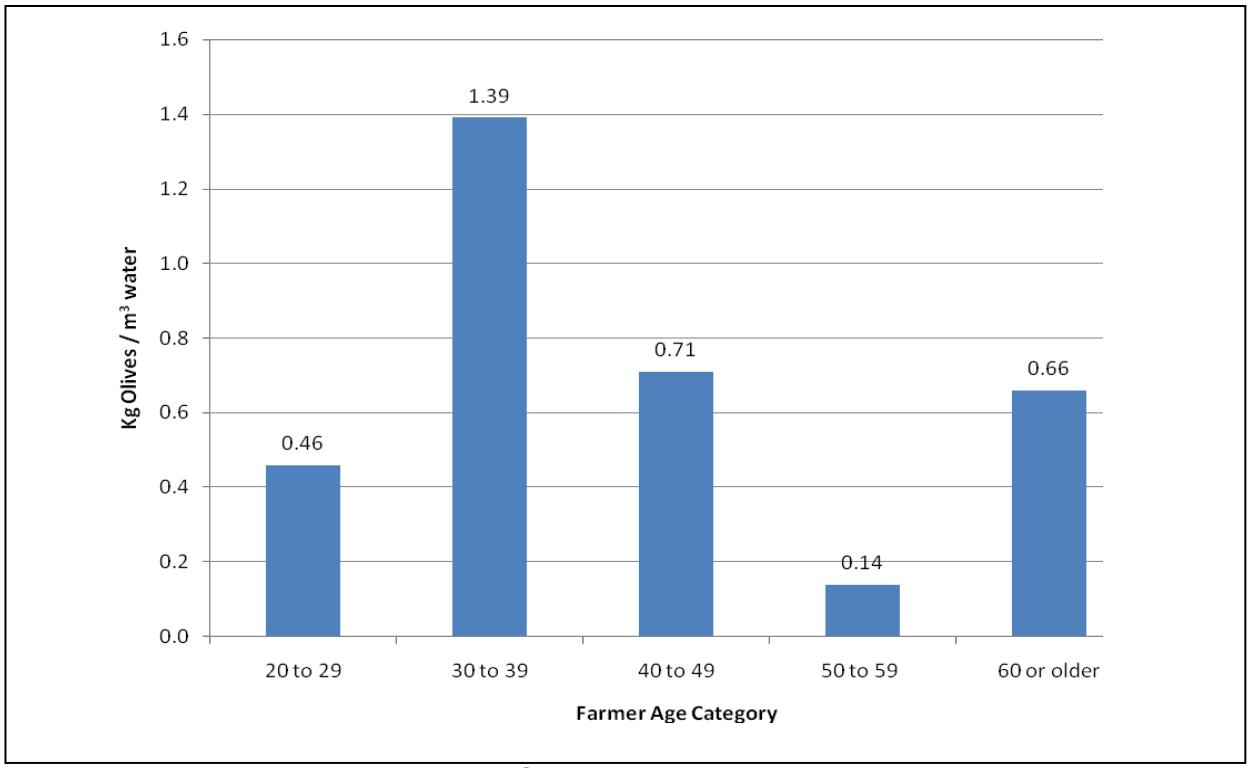


Figure 7. Productivity (kg olives / m^3 water) by Age.

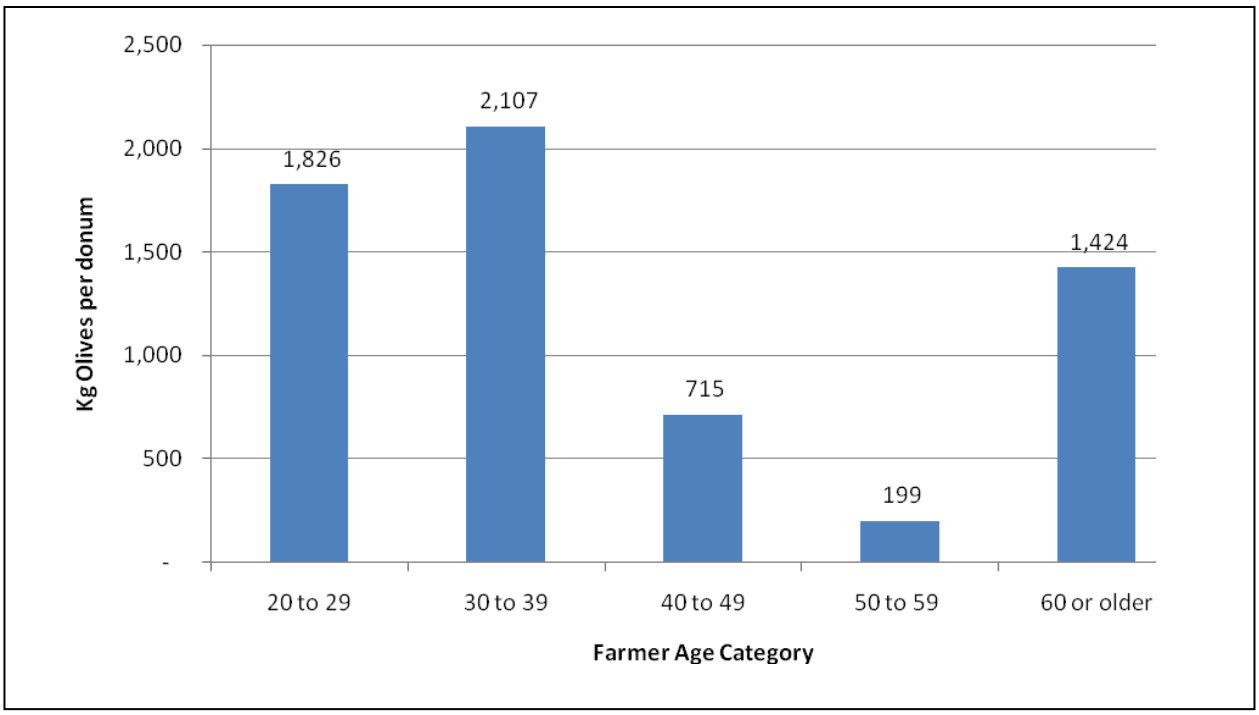


Figure 8. Olive Production (kg / Donum) by Age.

Findings and Recommendations

As an extremely arid country, Jordan must work to use its water resources efficiently. Recognizing this fact the Jordanian government has worked to balance the water needs of the agricultural industry with those of other, growing industries. Research regarding current agricultural practices, including irrigation and water use can help government officials better understand the impacts of existing and proposed policies regarding water. By better understanding current practices, government officials can better understand opportunities to encourage conservation that might allow increased water use outside of agriculture while still maintaining a viable agricultural sector.

Specific Recommendations to Reduce Water Use:

- Farmers in the Disi basin tend to use significantly more water than what is agronomically recommended for the crops grown in the region. This overuse may be the function of a number of factors, including low cost (no costs and no quotas), lack of information or training, and lack of irrigation infrastructure. The government might consider requiring meters on all irrigation wells and enforce a upper limit of water pumped based on sound agronomic research on crop water requirements.

- Farmers who live on-farm use 1,480 m3 of water/donum compared to 2,036 m3 of water /donum for the farmers who live off-farm. Additionally, farmers who live on-farm are more efficient in their production, producing almost twice as much (kg olives per donum) as their off-farm counterparts. If the government imposed water use fees that increase with the volume of water used, particularly use of water above that needed by the crops, it is probable that all farmers and particularly those living off-farm might be encourage to use less.

- Farmers who considered farming their primary source of household income tended to be more productive in terms of their total output (measured in olives) and their output per unit of water used. This group made up a smaller proportion of the basin's farming population (22%) and generally had larger farms (average farm size 12 donum compared to seven donum). Appropriate water use fees should encourage conservation of water by farmers with mostly of-farm income sources to use less water and improve agronomic practices resulting in better yields and improved productivity.

- Farmers in the Disi basin tend to have lower educational levels. Policy makers should be aware that these individuals may find it difficult to transition out of agricultural professions without substantial investments in education and training.

- Information technology, e.g., internet, is not commonly used in the basin (either in personal life or as an information tool for farming). Increasing access to the internet and training could provide farmers with additional information relative to their farming practices (e.g., crop selection, fertilizer recommendations, etc.).

- A vast majority of farms in the Disi basin do not use outside assistance in making management decisions regarding their farm. For example, only seven farmers in the region had attending irrigation training. This suggests a possible role for extension and extension training.

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