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WATER VALUATION STUDY - SUMMARY REPORT

DISAGGREGATED ECONOMIC VALUE OF WATER IN INDUSTRY AND IRRIGATED AGRICULTURE IN JORDAN

October 2012

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Table of Contents

EXECUTIVE SUMMARY

The Water Valuation Study undertaken by the USAID/Jordan Institutional Support and Strengthening Program (ISSP)from 2011-2012 aimed to assess the value of water use in different economic sectors, with a particular focus on the agricultural sector to determine water's value in producing different crops, in different locations, and for different markets. To do this it applied a Residual Valuation Methodology which deducts the contribution of non-water production inputs from the gross output and attributes the remaining value to water. It applied this methodology first to the industrial and service sectors of the economy, and then to 104 different agricultural crops in 9 regions in both winter and summer seasons. It also employed a Value Chain Analysis on a sample of crops to examine how water value was allocated among enterprises from crop production to the consumer's table.

Water values in industrial and service economic sectors are high, but there is no evidence that currently operating enterprises are water constrained. In many cases, however, the cost of water to industrial enterprises is very low relative to water value, which may encourage future demands for additional water, rather than a more appropriate focus on improved efficiency, recycling, and reuse.

Water value in agriculture varies widely across crops, seasons, and production locations. After dividing crops into four categories – field crops, winter vegetables, summer vegetables, and fruit – winter vegetables are shown to be the crop type with the highest overall water value (JD 1.30/m^3), while field crops such as maize, barley, and wheat produce the lowest average water value (JD 0.26/m^3). Among fruits, irrigated olives show consistently low water value (JD 0.21/m^3), while citrus is only marginally better (JD 0.70/m^3). A number of specialty crops such as strawberries, brussels sprouts, and ginger, though presently grown only on a small scale, show water values in excess of JD 2.0/m^3 and offer potential for expansion.

Disaggregating water value by region, Jordan Valley cultivation shows water values that are almost twice as high (JD 0.85/m^3) as those prevailing in the highlands (JD 0.37/m^3). One reason for this is that winter vegetables, with their relatively high water value, are grown in the Jordan Valley, while the highlands produces mainly summer vegetables. Another reason is the extensive planting of irrigated olive groves in the highlands, which generally produce very low water values.

Irrigated area in the highlands has expanded steadily over the past 18 years, growing at a rate of about 17,900 dunum per year, despite a 1992 ban on the drilling of new wells. Highland irrigated agriculture is mining aquifers, pushing groundwater levels ever lower and risking their contamination with saline groundwater. This mining also puts at risk a far more valuable use of highland groundwater – urban supplies to Amman and other highland municipalities. The marginal cost of water used in Amman at present is about JD 1.0/m^3, and will increase by a factor of 2 or 3 as planned new water projects are implemented. It thus makes little economic sense to allow continued groundwater extraction from highland aquifers to produce relatively low water value crops.

Water prices are very low, especially relative to agricultural water value, in both the Jordan Valley and the highlands. In the Jordan Valley, farmers pay a water price of just JD 0.012/m^3, while in the highlands pumping costs run around JD 0.25/m^3, with effectively no resource fee charged. This encourages overdevelopment of groundwater-based irrigation in the highlands and provides no incentive for efficient water use in the Jordan Valley. Further, it can only generate grossly inadequate funding for operations and maintenance in the Jordan Valley.

Local marketing chains for produce are inefficient and costly, showing very high marketing margins. This means that, while consumers pay relatively high prices for fresh produce, farmers receive only a small fraction of that value. Reform of the local marketing system, providing farmers with higher farmgate prices, could be coupled with an increase in Jordan Valley irrigation water prices, offsetting the impacts of the price increases.

Exporting Jordanian agricultural products often results in considerably higher value per unit of water accruing to Jordan's economy than local sale. Exports to Eastern and Western Europe are almost always the highest value uses of water where crops produced are in demand there. Neighboring country and Gulf State markets provide enhanced water values for some crops, but not others. In part this is due to the high local marketing margins, which add value to the national economy, if not to farmers, and in part to the fact that many crops are shipped to neighboring markets only after local demand has been satisfied.

Jordan has substantial untapped potential to increase agricultural sector output, particularly by exporting high-value winter vegetables to Europe. However to accomplish this, a coordinated program by various ministries, private sector enterprises, and farmers is necessary. Farmers are in need of better information and technology and access to storage and packaging facilities, particularly smaller farmers who cannot afford to develop these facilities individually. They also need good connections with exporters who can develop and supply markets abroad. Government needs to provide higher-quality, measured irrigation service in the Jordan Valley, establish standards for product quality, provide laboratory facilities for soil, water and product testing, and strengthen farmer organizations that can facilitate joint action by smaller farmers. Private equipment and input suppliers need to do a better job of reaching farmers with information and new technology, while wholesalers and exporters need to invest in storage and packaging facilities and cultivate new sources of supply among small farmers.

Irrigated agriculture is important as a source of rural incomes and employment, improved nutrition, export earnings, and inputs to downstream agricultural processing industries. The Jordan Valley has unique advantages as a supplier of off-season winter vegetables for export and the country should mount a comprehensive multi-actor public and private sector program to enhance and exploit this comparative advantage.

In a country facing such a significant imbalance between limited supplies and ever-growing demand, the government must grapple with very difficult policy decisions and trade-offs in order to determine the best ways in which to allocate water across sectors. This is especially true for the agricultural and industrial sectors which consume significant portions of the national water supply and are central to the Jordanian economy. The ISSP Water Valuation Study was undertaken to support ISSP's objectives to improve policy-making in the water sector by providing decision-makers with a much deeper understanding of the productivity of water across sectors.

1. INTRODUCTION

ISSP

The USAID/Jordan Institutional Support and Strengthening Program (ISSP) works to address key institutional constraints to more effective and efficient management of water resources in Jordan. ISSP is implementing a comprehensive package of institutional reform and restructuring activities to improve transparency and participation in policy and planning, address key institutional conflicts of interest in the management, planning and protection of water resources, improve municipal and irrigation water service delivery across all key institutions and support legislative reform across the water sector.

A critical component of improved resources management is a more informed policy setting process. Jordan's water sector is struggling to keep up with rapid population growth and economic growth. Jordan is one of the most water scarce countries in the world, with very limited quantities of renewable water and high costs for providing water to people and businesses. To help Jordan to face these challenges, ISSP is working with the Ministry of Water and Irrigation (MWI), the Water Authority of Jordan (WAJ), the Jordan Valley Authority (JVA) and utilities to reform and restructure the water sector to become more efficient, sustainable, and responsive to people's needs. A set of reform goals was developed through an extensive multi-disciplinary Institutional Assessment and were confirmed by USAID and the Ministry of Water and Irrigation in an exchange of letters in April 2012. These reforms will result in a water sector better able to respond to future needs and achieve water security for Jordan.

In a country facing such a significant imbalance between limited supplies and ever-growing demand, the government must grapple with very difficult policy decisions and trade-offs in order to determine the best ways in which to allocate water across sectors. This is especially true for the agricultural and industrial sectors which consume significant portions of the national water supply and are central to the Jordanian economy.

The ISSP Water Valuation Study was undertaken to support ISSP's objectives to improve policy-making in the water sector by providing decision-makers with a much deeper understanding of the productivity of water across sectors. The ISSP Water Valuation Study was designed by Dr. Glen Anderson of International Resources Group (IRG) and Dr. Emad Karablieh of the University of Jordan and implemented by Dr. Karableih and Ra'edDaoud of ECO Consult. Dr. Mark Svendsen of IRG assisted with the analysis, writing, and presentation. This is a Summary Report to highlight the major findings, results and implication s of the study. There is also a detailed report[1] which fully explains the study methodology and presents the entirety of the analysis, findings, data and conclusions presented in this summary.

STUDY PURPOSE

Any society must allocate scarce water resources among uses and users. Those uses have different economic impacts and different social and political implications. The allocation process must balance these factors to divide up a resource that is often scarce and always valuable. Three different types of practices can be identified that are used to make water allocation decisions in different countries and situations: (1) administrative decision-making, (2) rights-based rules for access and use, and (3) transactions based on economic principles.

Administrative allocation operates when political authorities make decisions which award access to water to particular groups of users. This may be done by selectively authorizing withdrawal from rivers or the drilling of wells. Authorizing construction of an irrigation scheme can constitute a *de facto* allocation of water. Governments can also allocate water indirectly by establishing a schedule of charges for water used in different locations or for different purposes. Administrative allocation can be, and typically is, based on a combination of economic, social, and political factors.

Rights-based allocation systems rely on a set of rules established by government under which private parties can access and use water. It differs from administrative allocation in that once established, rules governing access are applied impartially until the resource is fully allocated. Generally some mechanism is established for approving or rejecting applications and resolving disputes, but these decisions must be based on the pre-established rules of access. Water rights systems based on "first in time, first in right" are an example of rights-based allocation.

Allocation based on **economic principles** typically takes place after primary allocation by some other means. It can involve sale of rights to access water to another party, purchase and retirement of a right to water for conservation purposes, exchange of surface for ground water access, and many others. Beyond such economic sales and exchanges, however, most allocational decision-making involves some

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[1] Al-Karablieh, Emad. 2012. Disaggregate Economic Value of Water in irrigated Agriculture in Jordan from Perspective of Value Chain Analysis. Draft report. ISSP.

consideration of the economic value of water, whether it a pure economic transaction or an administrative decision in which economic value is weighted, together with social and political considerations.

Any given system of allocation is most often a combination of all three of these sets of practices, though emphasis varies widely from country to country. Emphasis also over time in each country as economies and societies grow, diversify, and mature.

The purpose of the Water Valuation study is to provide decision-makers with information about the value of water in different sectors of the Jordanian economy, aiding them in making sound decisions about where water should be allocated, or reallocated, to yield greatest benefit for Jordan. It is intended to help address questions like these.

- Where and for what crops is water most productively used?
- How do agricultural water costs compare with the value of the water?
- How can the value of water in agriculture, and agriculture's contribution to the Jordanian economy, be increased?
- What is the value of water in the industrial sector and is water a limiting factor for industrial and economic growth?
- How do the prices paid for water in different uses compare with the productivity of water in those uses?
- How can Jordan increase the value to the nation of each drop of water used?
- What actions can be taken by the government to increase water use efficiency?
- How can pricing mechanisms be used to increase water use efficiency?

The specific objectives of the study were (1) to produce a set of well-differentiated estimates of current water values in different uses, with a particular focus on agricultural uses, and (2) to analyze options to improve efficiency of water utilization in Jordan. Clearly additional information and analysis are necessary to address all of these questions satisfactorily. However, the present study is intended to fill in blanks with respect to some of these important questions.

2. APPROACH

The approach taken in carrying out the study was to employ tested economic tools to assess the economic value produced when water was utilized for different purposes. In particular, the study assessed the value of water use in the major sectors of the economy and then drilled down into water values in the agricultural sector. In the agricultural analysis, agricultural production in Jordan was separated into 104 crops, 9 regions of the country, summer and winter seasons, and 3 sources of water to provide the granular detail needed for making decisions regarding water allocation. This level of detail sets it apart from previous studies of water values in Jordan.

The study also extended beyond the national borders, using a value chain analysis to examine the value added when agricultural output was sold in different international markets. In addition to local markets, the study looked at horticultural crop marketing to neighboring countries, the Gulf States, and Eastern and Western Europe.

Two related methodologies were employed in the study – the Residual Valuation Method (RVM), and Value Chain Analysis (VCA). Both are standard tools used by economists world-wide and they allow comparison with values derived both from other studies in Jordan and with studies in other counties. Methods are described briefly below.

Residual Valuation Method

Users of a commodity or service typically use its price as a guide in deciding how much of it to use. However for commodities like water, where price does not reflect true value, and is often far below its real value, a different approach is needed.

The RVM is a way of approximating the value of water use in such situations. It is a way of estimating water's economic value, which is equivalent to isolating the marginal contribution of water to the total value of the output.

In application, RVM considers the total output value of the commodity of interest, and deducts the portions of that total value that can be attributed to inputs other than water. It then takes the remaining value and attributes it to the unpriced input – water. Table 1 shows an example of such a calculation for Jumbo Medjool Dates grown in Jordan.

Table1.Illustrative value added calculation for Jumbo Medjool Dates

	Level	Rate	Total	
Gross Output [JD/du]	1.149	3,500	4,022	**4,022**
Variable Costs				
Tillage			10	
Fertilizer			125	
Manure			60	
Pesticide			25	
Fuel			30	
Plant husbandry material			50	
Miscellaneous			40	
Variable Costs (ex labor)				**340**
Gross Value Added [JD/du]			3,682	
Labor			214	**214**
Fixed Costs				**414**
Water Cost	817.9	0.03	25	**25**
Net Profit [JD/du]				**3,029**

Gross Value Added [JD/m^3]	4.50
Net Value Added [JD/m^3]	4.00
Operting Surplus [JD/m^3]	3.73

The gross value of output is first calculated by multiplying the yield per dunum by the farmgate price received by the farmer, in this case a total of JD 4022. Variable costs are added up, as are capital costs, and labor. These can be deducted from the gross value to yield a net profit per dunum to the cultivator. This is the type of calculation that the farmer, explicitly or implicitly, would rely on in managing his farm enterprise, as it determines the profit he receives.

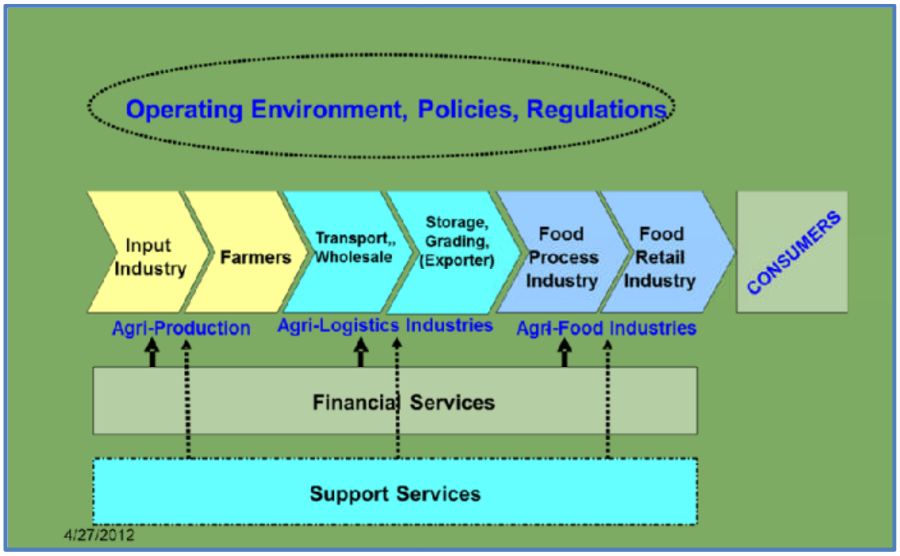
However, because the cost of the water used in this calculation is arbitrarily set, and is so small as to be virtually inconsequential in most cases, an additional calculation is needed to estimate the actual importance and value of the water used in producing the crop. To do this, three separate standard measures are employed – Gross Value Added (GVA), Net Value Added (NVA), and Operating Surplus (OS). GVA is calculated by subtracting variable costs from gross value and dividing the result by the amount of water used in producing the crop (818 m^3 in this example). When fixed costs are also deducted from gross value and the result divided by the water used, NVA results. The OS results when labor costs are also deducted from gross value before dividing by water used.

All three measures thus represent the contribution of water to the overall value of the output. They differ, however, in that some also include contributions from additional factors of production. Because the three measures are closely related, however, because data related to labor and fixed costs are sometimes difficult to obtain, and because Gross Value Added (GVA) is the value most commonly reported for such analyses, it is the primary measure used in the remainder of the report.

VALUE CHAIN ANALYSIS

A VCA assesses the value added at each stage of the process that moves agricultural products from the farm to the fork. Its application is depicted in Figure 1.

Figure 1. Agricultural value chain



It is measured as the difference between the value of all goods and services produced and the value of the purchased non-labor inputs which have been used in the production process. This type of measure avoids double counting, since what each enterprise or agent has purchased from other agents is deducted from the value of its own production. Inputs to be considered may include materials and supplies, fuel, electricity, contract work, repairs, maintenance and transportation as well as other services. The value at which these inputs were purchased is deducted from total revenue from production in order to obtain the value added by each agent or enterprise.

In practice all of the activities in the agricultural value chain; including production, storage, grading, transport, packing, marketing, and distribution; are separated out and the cost of each is determined. These costs are then aggregated for each of the enterprises which handle the product before its final sale to a consumer. The incremental costs at each stage are then divided by the quantity of water used in producing the product on the farm. An example of such a calculation is shown in Table 2.

Table 2.Illustrative value chain analysis for Jumbo Medjool Dates

	Jordan Wholesale	Local market	Neighbouring countries	Gulf States	Western Europe	Rest of world
Purchasing price [JD/ton]	3,500	6,000	6,000	6,000	6,000	6,000
Washing, grading	20	5	30	30	40	30
Pre-cooling, packing	25	10	20	70	130	90
Sorting, loading	5	10	10	10	100	50
Losses	10	55	30	40	60	60
Transportation, cooling	10	20	100	150	1000	750
Total transaction costs	**70**	**100**	**190**	**300**	**1330**	**980**
Selling price	6,000	8,000	8,500	10,000	12,000	10,000
Value added JD/ton	**2,430**	**1,900**	**2,310**	**3,700**	**4,670**	**3,020**
Water content [m3/ton]	712	712	712	712	712	712
Water value added [JD/m3]	**3.42**	**2.67**	**3.25**	**5.20**	**6.56**	**4.24**

DATA SOURCES

Data used in this study came primarily from official Jordanian sources, which included the Ministry of Water and Irrigation (MWI), the Department of Statistics (DOS), and the Ministry of Agriculture (MOA) as well as other relevant ministries and administrative units. The official data sources accessed included data from 2010 for the agricultural sector and data for the years 2007-2009 for industrial and services sectors. Data on external trade by market destinations, wholesale prices, retailers' prices, and export prices were retreived from DOS records, while annual production and yield for cereal crops, fruits, and vegetable were gathered from annual agricultural statistics.

Primary data on production costs were collected by the researchers from different locations in Jordan representing different production systems. Several questionnaires were designed, pre-tested and administered in the field for this purpose. Many personal interviews were also conducted with farmers (producers), agents in assembly markets, agents in wholesale markets, transporters, processors in the packing and grading houses, local traders, exporters and retailers.

3. BACKGROUND

ECONOMY

Jordan is a low-middle income country, with an average per capita GDP of about JD 3,069 in 2010, and a population of 6.11 million inhabitants (DOS, 2011). It is almost completely lacking in energy reserves and thus depends heavily on imports of crude oil, refined petroleum products and natural gas from neighboring Arab countries as main sources of energy.

Jordan's economy is among the smallest in the Middle East, with limited water, oil, and other natural resources underlying the government's heavy reliance on foreign assistance. Other economic challenges for the government include chronic high rates of poverty, unemployment, inflation, and a large budget deficit. Since assuming the throne in 1999, King Abdullah has implemented significant economic reforms, such as opening the trade regime, privatizing state-owned companies, and eliminating most fuel subsidies, which in the past few years have spurred economic growth by attracting foreign investment and creating some jobs. The global economic slowdown, however, depressed Jordan's GDP growth and foreign assistance to the government in 2009 plummeted, hampering the government's efforts to reign in the large budget deficit. However GDP rebounded to grow at a rate of 11% in 2010.The services sector accounts for over 70% of GDP and more than 75% of jobs.

Some summary economic statistics for four recent years are shown in Table 3.

Table 3. Summary statistics on Jordan's economy, 2006-11

	2006	2007	2008	2009	2010	2011
Agriculture [M JD]	276	307	377	459	561	598
Manufacturing [M JD]	1,815	2,295	2,933	3,026	3,146	3,485
GDP at Market Prices [M JD]	10,675	12,131	15,593	16,912	18,762	20,476
Agricultural share of GDP [%]	2.6%	2.5%	2.4%	2.7%	3.0%	2.9%
Manufacturing Share of GDP [%]	17.0%	18.9%	18.8%	17.9%	16.8%	17.0%
Per Capita GDP at Current Prices [JD]	1,906	2,120	2,666	2,828	3,069	3,277

WATER RESOURCES[2]

In 2009, the renewable freshwater resource available per capita in Jordan was about 130 cubic meters per year. This is less than one seventh of the widely recognized "water poverty line" of 1,000 cubic meters per capita per year. This sobering observation requires that water be well-managed and used as efficiently as possible.

Surface water supplies[3] contribute approximately 32% of Jordan's total water supply. Developed surface water in Jordan was about 288 MCM in 2010 (Table 4) and projected to rise to no more than 365 MCM by 2022.

Groundwater contributes about 57% to total water supply. However, the unsustainable abstraction of groundwater due to population growth, agriculture expansion, and declining recharge is a major problem today. It has been exacerbated by poor enforcement of regulations on private well drilling, and the near absence of controls on licensed abstraction rates. As water tables drop, pumping costs and salinity levels increase.

Fourteen major populated areas (62% of the population) are served by sewerage systems producing about 100 m^3 of effluent per year. Most of that treated wastewater is reused in Jordan Valley agriculture. In view of the increasing population and the social and economic development of the country, the increasingvolume of treated wastewater is likely to play an ever more important role in the future. It is estimated that by 2022 the volume of treated wastewater available for reuse will be 250 MCM.

Table 4. National Water Supply and Consumptive Use (MCM), by Sector, 2010

Source	Domestic	Industrial	Irrigation	Livestock	Total	Share
Surface	120.0	6.6	154.5	7.0	288.1	**31.9%**
Ground	231.7	33.9	245.0	0.3	510.9	**56.6%**
Treated WW	0.0	1.5	101.5	0.0	103.0	**11.4%**
Total Used	**351.7**	**42.0**	**501.0**	**7.3**	**902.0**	**100.0%**
Share	39.0%	4.7%	55.5%	0.8%	W/ treated wastewater	
			Totals Without Treated Wastewater			
Total Used	351.7	42.0	501.0	7.3	902.0	
Less Treated WW	0.0	1.5	101.5	0.0	103.0	
Total Net	**351.7**	**40.5**	**399.5**	**7.3**	**799.0**	
Share	44.0%	5.1%	50.0%	0.9%	W/o treated wastewater	

Source: MWI

[2] This section is drawn from Jordan's draft *Water Strategy Update: 2008-2022*, dated February 2012.

[3] Excluding treated wastewater, which is derived from both ground and surface water

Irrigation[4] uses just over half of the current available supply, around 500 M m^3, though these figures may underestimate both irrigation use and total water use for various reasons. Domestic use ranks second, using around 352 M m^3, while industrial use is currently around 42 M m^3, less than 5% of total supply, but expected to grow. The MWI 2012 strategy update envisions holding agricultural water use at 500 M m^3into the future, and so a strong challenge will be to generate a great deal more value from the use of that amount of water.

[4] Including treated recycled wastewater

4. WATER VALUE

INDUSTRY AND SERVICE SECTORS

The economy can be divided into sectors using the International Standard Industrial Classification (ISIC) framework of the UN Statistics Division. Table 5 shows water use, gross output, and water value for the industrial and service sectors[5].

Table 5. Industrial and service sector economic activity

Sector	Withdrawals [M m^3]	% of Total	Gross Output [JD/m^3]	Gross Value Added [JD/m^3]
Industry, Mining, Manufacturing	47.3	57%	215.0	77.6
Services	17.0	20%	113.1	71.6
Wholesales, Retail Trade	9.4	11%	218.9	163.6
Transport, Storage, Communication	4.5	5%	820.3	429.2
Construction	4.3	5%	385.9	100.0
Banks, Financial Institutions	0.8	1%	1,612.1	1,308.7
Insurance	0.1	0%	834.8	469.3
Total	**83.4**	**100%**	**250.1**	**118.1**

As seen, the value of water in these uses is quite high, corresponding to strong capacity of the enterprises in these sectors to pay for water. It should be noted that, unlike the case of agriculture, where water is generally a constraining factor, most of these enterprises are not constrained by water, and hence providing another cubic meter of water will not necessarily result in increased sector output. At the same time they should not be denied additional water if they do require it to increase output, subject to the condition that they pay a reasonable price for it, keeping the Gross Value Added (GVA) of the water in mind.

AGRICULTURE

The agricultural sector has grown significantly over the past 6 years, expanding from 276 M JD to 598 M JD, and its share of the national economy, while still small, has increased from 2.6% to 2.9% over the

[5] Water value in this table exceeds industrial sector water use reported earlier because much water used in producing industrial goods and services is drawn from municipal systems.

same period. In addition, however, agriculture provides important social, economic and political benefits. Chief among these are the creation of rural jobs and economic activity. Agriculture, particularly irrigated agriculture, provides the basis for settlement in the Jordan Valley through its upstream and downstream linkages with other economic activity.

LABOR

Labor use in agriculture was investigated during the study and is shown in Table 6. Total agricultural employment is around 60 thousand people, nationwide. However because some jobs are seasonal or casual, the effective rate of full-time employment in agriculture is around 32 thousand workers, of which about 10 thousand jobs are filled by Jordanians and around 22 thousand by non-Jordanian workers. Note that Jordanian laborers dominate the "seasonal" and "casual" categories, but are outnumbered in the "permanent" category by non-Jordanian workers.

Table 6. Agricultural labor in Jordan, 2010

Type of Labor	Nationality	Male	Female	Total
Permanent Labor	Jordanian	3,627	679	4,306
	Non-Jordanian	17,338	0	17,338
Seasonal Labor	Jordanian	1,268	17	1,285
	Non-Jordanian	770	84	854
Casual Labor	Jordanian	10,413	8,676	19,089
	Non-Jordanian	16,563	1,920	18,483
Total Labor	Jordanian	15,308	9,372	**24,680**
	Non-Jordanian	34,671	2,004	**36,675**
	Total	**49,979**	**11,376**	**61,355**
Standardized Total Labor	Jordanian	6,864	2,857	**9,721**
	Non-Jordanian	21,864	522	**22,386**
	Total	**28,728**	**3,379**	**32,107**

Note: Seasonal labor considered 0.50 of full-time, casual labor 0.25.

In addition, post-production food industries employed about 20% of the national labor force in 2009 and provided 16.4% of all employee compensation(DOS, 2010). Food industries consist of flour milling, baking, dairy products, cooking oil, meat products, chocolate and sugar confectionery, and canning and preserving food products, juices, and tomato paste. These industries rely on both locally-produced and imported primary food products, but the importance of downstream value-added processing of agricultural commodities for job creation is clear.

TYPE AND LOCATION OF AGRICULTURE

Nationwide, 60% of Jordan's agricultural land is rainfed, and the remaining 40% irrigated. However as seen in Table 7, the 40% of agriculture that is irrigated contributes 90% of the total value of production. This demonstrates the vast productive advantage that irrigation water brings to agricultural land in Jordan.

Table 7. Agriculture by type and value of production

	Area		Value of Production	
	[M Dunum]	%	[M JD]	%
Rainfed Area	1.569	60%	48.9	10%
Irrigated Area	1.025	40%	460.9	90%
Total	**2.594**	**100%**	**509.8**	**100%**

A part of the explanation for this difference is the type of crops grown on rainfed and irrigated land, respectively. As seen in Table 8, in rainfed areas, three-quarters of farmland is devoted to field crops such as wheat, barley, maize, and clover. In irrigated areas, on the other hand, 87% of cropland is planted to horticultural crops, i.e. fruits and vegetables. Of course horticultural crops would not grow well if planted on rainfed land, but the prevailing pattern of applying most irrigation water to higher-value crops is an important positive.

Table 8. Crop type grown by rainfed and irrigated

	[M Dunum]	Field Crops	Hort. Crops	Total
Rainfed Area	1.569	74%	26%	**100%**
Irrigated Area	1.025	13%	87%	**100%**

Irrigated area in Jordan has experienced significant growth over the past decade and a half, and irrigated area was more than half again as large in 2010 as it was in 1994 (Table 9). Driving this growth has been the explosive expansion of highland irrigated agriculture, as reflected in figures from the Department of Statistics, which is up some 77% over the period[6].

Table 9. Growth in irrigated area, by location, 1994-2010

	1994	2010	% Change
Jordan Valley	275,101	333,630	21%
Highlands	390,930	691,092	77%
Total	666,031	1,024,722	54%

6 These figures report cropped area and not physical area. In areas where both summer and winter crops are grown on the same land, therefore, the values reported will be larger than the actual physical area commanded by irrigation facilities. Nevertheless, they represent the actual area requiring water for crop production.

Despite a ban on well drilling in the highlands announced in 1992, steady expansion of irrigated area there has continued at an average rate of around 17,900 dunum per year (Figure 2).

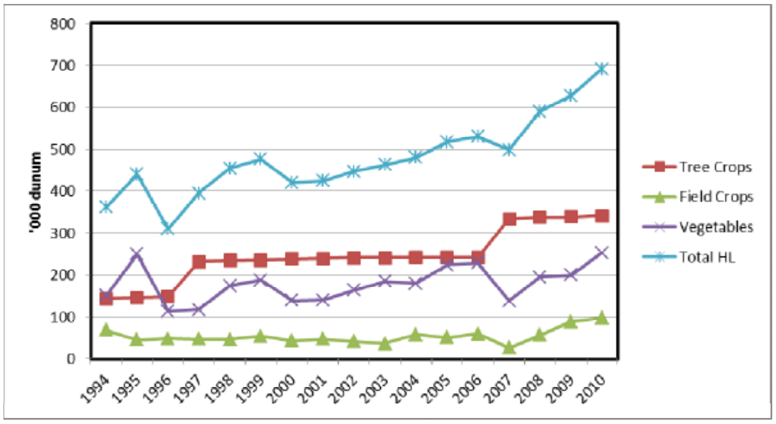


Figure 2. Growth in highland irrigated area, by crop type

As a result of this growth,two-thirds of Jordan's irrigated area is now located in the highlands, while the remaining one-third in is the Jordan Valley (JV) (Table 10). Irrigated area is predominantly devoted to horticultural crops – vegetables and fruits in both the JV and in the highlands. However while vegetables dominate in the JV, tree crops are the most important crop type in the highlands.

Table 10. Irrigated crops, by location, 2010

	Irrigated Area ['000 Dunum]					Percentage			
	Total	%	Tree Crops	Vegetables	Field Crops	Tree Crops	Vegetables	Field Crops	Total
Jordan Valley	334	33%	105	197	32	32%	59%	9%	100%
Highlands	691	67%	342	252	97	49%	36%	14%	100%
Total	1,025	100%	447	449	129	44%	44%	13%	100%

WATER VALUES

FIELD CROPS

The top five field crops, in terms of total water use, in both the JV and the highlands are shown in Table 11. As seen, field crops are much more common in the highlands than in the JV. They are also generally low value crops in both locations, in terms of water value, with all but one generating less than JD 0.40 of water value per cubic meter of water used. The exception is clover, which is grown extensively in the highlands where it supports an expanding dairy industry, and to a lesser extent in the JV. Its water value is JD 0.26 in the highlands and JD 0.60 in the JV. Note that these 5 field crops consume more than a fifth of all irrigation water pumped in the highlands.

Table 11. Water value of field crops in the Jordan Valley and the highlands

Field Crop, JV					
	Areas [Dunum]	**Water Use ['000 m3]**	**Water Use ['% JV FC]**	**Water Use ['% Total JV]**	**GVA [JD/m3]**
Maize	14,249	10,434	60%	6.0%	0.26
Wheat	7,444	2,528	14%	1.5%	0.19
Clover	3,735	2,370	14%	1.4%	0.60
Barley	3,666	1,232	7%	0.7%	0.12
Sorghum	852	518	3%	0.3%	0.13
Total	**29,946**	**17,082**	**98%**	**10%**	**0.31**
Field Crop, Highland					
	Areas [Dunum]	**Water Use ['000 m3]**	**Water Use ['% HL FC]**	**Water Use ['% Total HL]**	**GVA [JD/m3]**
Clover	62,036	81,607	84%	18.4%	0.29
Sorghum	19,151	10,985	11%	2.5%	0.15
Barley	6,371	2,027	2%	0.5%	0.07
Wheat	2,770	1,013	1%	0.2%	0.27
Vetch	1,551	470	0%	0.1%	0.05
Total	**91,879**	**96,104**	**99%**	**22%**	**0.26**

WINTER VEGETABLES

The top 10winter vegetables, in terms of water use, in the JV and in the highlands, are shown in Table 12.

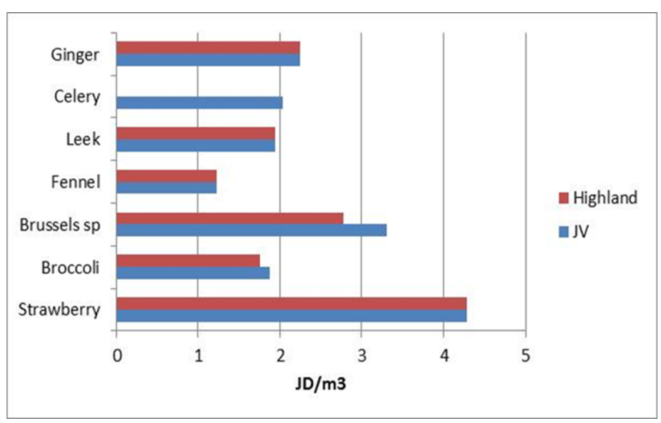
Table 12. Water value of winter vegetables in the Jordan Valley and the highlands

Winter Vegetables, JV	Areas [Dunum]	Water Use ['000 m^3]	Water Use ['% JV Winter Veg]	Water Use ['% Total JV]	GVA [JD/m^3]
Tomatoes	50,356	18,273	38%	10%	1.36
Eggplants	19,493	6,002	12%	3%	1.05
Potatoes	17,735	5,882	12%	3%	0.88
Cucumbers	12,932	4,109	9%	2%	4.60
Squash	16,857	3,919	8%	2%	1.01
Sweet peppers	6,193	2,551	5%	1%	1.70
Broad beans	4,802	1,718	4%	1%	1.03
Lettuce	4,872	1,146	2%	1%	1.47
Cabbages	2,483	747	2%	0%	0.32
Hot peppers	2,522	712	1%	0%	1.68
Total Win Veg	**138,245**	**45,058**	**93%**	**26%**	**1.55**

Winter Vegetables, Highland	Areas [Dunum]	Water Use ['000 m3]	Water Use ['% HL Winter Veg]	Water Use ['% Total HL]	GVA [JD/m3]
Tomatoes	24,863	11,257	36%	2.5%	0.71
Potatoes	15,901	5,486	18%	1.2%	1.36
Broad beans	7,663	3,556	11%	0.8%	1.38
Onion, dry	4,422	2,714	9%	0.6%	0.30
Cauliflower	6,263	2,557	8%	0.6%	0.71
Squash	2,359	863	3%	0.2%	0.69
Cabbages	1,985	821	3%	0.2%	0.28
Peas	1,727	771	2%	0.2%	2.02
Lettuce	1,897	500	2%	0.1%	0.70
Cucumbers	1,152	425	1%	0.1%	4.61
Total Win Veg	**68,231**	**28,951**	**93%**	**7%**	**0.91**

As seen, tomatoes are the biggest water user in both regions, consuming more than 10% of all water used in agriculture. The water value of tomatoes is reasonably high in the JV, and much lower in the highlands. After tomatoes, water use is divided among a number of vegetables. Cucumbers stand out as being the biggest value producer per unit water consumed in both regions. Other standout crops include sweet and hot peppers, broad beans and lettuce in the JV, and peas, broad beans, and potatoes in the highlands.

Figure 3. Promising high water value



In addition to these widely-planted vegetable crops, there are a number of promising vegetables being planted on much smaller areas that show high water values (Figure 3). These crops should be studied to better understand their potential for being grown and marketed both in Jordan and abroad.

SUMMER VEGETABLES

The top ten summer vegetables, in terms of water use, in the JV and the highlands are shown in Table 13. As seen, the area of summer vegetables is much larger in the highlands, where summer temperatures are cooler, than in the JV. In the JV, Jew's mallow[7] is the biggest summer water user, followed by tomatoes and okra. Jew's mallow has a relatively low water value of JD 0.26/m^3, while water values of tomatoes and okra range between JD 0.54 and JD 0.9. Hot peppers and potatoes stand out as producing above average water value in the JV in summer.

In the highlands, tomatoes are the big water user, consuming 41% of highland summer vegetable water and almost 10% of total highland water for the year. The water value of tomatoes grown in summer is a relatively low JD 0.34/m^3. In the highlands, cucumbers and cauliflower stand out as high water value crops.

[7] A variety of jute used as a green vegetable when young.

Table 13. Water value of summer vegetables in the Jordan Valley and the highlands

Summer Vegetables, JV	Areas [Dunum]	Water Use ['000 m^3]	Water Use ['% JV Sum Veg]	Water Use ['% Total JV]	GVA [JD/m^3]
Jew's mallow	12,392	5,979	31%	3.4%	0.26
Tomatoes	7,913	3,567	18%	2.0%	0.54
Okra	6,885	2,918	15%	1.7%	0.90
Watermelons	2,936	1,353	7%	0.8%	0.69
Squash	4,424	1,137	6%	0.7%	1.03
Eggplants	3,034	1,120	6%	0.6%	0.54
Sweet melons	2,300	797	4%	0.5%	1.16
Potatoes	1,797	617	3%	0.4%	1.04
Hot peppers	1,134	422	2%	0.2%	1.33
Sweet peppers	694	338	2%	0.2%	0.83
Total	**43,507**	**18,246**	**94%**	**10%**	**0.72**

Summer Vegetables, Highland	Areas [Dunum]	Water Use ['000 m3]	Water Use ['% HL Sum Veg]	Water Use ['% Total HL]	GVA [JD/m3]
Tomatoes	58,129	40,995	41%	9.2%	0.34
Watermelons	27,828	13,204	13%	3.0%	0.46
Potatoes	22,535	13,188	13%	3.0%	0.59
Sweet melons	10,079	5,845	6%	1.3%	0.49
Eggplants	7,347	4,507	5%	1.0%	0.45
Cauliflower	8,837	3,784	4%	0.9%	0.86
Squash	9,140	3,783	4%	0.9%	0.64
Sweet peppers	4,164	2,538	3%	0.6%	0.56
Cucumbers	5,565	2,494	2%	0.6%	1.69
Hot peppers	4,004	2,368	2%	0.5%	0.45
Total	**157,628**	**92,706**	**93%**	**21%**	**0.51**

TREE CROPS

The top ten tree crops in the JV and the highlands, in terms of water use, are shown in Table 14.Although bananas are the largest single water user among tree crops in the JV, citrus as a group, are far more important. In terms of water value, however, bananas outperform all of the citrus crops except infrequently planted valencia oranges, grapes and red oranges.

In the highlands, olives dominate all other crops, in terms of water use, consuming nearly one-third of all highland agricultural water. Their water value, however, is a low JD 0.21/m^3. Where olives are rainfed, or primarily rainfed, with small amounts of supplemental irrigation water added at critical points in the growth cycle, they may use water efficiently. As a fully-irrigated crop, however, they are a very low value water user. Of the highland fruit grown, apples have the highest water value, at just under JD 0.46/m^3.

Dates are moderately important crops, in terms of water use, in both regions. However, on average, their water value is low. Nevertheless, certain date varieties, Medjool jumbo dates for example, can command very attractive market prices in both local and international markets. In this case they can produce much higher water value than this average. This is an important lesson, and opportunities for expansion may exist in particular sub-segments of other crop economies having low average water values, but where strong demand exists for particular varieties of high quality product.

Table 14. Water value of tree crops in the Jordan Valley and the highlands

Tree Crop, JV

Crop	Areas [Dunum]	Water Use ['000 m^3]	Water Use ['% JV Tree Crop]	Water Use ['% Total JV]	GVA [JD/m^3]
Banana	18,434	25,005	28%	14.3%	0.67
Dates	10,101	15,054	17%	8.6%	0.23
Lemons	15,395	9,589	11%	5.5%	0.62
Clementines	12,984	8,088	9%	4.6%	0.55
Oranges, navel	11,782	7,346	8%	4.2%	0.54
Mandarins	6,266	3,903	4%	2.2%	0.57
Oranges, shamouti	4,227	2,635	3%	1.5%	0.64
Pummelors	3,492	2,177	2%	1.2%	0.37
Oranges, red	3,189	1,988	2%	1.1%	0.84
Grapes	2,188	1,831	2%	1.1%	0.84
Oranges, valencia	2,820	1,758	2%	1.0%	1.10
Total	**90,877**	**79,374**	**89%**	**46%**	**0.58**

Tree Crop, Highland

Crop	Areas [Dunum]	Water Use ['000 m3]	Water Use ['% HL Tree Crop]	Water Use ['% Total HL]	GVA [JD/m3]
Olives	247,959	138,212	63%	31.1%	0.20
Apples	17,826	15,601	7%	3.5%	0.46
Peaches	15,945	13,964	6%	3.1%	0.39
Grapes	19,198	12,839	6%	2.9%	0.28
Other Fruits	11,086	9,057	4%	2.0%	0.30
Dates	6,979	8,023	4%	1.8%	0.22
Apricots	8,328	7,172	3%	1.6%	0.25
Pears	3,028	2,604	1%	0.6%	0.32
Plums, Pruns	2,858	2,455	1%	0.6%	0.25
Lemons	1,539	1,595	1%	0.4%	0.17
Pomegranates	1,270	1,093	0%	0.2%	0.06
Total	**336,016**	**212,616**	**97%**	**48%**	**0.26**

LIVESTOCK

Water for livestock production is generally a high value use (Table 15). Activities which stand out, in terms of water value, are sheep and goat raising and hatchery production of chicks.

Table 15. Water value of livestock production

Type	Water Used [M m^3]	Value Added [M JD]	Gross Output [JD/m^3]	GVA [JD/m^3]	Water Share of Inputs [%]
Sheep & Goat	5.2	112.3	52.0	21.6	2.5
Cattle	1.5	15.0	71.4	10.3	1.2
Broilers	1.4	20.7	170.0	14.6	0.5
Layers	0.7	5.9	101.3	9.0	0.8
Parent Stock	0.7	9.4	63.9	13.2	1.5
Hatchery	0.2	10.9	221.9	56.0	0.5
Livestock	**9.7**	**174.2**	**79.9**	**18.1**	**1.2**

SUMMARY

Average water values are consolidated by crop type, season, and location in Table 16. As a group, winter vegetables stand out as the highest value use of irrigation water, with the Jordan Valley being the most important location for winter vegetable production. On the other hand, olive trees and field crops are at the low end of the water value spectrum. Citrus in the JV uses large quantities of water, and while profitable on a per dunum basis, the value returned per unit water is rather limited.

Table 16. Average value of water for differentcrop types

	Field Crop	Winter Vegetables	Summer Vegetables	Citrus	Olives	Stone Fruits	Average
JV	0.31	1.55	0.72	0.73	0.35	0.49	0.85
Highland	0.26	0.91	0.51	0.18	0.21	0.34	0.36
Jordan	**0.27**	**1.29**	**0.54**	**0.70**	**0.21**	**0.40**	**0.49**

Table 17. Water value by source of supply

Crop	Surface (NJV/Safi)	Blended (MJVI/SJV)	Groundwater (HL/Disi)
Field Crop	0.37	0.29	0.26
Winter Vegetables	1.39	1.68	0.88
Summer Vegetables	0.75	0.69	0.49
Citrus	0.78	0.46	0.21
Olive	0.39	0.28	0.31
Stone Fruits	0.54	0.48	0.37
Dates	0.20	0.23	0.19
Banana	0.62	0.64	
Weighted Average	**0.86**	**0.84**	**0.40**

Water value can also be examined in terms of the type of water used for irrigation (Table 17). Three types can be identified. Surface water comprises fresh water,

principally from the Yarmouk and Jordan Rivers used in the upper part of the Jordan Valley. Blended water, used in the middle and southern part of the Jordan Valley, is a mixture of surface water and treated wastewater, coming principally from Amman. It is characterized by higher salinity levels due to the wastewater component and may pose phytosanitary problems for some crops in some markets. Groundwater is water withdrawn from potentially renewable highland aquifers and from unrenewable fossil aquifers in the Disi region.
As seen, surface and blended water generally produce more value per cubic meter than groundwater, with type of water being relatively neutral for some crops such as stone fruits, dates, and bananas. Other crops, such as citrus, appear to do better when irrigated with fresh water, probably because of its lower salinity.

Groundwater, somewhat surprisingly, produces lower value of output than either of the other two types of water. This may be because of locational factors rather than attributes of the water itself, but the reasons for this difference could use further investigation.

In summary, the value of water varies widely across crops, regions, and seasons. At present a relatively small fraction of the water used for irrigation (20%) generates much of the value of irrigated agricultural output (70%). In general, the value of water used on vegetables is much higher than that of water used on field crops and fruit trees. Moreover, the value of water used on winter vegetables is more than double that for summer vegetables. The Jordan Valley has a unique comparative advantage in growing winter vegetables early in the season and needs to exploit that advantage in carving out additional market share in European markets.

Water used to support livestock production also has high value and should not become constrained. Blended water use in the Jordan Valley is highly productive on some crops but appears to produce lower values on others, such as citrus. It should be noted, however, that citrus irrigation itself has a low water value and is not a preferred use of scarce irrigation water.

Figure 4. Private desalination plant, Jordan

The cost of water to mining and manufacturing enterprises which have their own wells is around JD 0.5/m^3, compared with an average value of water in mining and manufacturing of more than JD

70/m^3. Their capacity to pay for water thus substantially exceeds its current cost.

The price of irrigation water sold to farmers in the Jordan Valley is just JD 0.012/m^3, while the average value of water used in the Jordan Valley to produce crops is more than 50 times that value (JD 0.64/m^3). The average value of water used to produce winter vegetables in the Jordan Valley is more than 100 times the water price to farmers. Clearly there is wide scope for increasing the price charged, which would have a number of positive results, as discussed later. The value of water used in producing many Jordan Valley crops, including bananas, exceeds the cost of brackish water desalination (JD 0.25 to JD 0.35/m^3), making private investment in water supply for such crops feasible (Figure 4).

In the highlands, the cost of irrigation water to farmers is limited to the cost of pumping[8] (with subsidized electricity), and runs around JD 0.2 to JD 0.3/m^3. Some highland crops actually have water values below this abstraction cost in some years.

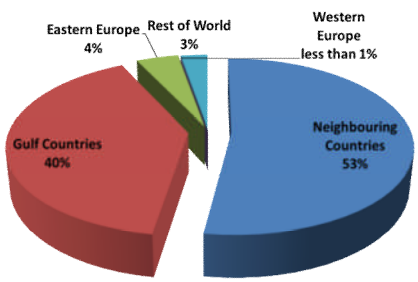
[8] The first 150,000 m^3 of water pumped each year is exempt from the water resource fee charged by MWI on water extracted above that level. The exemption is enough for around 300 dunum of farmland for each farmer – sufficient to fully irrigate most highland farms, and hence no payment is required from most farmers for the use of the water resource.

5. AGRICULTURAL VALUE CHAIN

AGRICULTURAL EXPORTS

About 38% of Jordan's annual vegetable production is exported, along with 15% of its fruit output. About 43% of the horticultural crops grown in the Jordan Valley are exported, as is 23% of highland output. The value of fruit and vegetable exports is about $450 M annually. Destinations are shown in Figure 5. There is, however, great potential for increasing exports of vegetables and fruits, with associated increase in local value added and export earnings.

Figure 5. Horticulture export destinations



Jordanian agricultural production, including that destined for export, receives incentives in the form of near-zero prices for irrigation water, subsidized electricity for pumping, and the willingness to ban exports temporarily in the face of perceived scarcities in the domestic market. Extra costs are imposed on the production and marketing chain in the form of requirements to use municipal markets, even in the case of exports or when direct sales to retailers could be made by farmers or farmer organizations. Required use of municipal markets involves paying a 6 JD/ton municipal sales tax (roughly 1.5% to 4% of value), a 6% commission agent fee, and a sales tax on the commission agent fee of 16%.

Current import tariff policy encourages water allocation to crops that represent inefficient uses of water such as bananas, apples, and oranges. In addition, in the case of apples and oranges at least, it is clear that Jordan does not have a comparative advantage in production. Syria produces oranges and apples of equal or higher quality at a much lower price.

Government policies have long considered marketing only as a supplementary service for production, despite the fact that marketing starts before production, creates greater economic benefits, and is critical in determining economic returns. Most policies have focused on developing production, which has resulted in over-supply of some products and wastage of large quantities of horticultural produce because of imbalances between supply and demand. The lack of organized production plans and weak farmer organizations adds to the problem of poor marketing.

The marketing infrastructure suffers from clear weaknesses, especially in the fruit and vegetable sectors. Fruit and vegetable wholesale markets do not represent real markets, with the exception of the one in Amman, lacking the essentials of supply and demand data for price formation. Infrastructure for post-harvest operations also suffers from shortages in the areas of pre-cooling, grading, packaging, refrigerated transport and storage, and processing of products. There is a virtual absence of support to farmers' organizations, which would allow them to acquire the cold chains and packaging facilities needed for vertical integration along the food supply chain.

Significant weaknesses also exist in the provision of marketing support services, including market research, agricultural extension services, market information, and to a lesser extent, financing. A comprehensive marketing policy is needed to address these gaps. A recent European Commission study of the agricultural sector recommended the establishment of private extension services operating on a commercial basis. Given the chronic and continuing weakness of the public extension service, this idea is worth exploring.

VALUE OF WATER IN THE VALUE CHAIN

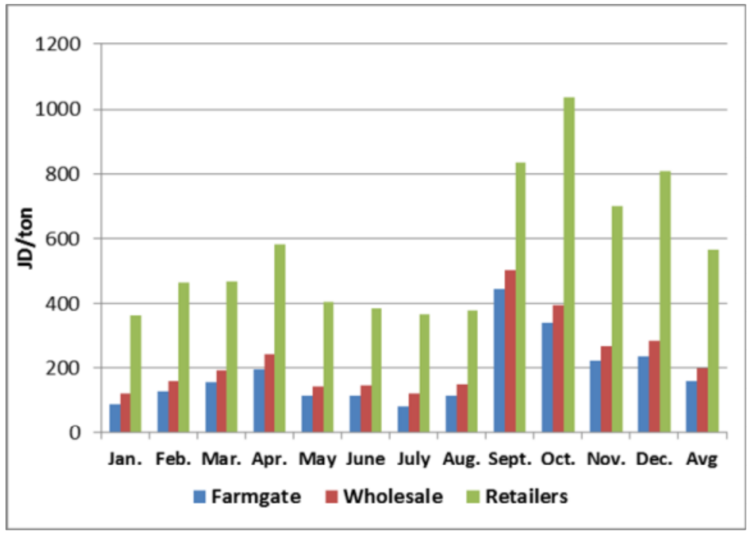
The value chain analysis examines horticultural crop exports to determine the value added, in Jordan, for different combinations of crop and destination. Examples are given below for tomatoes, dates, and strawberries.

TOMATOES

Tomatoes are the most important vegetable crop in Jordan, occupying some 30% of the total area devoted to vegetables. Because of its varied topography, Jordan has the advantage of being able to produce many vegetables across a variety of time periods. Tomatoes, for example, are harvested virtually year around, beginning in November and December south of the Dead Sea, with the harvest moving northward into the South Jordan Valley in January and progressing to the North Jordan Valley by March. Production in the highlands extends from May through October.

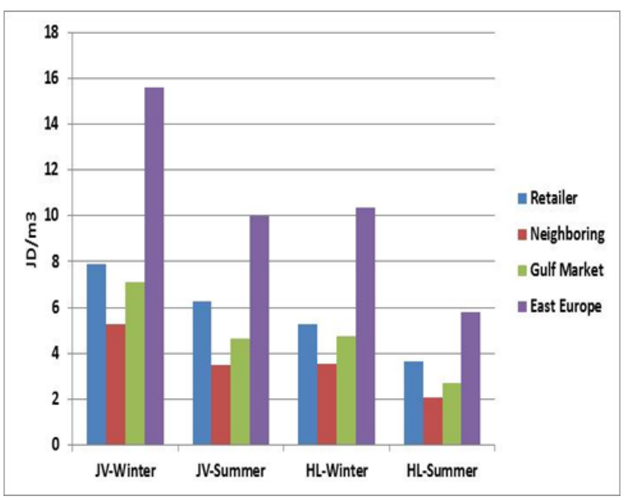
Prices vary considerably throughout the year based on the volume of tomatoes reaching the market and the demand from both local and export markets. Local monthly prices are shown in Figure 6. It can be seen that prices peak in the last quarter of the year, and again in March and April.

Figure 6. Local tomato prices, 2010



It can also be seen that, while wholesale prices are relatively close to farmgate prices, retail prices throughout the year include very large marketing margins, suggesting high profits reaped by the retailers at the expense of farmers and consumers. It also suggests high post-harvest losses in an inefficient local marketing set-up.

Figure 7. Total value of water for tomatoes, by



When marketed internationally, tomatoes produce somewhat different water values than when sold in local retail markets. As seen in Figure 7, while the water value of tomatoes exported to Eastern Europe is nearly double that of those sold locally in some seasons, the water value of tomatoes exported to neighboring and Gulf countries is actually below local market values.

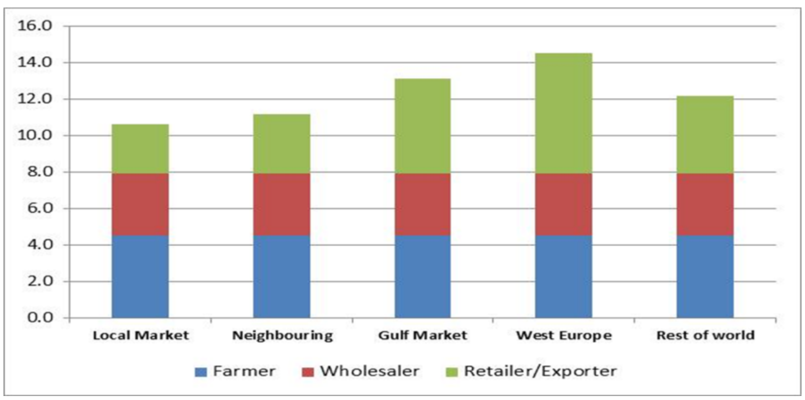
To some extent, this is a function of the inefficiency of local markets. It also reflects the fact that exports to neighboring and Gulf countries often take place when local markets are saturated and wholesalers move the excess into nearby countries. Clearly the Eastern European markets are the most important ones to target, however, from a water value standpoint.

DATES

Commercial cultivation of dates is a small but growing sector. Cultivated area has grown from 2.1 thousand dunum in 1995 to 17.0 thousand dunum in 2010. Most dates (85%) are produced in the Jordan Valley and Aquaba areas. The local market absorbs 73% of the date output, with the remainder exported, either from the farm directly (73%) or through exporters (27%). Medjool and Barhi are the most important and valuable varieties, with Jumbo Medjool dates commanding a premium price in the European market.

Figure 8 shows the total water value for Jumbo Medjool dates by market destination. As seen, the water value is high across the board, with Western European markets providing the highest value per cubic meter of water used. As with tomatoes, exports to Arab markets generally rely on the excess of the local market.

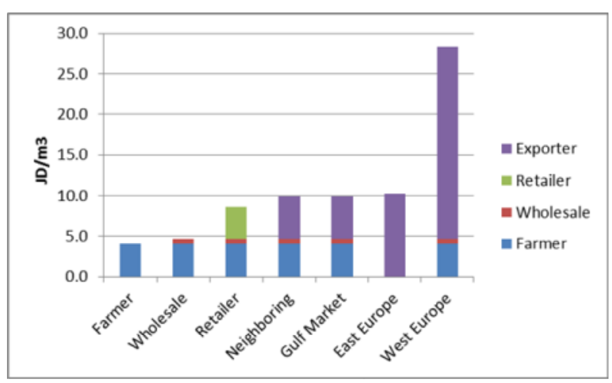
Figure 8. Total water value of Jumbo Medjool dates by market



STRAWBERRIES

Jordan University introduced strawberries to the country as a cash crop in 1986. Production has expanded slowly over the ensuing 25 year, and now 25 to 30 growers produce the fruit on 250 to 300 dunums in the Jordan Valley and 300 dunums in the highlands. Twenty to 25% of production is exported, mostly to the Gulf States during summer, with a small portion going to Western Europe in the winter.

Figure 9. Water value added for strawberries, by final destination



Highland-grown strawberries generally have slightly higher water value for all markets except Western Europe, where winter strawberries from the North JV command a premium price. Farmers claim a high share in the value chain, and export to Western Europe adds extraordinary value to the Jordanian economy per unit water used (Figure 9).

6. POLICY CONSIDERATIONS

1. Industrial and service sectors currently use less than 10% of Jordan's annual water withdrawals, and while the computed gross value added of that water use is large, there is little evidence that a lack of water is currently constraining these sectors. Consequently allocating additional water to them is unlikely to add significantly to their output. At the same time, the price industries pay for that water is very low relative to the value added, which may lead to future demands from these sectors for additional water, without encouraging the improvements in water use efficiency and recycling which should precede any additional water allocations. Water pricing policy for these sectors should be revised to provide incentives which favor increased recycling and improved efficiency over supply expansion.

2. Irrigated agriculture generates 90% of all agricultural value in Jordan from the 40% of national cropland which is irrigated. In addition, it provides significant rural employment, improves nutrition, generates substantial export earnings, and serves as the backbone of the Jordan Valley economy. At the same time, it uses more than half of the Kingdom's annual water withdrawals. Irrigated area has expanded more than 50% over the past 16 years, driven by growth in groundwater irrigation in the highlands, where it plays a major role in depleting the high-value water resource stored in highland aquifers.

3. Value added to the Jordan economy from water use varies considerably among crops, and, particularly, among destination markets. For many vegetables, markets in Eastern Europe provide the highest value to Jordan per cubic meter of water used in producing them. Neighboring country and Gulf State markets serve as "relief valves" for production that local markets can't absorb, as with tomatoes for example, and so often provide lower value added.

4. Local marketing margins for most crops are very high, and deliver large profits to retailers at the expense of both farmers and consumers. The inefficient local marketing system creates dissatisfaction on the part of farmers, who see huge gaps between farmgate prices, on the one hand, and retail prices in consumer markets on the other. Local market reforms which would increase farmers' share of the value of agricultural products sold in local consumer markets could go a long way towards offsetting the water price increases which are an important part of any agricultural reform package.

5. Jordan Valley irrigated agriculture has much higher water value than does irrigated agriculture in the highlands. Winter vegetable production in the Jordan Valley stands out as generating the largest value per cubic meter of water used. Perishable vegetables such as celery, peas, asparagus, beans, fennel, leaks, and lettuce have high value in local and export markets during the off season. Their production has been expanding and presents continuing opportunity for growth. Olives, field crops, and citrus, on the other hand, in both the Jordan Valley and the highlands, produce relatively low water values and their production with scarce irrigation water should generally be discouraged. Cultivation of vegetables requires between 2 and 5 times the labor days per dunum that cultivation of cereal crops does, and can generate additional off-farm jobs as well.

6. Export of vegetables, particularly winter vegetables to Europe, has considerable upside potential. However to realize this potential actions are needed to raise the quality of produce destined for export, introduce new high-demand crops into the pattern, and improve packaging, storage and transportation facilities. Government should not act alone in attempting this, since it lacks a comparative advantage in performing a number of these activities. Its role should be focused on setting quality and sanitary standards, providing analytic services, supporting agricultural research, providing farmers with new information, regulating the quality of treated wastewater returned to the Valley, providing the necessary transportation and communications infrastructure, and similar activities. Government must partner with private sector enterprises to deliver new irrigation and agricultural technology to farmers, and to provide the information, storage, transportation, grading, and international marketing services required to expand export volume to high value markets.

7. Much of the export of horticultural crops is undertaken directly by large growers. This should be encouraged; however it is equally important to facilitate the entry of smaller farmers into export-oriented production. Promoting and disseminating appropriate knowledge and technologies, providing access to processing and packaging facilities, and promoting farmer-based cooperative organizations to facilitate joint action are steps that could lead in this direction. Water User Associations, which have recently been established across the Jordan Valley, may be able, in some cases, to take on such additional, production-related functions more effectively than atrophied agricultural cooperatives.

8. Water provided by the JVA in the Jordan Valley is vastly under-priced. Current prices charged for water are substantially below both the average value of water for producing crops and JVA's cost of service provision. Higher water prices could (a) encourage more efficient water use by farmers,

(b) encourage shifts to higher value crops, (c) encourage private development of desalinated brackish water sources and(d) provide funds for better irrigation system maintenance and more effective operation. Note, however, that more efficient water use in response to higher prices would only occur if water is billed by volume rather than by area. Returning to a system of volumetric billing in the JVA service area would require retrofitting all connections with reliable meters and reestablishing a meter-reading and billing system, a process which should be closely integrated with the newly-established WUAs.

9. Highland agriculture continues to expand rapidly, despite an ostensible ban on new wells in place since 1992. This has led to serious over-exploitation of highland groundwater and to a growing risk of saline aquifer contamination, as water levels fall toward the bottom of the aquifer. At the same time, highland irrigated agriculture is far less productive, per cubic meter of water used, than is Jordan Valley agriculture, creating a lose-lose scenario from the nation's point of view. The failure to charge most farmers a water resource fee, the below-cost electricity they receive for pumping, and ineffectual regulation of drilling and extraction has created a set of highly perverse incentives that encourage this inefficient and damaging situation to continue and expand. Tariff and subsidy policies are in urgent need of reassessment and revision, and regulatory enforcement must be stiffened significantly.

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