USAID MONITORING, EVALUATION, AND LEARNING ACTIVITY

FINAL REPORT: WATER CONSUMPTION PATTERNS IN AGRICULTURE - MARKET SYSTEMS DEVELOPMENT ASSESSMENT

May 31, 2021

ABSTRACT

This assessment aims to shed light on water use in agriculture in Jordan. It also examines water use in key service industries and provides lessons from a market systems development program aiming to improve adoption of water-saving technologies. The assessment uses quantitative and qualitative data collected from primary and secondary sources. The paper identifies 13 key crops together using an estimated 75 percent of Jordan's agricultural water. Olives lead the way with 35 percent of all agricultural water use in Jordan. Farmers are aware of technologies that might save them water but are unable or unwilling to pay for them. Part of the issue is the lack of knowledge on actual water-savings of different technologies. Were Jordan able to adopt Israel levels of crop water consumption, it could save as much as a third of its agricultural water. In non-agricultural services water use, there is a general lack of awareness of water conservation technologies and practices. The Water Innovation Technologies (WIT) Project part of the assessment found that WIT's need to meet overly ambitious short-term water-saving targets negatively influenced the market systems design of several of WIT's activities. It also found that the business case for water-saving is emerging but must be strengthened and integrated into the project strategy*.* WIT's investment fund may have unintendedly limited more innovative applicants who had less experience working with donors. Market actors are interested in engaging with the project but progress with the government has been slower. The need to meet high short-term water-saving targets influenced several of WIT's activities.

EXECUTIVE SUMMARY

PURPOSE AND BACKGROUND

This assessment aims to inform the United States Agency for International Development's (USAID) future work in water and agriculture in Jordan. Jordan is one of the most arid countries on earth, and agriculture uses over half of its scarce freshwater resources while contributing just three to four percent to the country's gross domestic product. Water scarcity is expected to worsen in the coming years.

The assessment includes analysis of the USAID-funded Water Innovation Technologies Activity (WIT) to find lessons to learn from that project. WIT aims to increase farm and household use of water-savings technologies through a market systems development approach. The assessment also includes analysis of the water use of three key non-agricultural service industries.

ASSESSMENT QUESTIONS

The assessment responds to 18 questions under three broad topics. The first topic is agriculture, which constitutes the majority of this assessment with 12 assessment questions. Within agriculture, there are three subtopics: production, markets and water use. The production questions focus on the production area, volume, trends over time and number of farmers for key crops. The market questions focus on identifying the markets and market outlooks for key crops, and the water "balance of trade". The water use questions focus on estimating the quantity of water used for key crops, the types of water used, the water-savings practices used, constraints to adoption of water savings technologies and potential water savings.

The non-agriculture services water use topic has three questions on identifying the main water using services and the challenges and opportunities for them to reduce their water use. The WIT topic has three questions which cover challenges, successes and lessons learned.

METHODOLOGY

The assessment uses quantitative and qualitative data from primary and secondary sources. Primary qualitative data is from 173 semi structured interviews conducted in early 2021 with a range of respondents, most notably farmers. Quantitative data is from secondary sources including Jordan's 2017 agricultural census, a previous water use study conducted by USAID in 2012 and United Nations trade data. Water use estimates, a key finding of the report, are estimated using the coefficients for water use by crop from this 2012 assessment and the irrigated area for crops from the 2017 agricultural census. The assessment also makes use of a range of related reports and articles.

LIMITATIONS

Key limitations of this assessment are the age of the data and the inherent imprecision of estimating crop water use. Our assessment relies on data from the 2017 census and from a study completed in 2012. Furthermore, the estimate we produce differs from the government recorded agricultural water use estimate which itself differs from a study conducted using remote sensing and other methods. The incongruence among different estimates of agricultural water use has been found in other countries in the region.

KEY FINDINGS AND CONCLUSIONS

Agriculture

Three quarters of Jordan's estimated 499 million cubic meters of agricultural water use is concentrated in 13 crops. The assessment identified key crops based on their water use. In order of water use, these crops are olives, tomatoes, dates, clover, peaches, potatoes, grapes, oranges, apricots, lemons, bananas, sweet melons and maize. Within these selected crops, there is concentration at the top with olives and tomatoes accounting for 35 percent of all agricultural water use. By focusing on these highest water use crops, this assessment aims to identify findings and conclusions that can lead to high impact recommendations for USAID.

Jordan's agriculture receives low export and sometimes domestic prices. Among key crops, tomatoes, peaches and sweet melons are the major exports. Jordan's fruit and vegetable exports predominantly go to the Middle East where prices are relatively low. In some cases, prices received for exports to European markets can be twice as high. Domestic market prices are prone to drops due to gluts influenced by the volatility of Jordan's neighbors' markets and trade routes.

Irrigated agriculture is constrained by water shortages, contamination and high electricity prices. Farmers respond to water shortages by irrigating less, cultivating less land or purchasing water, which negatively affects yields, revenue and profitability. Salinity largely from over abstracted wells is common and poses similar problems by reducing the per unit effectiveness of applied water if not treated. Turbidity damages irrigation equipment if not filtered. Both problems can be managed but add to farmers costs of production, reducing profitability. Similarly, electricity costs associated with agriculture, including pumping irrigation water, add significantly to the costs of production.

Adoption of water conservation technologies constrained by capital and knowhow more than awareness. Most farmers interviewed knew about some water conserving technologies they were not using. They did not use them however, mostly because of their cost but also because they did not know how to use them. Extension services are not widespread and few farmers interviewed said that their input suppliers offered technical services.

Knowledge of the potential water-savings of different water conservation technologies is limited. Experts in government and input providers alike have limited knowledge of the potential water savings from different technologies for agriculture. This limited knowledge on the actual water savings potential of technologies constrains the government, the private sector and NGOs from making rational water conservation technology and practice recommendations. And it limits farmers' ability to make sound technology adoption decisions for their farms. Furthermore, it may reduce confidence in promotion of water conserving technologies if results from expensive technology adoption are not consistent with expectations.

There is the potential for Jordan to save significant water in agriculture. A recent study estimated that if Jordan could replicate Israel's water use efficiency it could reduce its water use by 33 percent. The estimated water-savings would be greatest for clover, olives and tomatoes.

Non-agricultural services water use

Among hotels, hospitals and restaurants interviewed, there was a limited awareness of water saving technologies and practices. Businesses may not monitor and optimize their water use, water savings technology sellers often do not market products based on water savings and water savings promotional campaigns target households rather than businesses use.

Government coordination related to commercial water use could be improved. Respondents report a lack of an overall vision for water use conservation across different sectors as well as a siloed approach to policy and program implementation. For example, there is not a common set of targets for water conservation across different sectors in Jordan.

WIT

WIT transitioned to the Market System Development (MSD) approach after implementation started. Although some actions were taken to support during this strategic shift, more could have been done to set the project up for success. For example, the results framework was not adapted for the MSD approach and the existing team was not supported with the breadth of skills that an MSD Activity requires.

The need to meet overly ambitious short-term water-saving targets negatively influenced the MSD design some of WIT's activities. This, at times, undermined the sustainability of WIT's interventions. For example, WIT subsidized the cost of water-saving technologies to achieve sales targets, without targeting the high cost of the technologies themselves, or mapping out the return on investment for consumers.

The business case for water-saving is emerging but must be strengthened and integrated into the project strategy*.* WIT has shown that the adoption of water saving technologies can bring some returns to farmers (both in terms of yield and quality) and consumers. These lessons should be a starting point for future work in this space so that the incentives of all consumers (households, farmers, services) are quantified and leveraged more effectively.

Core to WIT's MSD approach was the rollout of a co-creative investment fund that disbursed grants through an open solicitation process. WIT did not significantly engage in co-creation activities with companies until after they had applied for funding via the Investment Fund. While this does maximize companies' ownership of a new initiative, it can have shortcomings including excluding more disruptive organizations that have less experience working with donors.

There is appetite from market actors to engage with the market systems approach. After some initial hesitancy and resistance to this change, some market actors engaged constructively with WIT, and spoke positively of the co-creation process. On the other hand, WIT struggled to gain traction with public sector actors who are more used to receiving direct funding support from development programs.

The adoption of financial services to support water-saving technologies brought mixed results. One of the success stories of WIT was the successful rollout of the revolving loan program for households in partnership with local community organizations. WIT's financial services activities, however, were rarely integrated into WIT's agriculture and household components. Engagement with banks and more traditional financial services providers did not therefore yield significant results. Banks saw a lack of demand from consumers for water-saving technologies, and a lack of integration of loans into the sale process as a key barrier.

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LIST OF ACRONYMS

AQ	Assessment Question
CBOs	Community-Based Organizations
DOS	Department of Statistics, Jordan
GDP	Gross Domestic Product
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GR	Green Revolution
ISSP	Institutional Support and Strengthening
JV	Jordan Valley
JVA	Jordan Valley Authority
KG	Kilogram
MCM	Million Cubic Meters
MT	Metric Ton
MSA	MarketShare Associates
MSD	Market Systems Development
MWI	Ministry of Water and Irrigation
TTW	Treated Wastewater
UAE	United Arab Emirates
USAID	United States Agency for International Development
USD	United States Dollar
UNDP	United Nations Development Program
WIT	Water Innovations Technologies
WRE	Water Resources and Environment

1. ANALYSIS PURPOSE AND ASSESSMENT QUESTIONS

1.1 ANALYSIS PURPOSE

This study has been commissioned by the United States Agency for International Development (USAID). For over sixty years, USAID has worked to improve Jordan's water security through improved infrastructure and expertise. Agriculture is one of USAID's Water, Resources and Environment (WRE) Office focus areas in Jordan. Whereas in the past, USAID had focused on economic growth in agriculture, in the past 10 years USAID's focus has shifted exclusively to water conservation in agriculture. USAID's current five-year Water Innovation Technologies (WIT) Activity, implemented by Mercy Corps, utilizes a market system approach to expand access to and use of water conservation technologies in agriculture.

The primary purpose of this assessment is to inform the design of USAID's work in water crop agriculture in Jordan. This assessment is implemented by MarketShares Associates through USAID's Monitoring, Evaluation and Learning Activity, Specifically, the study objectives are to:

- Identify the business opportunities and challenges to promote water conservation for the agricultural sector,
- Identify the quantities and types of water (surface, ground, blended, treated wastewater) used by agriculture in different agricultural production zones (highlands, Jordan Valley, Madaba, etc.) in Jordan.
- Identify opportunities and quantities for water conservation at the non-agricultural services level[1], and
- Capture the lessons learned for the Water Innovation Technologies Activity WIT Activity from a market systems perspective.

1.2 ASSESSMENT QUESTIONS

This assessment answers questions under five question areas: 1) agricultural production, 2) agricultural markets, 3) agricultural water usage, 4) non-agricultural services water usage and 5) Learning from the USAID Water Innovation Technologies Activity (WIT) market system development work. The first three agricultural assessment questions (AQs) are closely related, and this report treats them accordingly as a single section. Questions 4 and 5 are distinct from each other and from questions 1 through 3 and considered separately.

Table 1: Assessment Questions

Topic	Question area	Questions[2]
	1. Production	• What key crops are produced per agricultural production zone? • What is the area and volume of production of key crops per zone? • How many farmers are involved in cultivating these key crops? • What are the trends over time with regard to production of key crops (e.g. substitution of crops)?

[1] Through discussions with USAID, it was determined that the municipal water use objective and questions should be aimed at assessing water use of select non-agricultural services.

[2] Modified from the original illustrative study questions

Agriculture	2. Markets	● What are the primary markets for the products grown (e.g. consumption, local, domestic, regional export, export)? ● What is the market outlook for these key crops? ● What is the agricultural water "balance of trade"?
	3. Water use	● What is the quantity of water used by key crops per agricultural production zone? ● What types (e.g. surface, ground, blended, treated wastewater) are used for irrigating key crops? What irrigation systems and practices are used by these farmers? ● Besides irrigation, which water saving technologies and practices are being used by farmers and why? How effective are these technologies and practices seen to be by producers and others? ● What are the constraints to greater adoption of improved water conservation practices and technologies? ● What are the potential water-savings in agriculture by key crop and zone?
4. Non-agricultural services water use		● What are the key (3 to 5) service business types in terms of their volume of water use? ● What are the opportunities to reduce water use? ● What are the challenges to reducing their water use?
5. Water Innovation Technologies Activity market system development		● What have been the biggest challenges faced by the Water Innovation Technologies Activity in following a Market Systems Development (MSD) approach? ● What have been the key successes by the Water Innovation Technologies Activity team in applying the MSD methodology towards conserving water? ● What lessons can be learned on applying MSD in a Jordanian context?

2. BACKGROUND

Water in Jordan

Jordan is one of the most arid countries in the world. In 2014, there were 76 cubic meters of renewable freshwater per person in Jordan, down from 675 cubic meters in 1962.[3] By comparison, in the countries classified by the World Bank as the Arab world, the average availability of renewable freshwater was 292 cubic meters per person in 2014. For the world as a whole, the availability of renewable freshwater per person was 5,931 cubic meters.[4] According to the Ministry of Water and Irrigation (MWI), water availability per person is currently 88% below the international water poverty line of 1,000 cubic meters annually.[5]

[3] World Bank. 2017. "Renewable Internal Freshwater Resources Per Capita (cubic meters) – Jordan, World, Arab Bank". Retrieved from: https://data.worldbank.org/indicator/ER.H2O.INTR.PC?locations=JO-1W-1A

[4] Ibid

[5] Nahhas, Roufan. March 19, 2017. "Jordan's Water Shortage Made Worse by the Refugee Crisis". *The Arab Weekly*. Available at: https://thearabweekly.com/jordans-water-shortage-made-worse-refugee-crisis

The declining availability of freshwater per capita can largely be attributed to population growth. The population of Jordan has increased from one million in 1962 to 10 million in 2019.[6] In recent years, the Syrian refugee crises accelerated population growth – as of 2020, there were 1.36 million Syrian refugees in Jordan.[7] Furthermore, according to a United Nations model, climate change could increase temperatures in Jordan by 1.6 degrees and decrease rainfall by nearly 14 percent by 2035. As a result, freshwater availability per capita could further decrease by nearly 30 percent in 2040.[8]

Municipal water use accounts for 45 percent of water use in Jordan. This is shown in Table 2 below. Municipal water use comprises domestic water use at the household level and water for services, such as commerce, health, education, workshop, governmental offices, and communal green spaces. About 72 percent of the municipal water used is groundwater. The sector receives water through the public water network which is managed by the Water Authority of Jordan and Jordan's three public water utilities.

Table 2: National water use by type in 2017 (million cubic meters)[9]

	Livestock	Irrigation	Industrial	Municipal	Total
Surface water	5	149.4	2.4	131.3	288.1
Ground water	2.1	251.1	27.2	338.4	618.8
Treated wastewater	0	144.2	2.5	0	146.7
Total	7.1	544.7	32.1	469.7	1,053.6

Agriculture contributes 3 to 4 percent to Jordan's gross domestic product, but uses 52 percent of Jordan's freshwater resources. The largest share of irrigation water in 2018 was groundwater at 219 Million Cubic Meters (MCM). Groundwater is primarily used in the highlands. Surface water accounts for 184 MCM of irrigation water. Finally, Treated Waste Water (TWW) accounted for 157 MCM of recorded agricultural water use in 2018.[10]

Agriculture in Jordan

Jordan is a food deficit country. Only 5 to 6 percent of its land is arable and the country imports about 90 percent of its cereal and animal feed requirements.[11] Vegetable production predominates with over 1.7 million Metric Tons (MTs) of vegetables produced in 2017, compared to half a million MTs of fruit and two-hundred thousand MTs of field crops.[12] Expansion of fruits and vegetable production has occurred over the past 40 years, aimed primarily at export markets. Cereal production has shrunk and been replaced with imports.[13] Jordan's agricultural exports are mostly destined for regional markets in the Middle East and North Africa with a relatively small share going to Europe's higher-value markets.[14]

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[6] World Bank. 2019. "Population, total – Jordan". Retrieved from: https://data.worldbank.org/indicator/SP.POP.TOTL?locations=JO

[7] Hashemite Kingdom of Jordan. 2020. "Jordan Response Plan for the Syria Crisis 2020-2022". Available at: http://www.jrp.gov.jo/Files/JRP%202020-2022%20web.pdf

[8] GIZ. 2020. Rapid Assessment of the Consequences of Declining Resources Availability and Exploitability for the Existing Water Supply Infrastructure.

[9] Department of Statistics, Jordan. 2018. "Jordan in Figures, 2018". Available at: http://dosweb.dos.gov.jo/DataBank/JordanInFigures/2018.pdf

[10] Department of Statistics, Jordan. 2019. "Jordan in Figures". Available at: http://dosweb.dos.gov.jo/DataBank/JordanInFigures/Jorinfo_2019.pdf

[11] Ibid.

[12] Department of Statistics, Jordan. 2017. "Area, Average Yield and Production of Vegetables/Field/Fruit by Area & Production, KIND, Crop, Level and Time". Retrieved from: http://jorinfo.dos.gov.jo/Databank/pxweb/en/DOS_Database/

[13] Fileccia, Turi, Vasyl Hovhera, Inna Punda, and Stefania Manzo. 2015. "Jordan: Water Along the Food Chain, An analytical brief of selected food chains from a water perspective". Available at: http://www.fao.org/3/a-i4608e.pdf

[14] World Integrated Trade Solutions. 2018. "Jordan Food Producers Exports by Country in US$ Thousand". Available at: https://wits.worldbank.org/CountryProfile/en/Country/JOR/Year/2018/TradeFlow/Export/Partner/by-country/Product/16-24_FoodProd

Jordan is commonly divided into two main agricultural zones. The Jordan Valley (JV) is the most fertile part of the country. It has warm winter weather compared with the rest of the Kingdom and enjoys the exclusive advantage of early agriculture production, especially for vegetables and fruits. This geographically small area accounts for half of Jordan's agricultural production. The main source of irrigation for the Jordan Valley is surface and TWW water from the King Abdullah Canal. The highlands depend primarily on groundwater for irrigation, which competes with drinking water. The Highlands account for the largest share of Jordan's irrigated land. The Eastern Badia desert makes up over 80 percent of Jordan's landmass and has limited commercial agriculture.

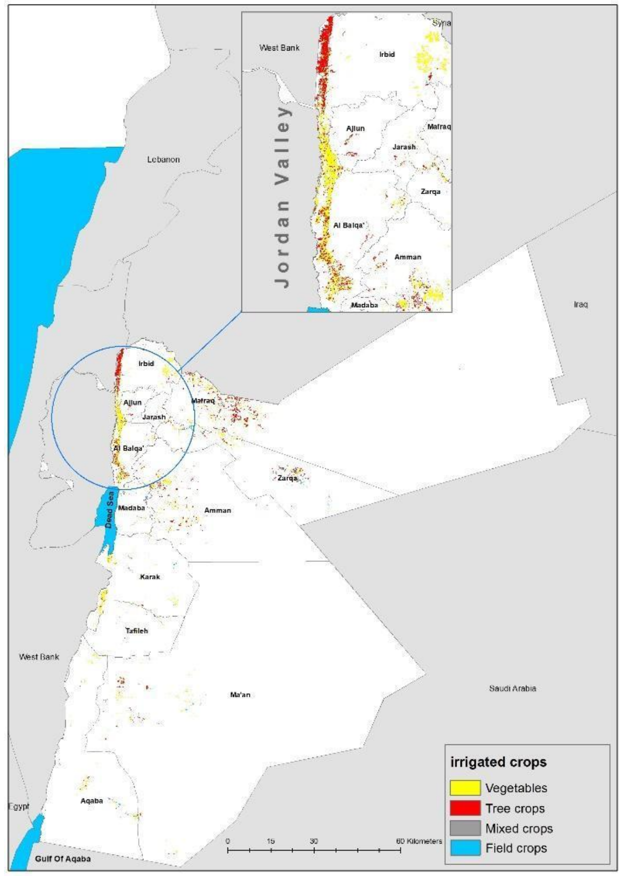

Figure 1: Irrigated crop production in Jordan[15]

USAID Jordan

USAID's focus in Jordan is on water conservation at the household and farm level. In 2017, USAID launched the Water Innovation Technologies (WIT) Project, a five-year initiative implemented by Mercy Corps, to utilize a market systems approach to increase water conservation by promoting water-saving technologies and techniques to households, communities, and farmers in the northern region where groundwater reserves are under extreme pressures. WIT has partnered with private-sector equipment suppliers and Community-Based Organizations (CBOs) to promote sustainable and scaled adoption of water saving technologies and practices at the household, community and farmer-level.[16] WIT also works at the municipal level to facilitate access to water-saving technologies and practices by households.

3. ASSESSMENT METHODS AND LIMITATIONS

This assessment uses quantitative and qualitative data collected from secondary and primary sources. Quantitative data is largely from government sources, especially the 2017 Agricultural Census, but also other sources described below. Qualitative data was collected through interviews with a wide range of actors from late January to early March, 2021. In total, 173 qualitative interviews were completed. In addition, this assessment utilizes secondary

[15] GIZ & MWI. 2021. "Assessment of Ground Water Abstraction in all Irrigated Areas in Jordan During Years 2017, 2018, and 2019". *Third National Water Master Plan (NWMP-3), Volume C, Annex C-1*

[16] WIT works in collaboration with the Government of Jordan (GOJ) through the Ministry of Water and Irrigation, the Jordan Valley Authority and the Water Authority of Jordan, the Ministry of Agriculture, the National Center for Agriculture Research and Extension, and the Ministry of Social Development along with other stakeholders, including the International Center for Biosaline Agriculture (ICBA), the International Water Management Institute (IWMI), the Jordan River Foundation (JRF) and the Royal Scientific Society (RSS).

qualitative data from reports and articles. Annex 3 provides a matrix showing which data source was used to answer each question.

Secondary data

This assessment utilizes several sources of secondary data, listed below.

- The 2017 Agricultural Census, conducted by the Department of Statistics (DOS) conducted every decade. This data was received in various spreadsheets, as well downloaded from the internet. Additionally, data from the census in 1997 and 2007 was used to track production area trends.
- The 2012 Water Valuation Study produced by the USAID Jordan-funded Institutional Support and Strengthening Project (ISSP) is used for crop water use coefficients
- The United Nations Comtrade database is used for trade data.
- Other data from the government of Jordan including water use by source from MWI.

Secondary data was compiled and analyzed using Excel and Stata. In addition to using quantitative data, this assessment references a number of studies and reports. A list of references and data sources can be found in Annex 4.

Primary data

Primary data were collected by four field researchers through semi-structured interviews. Question guides were used to guide conversations and ensure that key questions were asked to each of the same actor type. However, field researchers had flexibility to make interviews conversational, and to improvise questions to explore unanticipated and interesting topics. Interviews were conducted in Arabic and recorded or written down. Later, the field researchers translated their notes into English and uploaded them to Google Forms where they were automatically tracked and compiled by interview type.

Question guides were created for respondent type categories. In total, 11 different types of question guides were used. Table 1 below shows the breakdown of question guides and respondent types and completed interviews.

Interviews were concentrated in eight out of Jordan's 12 governorates. For logistical purposes and because they have limited agricultural production, only one remote interview with a local agricultural official was conducted in each of Ajloun, Jerash, Madaba and Tafila. The field researchers visited the other eight governorates and conducted interviews with a range of respondents that can be found in Table 3 below. Field researchers had target numbers of interviews to complete by type of respondent, as well as targets for which types of interviews should be completed in each of the eight governorates. Interviews with WIT affiliated respondents included input sellers and a financial service provider partnering with WIT, as well as farmers and household clients of these WIT partners. A breakdown of the number of interviews completed by the governorate can be found in Annex 3.

An initial list of potential interviewees was added throughout the fieldwork. The initial interviewees were identified by our Jordanian field teams based on their expertise and contacts, with inputs from the WIT T eam and USAID. Further interviews were identified through referral, with respondents suggesting other people relevant for our assessment.

Interview notes uploaded to Forms were read and analyzed through spreadsheets. A convenient feature of Forms is the automatic storage of notes in spreadsheet forms. This allowed for easy monitoring, reading and comparing of answers to the same questions by respondent types. Word or phrase count functions were also used to count the number of interviews providing the key words in their response to the same questions.

Table 3: Question guides, respondent types and number of completed interviews

Topic	Question guide	Respondent types	Interviews (WIT interviews)
Agri-culture	Farmers	Small, medium and large farmers	52 (11)
	Irrigation manufacturers/ sellers	Retailers, wholesalers, importers and manufacturers	25 (6)
	Output sellers	Buyers, wholesalers, retailers and exporters	12
	Local government and organizations	Extension officers, government offices, local organizations	34
	National government, universities, organizations	Government, universities, I/NGOs	16
	Financial services	Financial service providers	3 (1)
Services	Companies	Restaurants, hotels, hospitals	17
	Experts	Government, researchers	2
	Utilities	Utilities	1
WIT HHs	Households	Households	6
	Inputs	Importers, manufactures	2
WIT	None	WIT staff	3
TOTAL			173 (29)

Operationalizing assessment questions

The assessment questions refer to agricultural zones and key crops. In the interest of space, this assessment focuses on agriculture at the national level, with some disaggregation by Jordan Valley and the Highlands, which is a common distinction in agriculture in Jordan. Annex 10 includes data results at the governorate level.

This assessment focused on key crops as defined by their water usage. There are about 60 crops included in Jordan's agricultural census . Crop water use is a function of both the per unit water use of a crop and the irrigated area of cultivation of that crop. To define key crops, crops are sorted by water use from high to low. A key crop was then a crop which was among those accounting for 75 percent (or more) of agricultural water use. This definition applies at the national level, for Jordan Valley and the Highlands, and for each governorate.

Water use estimates

Water use is estimated using data from the 2012 ISSP study. Coefficients for water use by irrigated area of crop were created by dividing the total water used by the total irrigated area for each crop in the ISSP study. Besides creating unique water use coefficients by crop, this assessment uses coefficients for water use by crops produced in the Jordan Valley and crops produced in the Highlands. For vegetables, unique water use coefficients are created for the winter and summer seasons. All of these coefficients are multiplied by the irrigated area figures from the 2017 census to produce water use estimates.

Limitations

A limitation of this assessment is the age of the secondary data we use. Much of the agricultural data is from the agricultural census which is over three years old. The data used to create coefficients of water use by crop is over ten years old. While there are significant changes in the area of cultivation annually, these changes have an element of randomness and have not followed a steadily upward increasing trend over time. Therefore, even if data used was from 2020, it would not necessarily more accurately describe 2021 than data from 2017. It does seem likely that water use efficiency in agriculture has improved in the last decade, leading to over estimations of water use by crop when using 10 year-old data. However, as shown later in this assessment, this was not the case in our results which in fact appear to underestimate water use.

Another limitation is that water use coefficients for each crop are matched with crop irrigated area numbers on just two or three criteria. For tree crops and field crops, water use coefficients were based on the crop type and whether or not the farm was in Jordan Valley or the Highlands. For vegetables, a third differentiation was added – Winter or Summer season. Agronomic conditions and possibly practices differ geographically within these two geographic areas. Matching water use coefficients with irrigated areas based on more precise criteria would yield more precise water use estimates. Indeed, the total estimated agricultural water use for 2017 in this assessment is less than the government recorded, which is itself thought to be an underestimate.[17] Discrepancies between government recorded agricultural water use and researcher estimates in Jordan (and Israel) have been noted by other researchers.[18]

The water use results here should instead be used to compare relative water use of crops and governorates for the period of this report (2017). Caution should be used in making comparisons across times or claiming significance of a precise crop or governorate water use estimate Further research could aim to update these water use coefficients and propose how they might be most accurately and practically applied in the future.

4. FINDINGS

4.1 Agriculture and water use

The first step in the agriculture findings is to identify the key crops. These will be the subject of many of our findings in this section. Table 3 shows the results of the prioritization of key crops by water usage quantity. In each row, the crops listed are those which together account for 75 percent of water use in that area, in order from high to low, of water use estimates for 2017. Table 4 shows the importance of olives for this study. Not only are they the highest water using crop in Jordan, but they also are the highest water using crop in seven out of twelve governorates.

Table 4: Identifying key crops by water use[19]

Area	Crops accounting for 75% or more water use (in order)
Jordan	Olives, tomatoes, dates, clover[20], peaches, potatoes, grapes, oranges, apricots, lemons, bananas, sweet melon, maize[21]
Jordan Valley	Dates, tomatoes, oranges, bananas, lemons, maize, sweet peppers, eggplants, squash, potatoes, Jew's mallow, cucumbers
Highlands	Olives, tomatoes, clover, peaches, potatoes, grapes, apricots, sweet melons
Ajloun	Olives, other trees, wheat, grapes, lemons

[17] GIZ. 2021. Assessment of Ground Water Abstraction in Jordan during Years 2017, 2018 and 2019.

[18] Gilmont, Michael. Steve Rayner, Erica Harper, Lara Nassar, Nadav Tal, Mike Simpson, and Hilmi Salem, 2017. "Decoupling National Water Needs for Water Supplies: Insights and Potential for Countries in the Jordan Basin". The Wana Institute. http://wanainstitute.org/en/publication/decoupling-national-water-needs-national-water-supplies-insights-and-potential-countries

[19] Department of Statistics, Jordan. 2017. "Area, Average Yield and Production of Vegetables/Field/Fruit by Area and Production, KIND, Crop, Level and Time". Retrieved from: http://jorinfo.dos.gov.jo/Databank/pxweb/en/DOS_Database/ and USAID. 2012. ISSP Water Valuation Study: Disaggregated Economic Value of Water in Industry and Irrigated Agriculture in Jordan.

[20] Used for animal feed.

[21] Mostly used for animal feed.

Amman	Olives, tomatoes, squash, sweet melons, cauliflower
Aqaba	Potatoes, tomatoes, dates, clover, olives, watermelons
Balqa	Dates, tomatoes, banana, maize, sweet peppers, eggplants, squash, cucumbers
Irbid	Oranges, olives, lemons, clementine and mandarins, tomatoes, potatoes, dates, wheat, grapes, sweet peppers
Jerash	Olives, lemons, grapes
Karak	Tomatoes, olives, Jew's mallow, bananas, dates, onions (dry)
Ma'an	Tomatoes, olives, apples, clover, apricots
Madaba	Olives, wheat, clover, tomatoes, guava, cucumbers, nectarines
Mafraq	Olives, peaches, tomatoes, apricots, clover
Tafiliah	Olives, tomatoes, guava, potatoes
Zarqa	Olives, clover, dates, sweet melons

Production

This subsection responds to the assessment questions below. The first assessment question, "which key crops are produced per agricultural production zone", has already been addressed above in Table 4.

- What is the area and volume of production of key crops per zone? (AQ 2)
- What are the trends over time with regard to production of key crops (e.g. substitution of crops)? (AQ 3)
- How many farmers are involved in cultivating these key crops? (AQ 4)

Area and volume of key crops (AQ 2)

Most of the agricultural land in Jordan is in the Highlands, except for vegetable[22] production which is predominantly in the Jordan Valley. This is shown in Table 5 below. Irbid, Amman, Mafraq, Karak and Balqa together make up 74 percent of Jordan's agricultural area. Irbid and Mafraq together make up 47 percent of Jordan's area cultivated by tree crops. Vegetable production is concentrated in Balqa, Karak and Irbid, which together account for 65 percent of vegetable production area in Jordan. Two thirds of Jordan's field crop production is concentrated in Amman, Mafraq and Karak.

Table 5: Total area of production in 2017 (dunam)[23]

Area	Tree	Vegetable	Field	Total
Jordan	779,453	376,959	736,733	1,893,145
Jordan Valley	102,170	226,596	31,763	360,529
Highlands	677,249	150,364	704,970	1,532,616
Irbid	231,288	58,964	56,555	346,831
Amman	76,169	25,168	198,475	299,825
Mafraq	137,573	36,722	110,008	284,317
Karak	26,503	62,887	176,810	263,025
Balqa	64,764	124,551	18,182	207,457
Zarqa	69,576	11,480	39,387	120,549
Ma'an	21,698	17,203	72,548	111,452
Jerash	69,224	784	4,380	74,392
Madaba	23,170	1,523	33,309	58,008

[22] The DOS classifies sweet melon and watermelon as vegetables.

[23] Department of Statistics, Jordan. 2017. Data received via email.

Aqaba	10,960	35,637	3,554	47,434
Ajloun	39,561	633	5,066	45,266
Tafiliah	8,968	1,408	18,462	28,840

Table 6 below shows the area and volume of production by key crops identified in Table 4 above. Tables presenting findings for key crops by governorate are shown in Annex 10. A few observations stand out. For one, even though the Highlands have over four times more land dedicated to agriculture, JV has a very similar volume of production. This is driven by the large share of low-yielding field and tree crops cultivated in the Highlands.

Olives, grown mostly in the highlands, make up almost 30 percent of the cultivated area in Jordan, but only six percent of its volume of production. Tomatoes on the other hand make up six percent of Jordan's area of production but 28 percent of its harvested volume of production. Potatoes and clover are the only two other crops with production over 100,000 MT in 2017.

Table 6: Key crops area and production in 2017 – Jordan valley and Highlands[24]

Crop	Jordan		Jordan valley		Highlands	
	Area (dunam)	Production (MT)	Area (dunam)	Production (MT)	Area (dunam)	Production (MT)
All crops (كل المحاصيل)	1,893,145	2,486,810	360,529	1,250,990	1,532,616	1,235,820
All tree (كل شجرة)	779,453	531,663	102,170	170,123	677,249	361,531
All vegetable (كل الخضار)	376,959	1,749,346	226,596	1,027,695	150,364	721,651
All field (كل المحاصيل الحقلية)	736,733	205,802	31,763	53,163	704,970	152,638
Olives (زيتون)	562,141	145,404	3,369	1,618	558,772	143,786
Tomatoes (طماطم)	121,945	691,910	73,282	430,225	48,663	261,685
Dates (بلح)	32,226	24,586	24,804	16,882	7,422	7,703
Clover (زهرة البرسيم)	23,085	100,935	4,316	17,879	18,769	83,055
Peaches (خوخ)	27,396	69,494	48	47	27,448	69,447
Potatoes (بطاطا)	40,082	156,072	15,719	46,240	24,362	109,832
Grapes (العنب)	28,939	50,448	4,768	8,592	24,170	41,855
Oranges (البرتقال)	24,200	40,897	23,653	40,339	547	558
Apricots (المشمش)	15,294	18,791	36	31	15,258	18,760
Lemons (ليمون)	20,883	34,546	17,474	30,380	3,409	4,156
Bananas (موز)	7,156	29,123	7,156	29,123	0	0
Sweet melons (شمام حلو)	11,941	60,460	3,506	18,029	8,435	42,431
Maize (الذرة)	12,617	37,179	10,204	28,864	2,413	8,315

Production trends over time (AQ 3)

Table 7 shows the change in crop area over ten-year intervals from 1997 to 2017. We can see that the total area cultivated by crops in Jordan declined between 1997 and 2007, driven by an over 50 percent decline in the cultivated area for field crops as farmers switched to more profitable fruits and vegetables. This decline in production of cereals over this time period was replaced by imports. Over the same time period, imports of wheat, barley, maize and rice (Jordan's primary cereal imports) increased by 53 percent.[25] While the area under cultivation with olives has declined slightly since 1997, the area of cultivation of the next four key crops has

[24] Department of Statistics, Jordan. 2017. "Area, Average Yield and Production of Vegetables/Field/Fruit by Area and Production, KIND, Crop, Level and Time". Retrieved from: http://jorinfo.dos.gov.jo/Databank/pxweb/en/DOS_Database/

[25] UN Trade Statistics. UN Comtrade Database. Retrieved from: https://comtrade.un.org/data/

increased dramatically over that period. Apricot cultivated land nearly doubled between 2007 and 2017 whereas the area cultivated with bananas decreased by more than 50 percent over that same period.

About a third of farmers we interviewed said they had made a "major" change in the crops they cultivated in the last five years. Below are some examples of changes made and reasons given by farmers for making the changes.

- Crop damage – Farmers replaced olive trees with grapes and dates due to frost damage.
- Reduce perishability – Farmers switched from tomatoes to onions, garlic and field crops because they can be stored and the farmer can avoid market gluts which reduce prices.
- Improved variety – Farmers changed the variety of their crop based on market conditions, including early harvestability.
- Reduced water use – Farmers switched to olives and field crops because they said they required less water.
- Improved price and reduced costs – Farmers switched to crops which were projected to have higher prices, including switching from vegetables to dates. Others switched because profitability was low due to high costs of production and/or low sales prices.

The changes may be experimental and incremental. For example, one large farmer was experimenting with cactus, aloe vera and quinoa because of their low water requirements, resistance to salinity and export potential. He said if they did well, he would expand cultivation.

Table 7: Crop area trend 1997, 2007, 2017 - Jordan (dunam)[26]

Crop	1997	2007	2017
All crops	2,702,776	1,880,741	1,893,145
All tree	830.812	812,882	779,453
All vegetables	302,824	334,057	376,959
All fields	1,569,141	733,803	736,733
Olives	616,017	601,401	562,141
Tomatoes	81,919	105,570	121,945
Dates	2,121	15,727	32,226
Clover	9,022	21,651	23,085
Peaches	5,945	17,644	27,496
Potatoes	40,184	35,540	40,082
Grapes	36,843	30,894	28,939
Oranges	19,590	25,874	24,200
Apricots	7,457	8,985	15,294
Lemons	22,052	17,027	20,883
Bananas	13,303	15,418	7,156
Sweet melons	12,294	6,872	11,941
Maize	9,168	7,917	12,616

Farms and farm size (AQ 4)

Table 8 below shows the number of farms in Jordan cultivating each key crop. It also shows the percentage of crop area cultivated by small (<30 dunam), medium (30 to 200 dunam) and large (>200) farms. By far the most common crop is olives with 58,277 farmers cultivating it in 2017. Nearly half of olives are produced on farms with under 30 dunams. This pattern does not apply to other key tree crops: 67 percent of dates, 80 percent of oranges and 66 percent of lemons

[26] Department of Statistics, Jordan. 1997, 2007, 2017. "Area, Average Yield and Production of Vegetables/Field/Fruit by Area and Production, KIND, Crop, Level and Time". Retrieved from: http://jorinfo.dos.gov.jo/Databank/pxweb/en/DOS_Database/

are produced on medium sized farms, while 94 percent of peaches and 52 percent of grapes are produced on large farms. Most vegetables are produced on medium or large sized farms, including 54 percent of tomatoes and 58 percent of potatoes. Two thirds of field crops are produced on farms over 200 dunams, including 94 percent of clover and 88 percent of maize.

Table 8: Number of farmers and farm size by crop – Jordan 2017[27]

		% of total crop area by farm size		
Crop	**# of farmers**	**<30**	**30 to 200**	**>200**
All tree	63,288	38	29	34
All vegetables	7,585	14	55	31
All field crops	8,629	6	27	67
Olives	58,277	47	24	30
Tomatoes	3,303	16	54	30
Dates	931	4	67	29
Clover	493	6	34	60
Peaches	366	1	5	94
Potatoes	853	6	36	58
Grapes	2,666	22	26	52
Oranges	4,992	19	80	0
Apricots	373	2	7	91
Lemons	2,708	24	66	10
Bananas	489	15	82	3
Sweet melons	449	10	32	58
Maize	712	12	72	16

Market

This subsection responds to two assessment questions. The third question that was initially to be answered under markets has been moved to the next sub section.

- What are the primary markets for the products grown (e.g. consumption, local, domestic, regional export, export)? (AQ 5)
- What is the market outlook for these key crops? (AQ 6)

Markets and market outlook (AQ 5 & 6)

The majority of Jordan's crop agricultural exports are destined for markets in the Middle East. Of the 226 million dollars of vegetable exports Jordan had in 2019, 92 percent went to Saudi Arabia, Kuwait, UAE, Bahrain and Israel. Of the 137 million dollars of fruit exports in 2019, 90 percent went to Iraq, Saudi Arabia, Kuwait, UAE, Bahrain, Oman, Qatar, free trade zones and Lebanon. Jordan's cereal crop exports are minimal, totaling just four million dollars in 2019.[28]

Tomatoes, peaches and nectarines and sweet melons are primary exports among key crops (see Table 9). Exports for these crops primarily go to the Middle East. In 2019, Jordan was the world's seventh largest tomato exporter by volume. The country's tomato exports were imported, in order of volume, by Saudi Arabia, Kuwait, the United Arab Emirates (UAE), Bahrain and Oman. Jordan is the second largest exporter of tomatoes in the Middle East with about half the volume of exports as Turkey. However, unlike Jordan, Turkey's tomato exports are largely destined for Eastern European markets where prices are slightly higher. In 2019 Turkish tomato exports earned about 0.57 United States Dollars (USD) Per Kilogram (KG) exported, compared

[27] Department of Statistics, Jordan. 2017. Data received via email.

[28] UN Trade Statistics. 2019. Retrieved from: https://comtrade.un.org/data/

to 0.50 USD for Jordan's tomato exports. By comparison, Morocco's top tomato importers are France and the United Kingdom, and they paid Morocco an average of 1.30 USD per KG for its tomato exports. [29]

Jordan was the world's eighth largest peach and nectarine exporter in 2019 trailing only Turkey in the Middle East. Over three quarters of Jordan's peach and nectarine exports ended up in Iraq and Saudi Arabia. Jordan earned 0.79 USD per KG for its peach and nectarine exports, compared to Turkey's 0.85 USD per KG.

Jordan was the world's 15th ranked sweet melon exporter in 2019. Jordan's sweet melon exports were once again primarily to Middle Eastern countries. Jordan earned 0.48 per KG for its sweet melon exports. By comparison, Morocco, the world's 11th ranked exporter, earned 1.18 USD per KG which largely went to Europe.[30]

Prices received for fruits and vegetable exports to the European Union market are significantly higher than to Middle Eastern markets. Additionally, Jordan has climate-related seasonality advantages compared to European producers and could export fresh produce when domestic supply is low. However, stringent traceability and food safety standards pose significant challenges for Jordanian exporters to access European Union markets.[31]

Table 9: Exports and domestic market hubs – Jordan, 2017[32]

			% sold through domestic marketing hubs		
Crop	**Production (MT)**	**Exports (MT)**	**Amman**	**Irbid**	**Zarqa**
Olives	145,404	1,130	93	0	7
Tomatoes	691,910	282,271	57	39	4
Dates	24,586	4,964	72	26	2
Clover	100,935	NA	0	0	100
Peaches and nectarines	91,566	59,005	66	33	1
Potatoes	156,072	5,304	63	34	4
Grapes	50,448	629	73	26	2
Oranges	40,897	476	63	34	3
Apricots	18,791	8,366	76	22	2
Lemons	34,546	910	62	23	4
Bananas	29,123	232	78	18	4
Sweet melons	60,460	35,417	62	35	3
Maize	37,179	72[33]	63	34	4

Jordan has three primary domestic agricultural market hubs: Amman, Irbid and Zarqa. As Table 8 shows, most of the key crops are primarily marketed through Amman. The only exception is clover which is entirely marketed through Zarqa.

Traders interviewed complained about gluts on the market for fruits and vegetables. Part of this is due to the COVID19 pandemic. The cost of trade logistics has increased making exports

[29] UN Trade Statistics. 2019. Retrieved from: https://comtrade.un.org/data/

[30] Ibid.

[31] World Bank Group. 2018. "The role of food and agriculture for job creation and poverty reduction in Jordan and Lebanon". Available at : http://documents1.worldbank.org/curated/en/325551536597194695/pdf/Agricultural-Sector-Note-Jordan-and-Lebanon.pdf

[32] UN Trade Statistics. 2017. Retrieved from: https://comtrade.un.org/data/ and Department of Statistics, Jordan. 2017. Data received via email.

[33] Excludes re-exports.

less competitive and oversaturating the domestic market. However, another issue is the instability of Jordan's neighbors Syria and Iraq which leads to border closings. Before its civil war, Syria was one of the largest importers of Jordanian fruits and vegetables but now there are very limited agricultural exports. Furthermore, land routes to markets in nearby countries including Lebanon have been disrupted. The limitations on access to these export markets leads to oversupply in local markets and low prices.

There is some reason for optimism on the domestic market for fruits and vegetables. One retailer interviewed said they were seeing an increasing trend in health conscientiousness, especially among younger people. This observation is supported by research which found that vegetable consumption among those under 35 in Amman was significantly higher than for those over 35.[34] A trader expressed an expectation that the market share for organic growth will grow.

About 80 percent of Jordan's olive production is used to make olive oil with the remaining portion going for table olives.[35] Domestic olive oil production was about 23 to 24 thousand tons in 2020, which is very close to the quantity consumed, making Jordan essentially olive oil self-sufficient.[36] The government plays an active role in promoting the olive oil industry. In the past it has protected the local olive oil industry from competition with import bans and has launched public awareness campaigns about the health benefits of olive oil consumption aiming to increase consumption among youth.[37]

Water use

The water use subsection responds to the following assessment questions. In addition, one question originally in the production subsection is deemed more appropriately here.

- What is the quantity of water used by key crops per agricultural production zone? (AQ 7)
- What types (e.g. surface, ground, blended, treated wastewater) are used for irrigating key crops? What irrigation systems and practices are used by these farmers? (AQ 8)
- Besides irrigation, which water-saving technologies and practices are being used by farmers and why? How effective are these technologies and practices seen to be by producers and others? (AQ 9)
- What are the constraints to greater adoption of improved water conservation practices and technologies? (AQ 10)
- What are the potential water-savings in agriculture by key crop and zone? (AQ 11)
- What is the agricultural water "balance of trade"? (AQ 12 - from markets section)

Irrigation and agricultural water use by crops and areas (AQ 7 and AQ 8)

Table 10 shows the area of cultivated irrigation and water used for key assessment crops. As was discussed previously, these key crops were selected because they use the most agricultural water. Together these crops accounted for an estimated 75 percent of Jordan's agricultural water use. The top 3 irrigated crops – olives, tomatoes and dates –used an estimated

[34] Sacre, Yonna, Rachad Saliba, and Michael Henry Bohme. 2016. "Evaluation of fruit and vegetable consumption as phytonutrients potential in Jordan". Available at : https://www.researchgate.net/publication/310047169_Evaluation_of_fruit_and_vegetable_consumption_as_phytonutrients_potential_in_Jordan

[35] Al-Zoubi, Julie. 2020, October 9. "Olive Mills Open in Jordan with Average Harvest Predicted". *Olive Oil Times.* Available at :https://www.oliveoiltimes.com/briefs/olive-mills-open-in-jordan/86206

[36] Weldali, Maria. 2020, September 30. "Olive oil producers expect an average harvest this season". *The Jordan Times*. Available at : http://jordantimes.com/news/local/olive-oil-producers-expect-average-harvest-season

[37] JT. 2015, July 12. "Ban on olive oil imports remains in place". *The Jordan Time.s.* Available at: http://www.jordantimes.com/news/local/ban-olive-oil-imports-remain-place and Namrouqa, Hana. 2017, October 12. "The Ministry of Agriculture encourages olive oil consumption among youth". *The Jordan Times*. Available at : https://www.jordantimes.com/news/local/ministry-agriculture-encourages-olive-oil-consumption-among-youth

45 percent of Jordan's agricultural water in 2017. The remaining ten key crops used a combined 30 percent of Jordan's water.

Nearly all vegetable production is irrigated, primarily by drip irrigation (95 percent). On the other hand, only 10 percent of field crops are irrigated. This low rate of irrigation is largely due to barley, which accounts for 30 percent of Jordan's cultivated land and is only 4 percent irrigated. The two key field crops in this assessment, clover and maize, are 100 percent irrigated. Olives, cultivated by 71 percent of Jordan's farmers (see Table 7), use 23 percent of Jordan's agricultural water despite being only 38 percent irrigated.

Table 10: Irrigation and water use – Jordan (2017)[38]

Crop	Irrigation (dunam)					Water use (MCM)
	Not irrigated	Sprinkler	Drip	Surface	Total irrigated	
All crops	1,029,458				863,741	498.8
All tree	362,270				417,157	285.4
All vegetables	7,213	82	351,041	18,706	369,829	163.4
All fields	659,975	21,258	18,159	37,349	76,755	50
Olives	348,323	NA	NA	NA	213,827	112.7
Tomatoes	257	NA	117,610	4,080	121,690	63.1
Dates	0	NA	NA	NA	32,227	47.8
Clover	0	14,295	1,573	7,217	21,581	25.4
Peaches	492	NA	NA	NA	27,005	22.7
Potatoes	0	0	39,294	791	40,085	18.2
Grapes	5,713	NA	NA	NA	23,055	15.4
Oranges	0	NA	NA	NA	24,200	12.7
Apricots	603	NA	NA	NA	14,694	12.3
Lemons	0	NA	NA	NA	20,869	12.1
Bananas	0	NA	NA	NA	7,156	10.3

In total, our estimate shows that 498.8 MCM of water were used in Jordan in 2017.[39] This is shown in Table 11 below, which also lists the governorates in order of their estimated water use. Fifty seven percent of this water was used by fruit and 33 percent by vegetable production with the remaining 10 percent for field crop production. The Highlands utilized 64 percent of the irrigation water. Among governorates, the highest agricultural water users were Mafraq followed by Balqa and Irbid. Together these three governorates accounted for 57 percent of Jordan's agricultural water use in 2017.

Table 11: Water use by governorate (MCM)[40]

Area	Fruit	Vegetable	Field	Total
Jordan	285,378	163,430	49,988	498.8
Jordan Valley	84,924	81,971	14,918	181.8
Highlands	200,453	81,459	35,071	317

[38] Department of Statistics, Jordan. 2017. "Area, Average Yield and Production of Vegetables/Field/Fruit by Area & Production, KIND, Crop, Level and Time". Retrieved from: http://jorinfo.dos.gov.jo/Databank/pxweb/en/DOS_Database/ and USAID. 2012. ISSP Water Valuation Study: Disaggregated Economic Value of Water in Industry and Irrigated Agriculture in Jordan.

[39] This is less than the 545 MCM water recorded to be used in 2017 by MWI. See discussion in methodology limitations section 3.

[40] Department of Statistics, Jordan. 2017. "Area, Average Yield and Production of Vegetables/Field/Fruit by Area and Production, KIND, Crop, Level and Time". Retrieved from: http://jorinfo.dos.gov.jo/Databank/pxweb/en/DOS_Database/ & USAID. 2012. ISSP Water Valuation Study: Disaggregated Economic Value of Water in Industry and Irrigated Agriculture in Jordan.

Mafraq	80,179	21,765	9,953	111.9
Balqa	45,156	43,810	9,516	98.5
Irbid	49,228	21,580	5,901	76.7
Zarqa	37,408	6,776	12,365	56.6
Amman	24,885	12,223	1,359	38.6
Karak	8,511	24,651	1,838	35
Aqaba	9,055	19,639	2,395	31.1
Ma'an	14,110	10,880	4,839	29.8
Jerash	9,338	380	72	9.8
Ajloun	3,008	194	749	4
Madaba	2,334	733	827	3.9
Tafiliah	2,165	799	175	3.1

Types of water used (AQ 8)

The official MWI-recorded figure for irrigation water abstraction in 2017 is 545 MCM. Groundwater, which predominates in the Highlands, is the most significant source of water for irrigation with an estimated 251 MCM used for irrigation in 2017. Groundwater is primarily abstracted through artisanal wells. Surface water is the second largest source of irrigation water, with most of this coming from the King Abdullah Canal in the JV. Recorded use of treated wastewater in agriculture was nearly at the same level as surface water in 2017. Very few farmers interviewed reported using treated wastewater.

Table 12: Agricultural water use in 2017[41]

Water type	Water use (MCM)
Surface water	149.4
Ground water	251.1
Treated wastewater	144.2
TOTAL	544.7

The recorded figure total of 545 MCM is 46 MCM or 9 percent higher than the estimate in this assessment. This recorded figure is thought to be an underestimate due to illegal abstraction. A study conducted by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) using remote sensing and other data estimated agricultural water use of 691 MCM in 2017, including 365 MCM groundwater.[42] Such discrepancies between different measures of water use are not uncommon. A study comparing agricultural water use in Jordan and Israel conducted in 2017 found that water use calculated using per crop water use coefficients was about 40 percent lower than officially recorded water use. For Jordan, the estimated water use was higher than recorded results, but this relationship varied over time.[43]

Many farmers have less water than needed. This is true of both farmers relying on the King Abdullah Canal and those utilizing groundwater. Some farmers respond by combining irrigated and rainfed cultivation. Other farmers purchase water off-farm to help meet their excess irrigation water demands. Even when enough water is available, the price is sometimes prohibitive. When including the high costs of electricity involved in pumping the water, prices per cubic meter were said to be between 0.85 USD and 1 USD per cubic meter of water and about 15 to 20 percent of their cost of production. Several farmers said that price, not scarcity, was the limiting factor

[41] Department of Statistics, Jordan. 2018. "Jordan in Figures, 2018". Available at: http://dosweb.dos.gov.jo/DataBank/JordanInFigures/2018.pdf

[42] GIZ. 2021. Assessment of Ground Water Abstraction in Jordan during Years 2017, 2018 and 2019.

[43] Gilmont, Michael. Steve Rayner, Erica Harper, Lara Nassar, Nadav Tal, Mike Simpson, and Hilmi Salem, 2017. "Decoupling National Water Needs for Water Supplies: Insights and Potential for Countries in the Jordan Basin". The Wana Institute. http://wanainstitute.org/en/publication/decoupling-national-water-needs-national-water-supplies-insights-and-potential-countries

on how much water they could have, though one said scarcity would become a problem in the future.

Energy costs of using irrigated water are significant. One farmer said that energy costs account for 20 to 30 percent of their cost of production. The high cost of energy access irrigated water applied to both farmers using electricity from the grid or those using fuel operated pumps. Some farmers are using solar power, but they have problems integrating their solar power system with the electricity grid if it exceeds a certain output. A farmer said they were unable to integrate their two-megawatt system into the grid.

In interviews, nearly half of farmers complained about salinity. This complaint was made especially about ground water but also with surface water. Farmers said salinity had been increasing due to over-abstraction of aquifers. Water that is saline becomes more difficult for plants to absorb and so plants require more water. Past a threshold of about 3000 to 6000 parts per million, salinity becomes toxic for plants.[44] One farmer said that their water had been tested at 2,700 parts per million. Some farmers are treating their water to reduce salinity, but this obviously adds a cost which others cannot afford. Some farmers also had turbidity issues, which can cause clogging issues for drip irrigation systems. In some cases, filters were used to address this issue.

Irrigation (AQ 8)

Drip irrigation dominates vegetable production. Table 9 shows that 95 percent of irrigated vegetables were irrigated with drip irrigation. About half of all irrigated field crops, which represent 10 percent of all field crops, are irrigated using surface irrigation. The rest are irrigated with drip and sprinkler irrigation. Unfortunately, there is no data on tree crop irrigation systems in the census data. However, in our interviews we found that all 21 farmers who were cultivating tree crops were using drip irrigation.

Most farmers reported using so- called GR (Green Revolution) irrigation systems. GR is a local name for drip systems with inline emitters which release drops of water directly from the tubes. While this type of drip irrigation is popular, it is said to be easily obstructed with debris and turbid water. As mentioned previously, some farmers do use filters to improve water quality.

Some farmers were using pressure regulating emitters. They are a relatively costly technology in Jordan and are intended to increase irrigation by delivering consistent quantities of water over time, regardless of water pressure fluctuations in the system. These technologies were promoted by the WIT activity and according to a few farmers the results were mixed.

Many farmers expressed satisfaction with their drip irrigation systems. However, they noted the deterioration in drip system efficiency over time, especially when using unfiltered turbid water. Some were cognizant of the need to clean the drip system periodically with acid. Over a period of four years, drip system decline was said to reduce efficiency from 100 percent to 70 percent. After this time the systems should be replaced. At least one irrigation system dealer offers a buy-back program for old drip irrigation systems.

[44] Muir, Patricia. 2014. "Salinization". Available at: http://people.oregonstate.edu/~muirp/saliniz.htm

Box 1: Jordan's estimated agricultural water balance of trade (AQ 12) – The agricultural water balance of trade is the amount of water a country would have had to use to produce the crops it imports minus the water it used in producing the crops it exports. Because of its massive deficit in cereal crops, Jordan has a very large positive water balance of trade. In 2017, Jordan's estimated agricultural water balance of trade was 30 percent higher than the estimated total agricultural water used.

Table 13: Water balance of trade ('000 M^3) - 2017[45]

	Trees	Vegetables	Cereal	Total
Exports (MT)	148,366	385,820	9,165	543,351
Imports (MT)	190,355	91,183	2,693,811	2,975,349
Water exported	79,638	36,045	2,226	117,908
Water imported	102,176	8,519	653,314	765,009
Water balance of trade	22,538	-27,526	652,088	647,101

Water savings practices (AQ 9)

The most common water-saving irrigation practice found to be used by farmers is irrigating at night. This practice reduces evaporation from the heat of the day. Some farmers also use irrigation scheduling. Schedules are based on the season, crop type and crop maturity, and are intended to optimize water application. These practices are said to be traditional and learned from experience and neighbors.

Other non-irrigation practices are used by farmers to conserve water. Two common practices are the use of mulch, including volcanic tuff, on the surface and animal manure in the soil to conserve moisture. The use of so-called black mulch was claimed by one farmer to reduce irrigation requirements by 35 percent. Cover is also used to provide shade and prevent evaporation. Nets are used to cover grapes, greenhouses to shelter vegetables, and tents to cover bananas.

Technology adoption (AQ 10)

Nearly all (~80 percent) the farmers interviewed were aware of water saving technologies they were not using. Below are the most commonly named technologies which had not yet been adopted by the farmer:

- Smart irrigation systems - Uses data from soil moisture meters to optimize water allocation.
- Hydroponics - Involves growing plants in nutrient rich water, a practice which ironically reduces water consumption
- Fertigation – Irrigation with liquid fertilizer which improves nutrient delivery and reduces water use.
- Pressure regulating/compensating emitters – Deliver a precise amount of water regardless of pressure.

Farmers did not express apprehension about the effectiveness of these water-saving technologies that they were aware of but not using. In fact, farmers were motivated to adopt

[45] Department of Statistics, Jordan. 2017. "Area, Average Yield and Production of Vegetables/Field/Fruit by Area and Production, KIND, Crop, Level and Time". Retrieved from: http://jorinfo.dos.gov.jo/Databank/pxweb/en/DOS_Database/ and UN Trade Statistics. 2017. Retrieved from: https://comtrade.un.org/data/. Note that water estimates are made at the crop category level (fruit, vegetable and field crops) because of inconsistencies in naming crops between some DOS and Comtrade data.

water saving technologies. State motivations included being able to adequately irrigate existing crops, expanding production areas and saving money.

The main reason for not adopting new water-saving technologies was their cost. Most farmers funded their existing irrigation equipment through savings or by paying the input supplier back at the end of the harvest season. The conditions on bank finance for agriculture makes it difficult to access according to farmers. Another reason for non-adoption was lack of knowledge about how to use and maintain the new technologies and practices. Most farmers say that their input supplier does not offer them services to help set up and manage irrigation systems. A few reported having learned about new technologies or practices from the government.

Potential water savings (AQ 11)

Information on the water conservation potential of new technologies and practices is scarce. Even among experts it was difficult to solicit estimates for what different water savings technologies and practices might save. The team did however assemble some estimates for water savings from agricultural researchers, extension officers and farmers themselves. These are shown in Table 14.

Table 14: Water savings estimates

Technology or practice	% savings
Hydroponics	30 to 60
Isolite	50
Protected agriculture	30 to 50
Soilless or artificial soils	30 to 50
Volcanic tuff as mulch	35
Pipes in place of canal	35
Irrigating at night	30
Fertigation	10 to 25
Smart agriculture	10 to 20

A recent study found that Israel was using agricultural water more efficiently than Jordan. Using 14 crops and average crop production data from between 2009 and 2014, the study estimated that Jordan would save 168 MCM or 33 percent per year if they were able to reach the same water use efficiency as Israel.

Table 15 estimates Jordan's water savings for key crops using Israel water use rates. Where available, we use the study's estimated crop water savings estimate for each of the key crops water use estimates in this assessment. These estimates show that if Jordan could adopt Israel's water use efficiency, it could save nearly 84 MCM or 28 percent of the water. Clover would yield the biggest water savings under this scenario. In Israel, clover is entirely rainfed because of its low economic value and the opportunity cost of agricultural water.[46] Excluding the water savings from clover, the water savings for the remaining crops is 56 MCM or 21 percent. Potential savings would be higher if scaled to the MWI or GIZ's figures for water use.

Table 15: Jordan's estimated water savings adopting Israeli water use efficiency (MCM)[47]

Key crop	Water use 2017	Savings %	New water use	Savings
Clover	27.4	100	0	27.4
Olives	112.7	21	89	23.6
Tomatoes	62.9	25	47.1	15.7
Dates	47.8	14	41.1	6.7
Oranges	12.4	23	9.5	2.8
Lemons	12.1	23	9.3	2.8
Bananas	10.3	26	7.6	2.7
Grapes	15.4	13	13.4	2
Total	300.9	28	217.1	83.8

[46] Ibid

[47] Ibid.

4.2 Non-agricultural services water use

The non-agricultural services water use topic addresses three research questions:

- What are the key (3 to 5) service business types in terms of their volume of water use?
- What are the opportunities to reduce water use?
- What are the challenges to reducing their water use?

The non-agricultural service businesses chosen for this assessment are hotels, hospitals, and restaurants. These selections are based on the water use presented in the table below which shows data from the highest 500 water subscribers of Miyahuna Water Company. Miyahuna Water Company serves the middle region of Jordan (Amman, Balqa, Zarqa and Madaba governorates) and about three quarters of the population of Jordan. This assessment omits public schools because they have been closed due to COVID-19 and shops because this category is too broad to effectively implement in fieldwork. Furthermore, non-agricultural service companies are omitted as they fall outside the scope of this assessment. What remains are hospitals, restaurants and hotels as the top non-agricultural services by water users. These businesses were the focus of our fieldwork. The selection of hospitals, restaurants and hotels was validated through interviews with other actors including utilities and the Jordan Chamber of Commerce.

Table 16: Top water users by type (‘000 M^3)[48]

Type	2017	2018	2019	2020
Uncategorized subscriptions[49] (أي إشتراكات غير ما ذكر ولا تشابه ما ذكر)	1,882	1,994	2,035	1,722
Ministries, Departments (الوزارات والدوائر)	739	771	762	730
Schools (المدارس_)	538	534	523	419
Retail shops (محلات التجزئة)	466	458	457	392
Companies, insurance, fright, newspapers, transportation, estates (الشركات ، التأمين ، الشحن ، العقارات ، النقل ، الصحف)	446	418	397	345
Offices (مكاتب)	392	387	372	303
Hospitals (المستشفيات)	**248**	**224**	**206**	**215**
Restaurants (مطاعم)	**247**	**245**	**226**	**185**
Factories, mills (المطاحن، المصانع)	163	152	156	122
Slaughter houses (المسالخ)	161	151	132	117
Banks (البنوك)	101	108	95	82
Hotels (الفنادق)	**96**	**94**	**92**	**78**
All (الجميع)	7,268	7,301	7,178	6,226

In general, water losses are high in the municipal sector including the businesses selected for this assessment. Water leakage, water loss and water theft are major problems in Jordan. Respondents estimated that 40% to 80% of the water supply is lost in the network, depending on the location. Inefficient administrative processes, outdated infrastructure and inadequate maintenance are the main reasons for this huge waste. Administrative shortcomings include unbilled water use due to metering issues and illegal extraction with little legal consequence.

Less than half of the seventeen businesses interviewed for this assessment were using advanced water conservation practices and technologies. These tended to be larger

[48] Data received via email from Miyahuna Water Company.

[49] Includes military establishments, Royal palaces, and other uncategorized establishments.

businesses. The most common water conserving technologies were faucets and toilets. One innovative new private hospital in Aqaba used three types of water: regular water from the network for laundry and toilets; reverse osmosis water from air conditioners and other filtration systems for medical machines; and reclaimed water for the kitchen. They had also installed water-saving faucets. Laundry was their main source of water use and they were attempting to reduce it by only washing full loads. A few hotels reported reusing water from their pools and air conditioners for irrigating gardens or cleaning. Another hotel used water saving faucets, lower capacity flush tanks for toilets, water monitoring devices and a small sea water desalination station. Yet another hotel had low flow shower heads, lower capacity flush tanks, water restrictors on all water mixers, ultra-sonic water mixers, water efficient washing machines and had awareness campaigns on water savings for their staff. Through these practices they reduced their water consumption from 120 to 80 cubic meters per year. Restaurants interviewed did not use water savings technologies beyond faucets and toilets.

Most companies interviewed, however, did not use advanced water conservation technologies or practices. The main reason given is that they were not aware of the water savings benefit of these technologies and their costs. Therefore, they were not able to estimate the profitability of using many water savings technologies and were discouraged by their upfront costs. One restaurant interviewed bought an average 120 Jordanian Dinar of water from tankers per month but had no idea which technologies to use to reduce water use other than water saving faucets.

Only a few companies were able to identify the water usage in their establishments and the efficiency of their water use practices. One example is the new hospital in Aqaba discussed above which was using state-of-the-art technologies for water conservation. Their water conserving initiative was led by an innovative operations manager who proudly talked about searching for the best technologies online and at conventions and fairs. This level of proactiveness required to seek out state of the art water-savings technologies and practices is not common.

Companies lack water use best practices manuals or protocols. The measures taken in each establishment interviewed relied on the individual knowledge and experience of the operations managers, along with upper management decisions. The water conservation knowledge of interviewees varied greatly with most having limited knowledge. Most people interviewed had learned what they did know about water conservation practices on their own.

Sellers of water use technologies often do not promote their water savings potential. Information about water savings is often not part of the marketing of devices that might save water. Instead those businesses interested in water saving technologies seek out their own information, mostly online. Shops do have technical information on water savings that could help make purchase decisions based on the costs and benefits of each device. One big supplier said that they buy supplies based primarily on the price rather than water savings potential because of the preference of their customers. The supplier did not have a technical expert who was knowledgeable about the water savings of their products.

There are water conservation awareness campaigns but they are not focused on businesses. There have been nationwide campaigns to raise awareness for household water use reduction. These campaigns have been sponsored by MWI, water utilities, universities and donors. However, the campaigns have focused on household rather than business water conservation.

There is limited national harmonization and coordination of water management, and poor translation of strategies into action at the policy level. Respondents including donors and government said there is a lack of an overall vision for water use conservation across different sectors as well as a siloed approach to policy and program implementation. For example, there is not a common set of targets for water conservation across different sectors in Jordan. Furthermore, there is said to be a poor translation of plans into results, in part due to reliance on donor funding. Additionally, data on water use by area and business type is difficult to find.

4.3 WIT Activity Market System Development

The assessment of WIT's MSD approach followed three research questions:

- What have been the biggest challenges faced by the Water Innovation Technologies Activity in following a Market Systems Development (MSD) approach?
- What have been the key successes by the Water Innovation Technologies Activity team in applying the MSD methodology towards conserving water?
- What have been the key successes by the Water Innovation Technologies Activity team in applying the MSD methodology towards conserving water?

Program design

WIT was not originally designed to follow the Market Systems Development approach. Instead, it was designed to follow a "direct implementation approach" with a range of activities designed to work at the community level to support farmers and households to adopt new water saving technologies. The transition to an MSD approach resulted in a shift of strategic focus. WIT pivoted to engaging more directly with market actors to influence how they provide services and products to the target populations to promote the adoption of water saving technologies.

Box 2: What is market systems development? The market systems development approach is a methodology that guides the implementation of economic growth programs, generally following four key principles:

- **Systems thinking:** Activities not only work with core-value chain actors to address the symptoms constraining the achievement of a project's objectives (e.g. farmers do not use water saving technologies), but also address how other market actors in the system can transform their role to address root causes of system underperformance (i.e. water saving technologies are expensive, or farmers do not see the business case for the adoption of water technologies).
- **Facilitation:** Activities should influence the behavior of "permanent market actors" and work through them during the delivery of interventions, rather than implementing activities directly. Implementers should leverage market actors' incentives for doing things differently, shaping new business models or value propositions. Activities should support these new initiatives with a variety of tools, including buying-out risk or providing short-term technical assistance.
- **Sustainability:** Activities should strive to transform market actors so that their newly acquired behaviors, capacities and business models outlive the life of the project. This is achieved by ensuring that market actors see the value proposition of each new practice promoted, and that the market system has evolved to support the continued implementation of new practices.
- **Adaptation:** MSD Activities should not start with a prescribed set of interventions and solutions, but rather work with market actors to co-create disruptions, learn from their roll-out, and adapt the portfolio of interventions as implementation progresses. These adaptations are based on learning about what works and what does not work.

Program design was shaped by a water sector MSD assessment led by the Springfield Center. To diagnose what are the key system-level issues constraining farmers and households to adopting water saving technologies, the Springfield Center was contracted to lead a market system assessment of the Jordanian water sector and identify entry points for intervention. The study was conducted over the course of a few months, during which the Springfield Center worked closely with the implementing team to carry out the data collection and analysis of the market system.

No major changes to staffing or results management following the shift to MSD. WIT's reporting and results measurement framework remained the same, as the project transitioned to an MSD approach. USAID invested in the capacity building of the WIT team, sponsoring their participation in the Springfield Center's 2-week market systems development training in Bangkok, where the WIT staff was able to learn how the MSD approach is implemented. No changes to the staffing structure were immediately made as the team transitioned to the new approach, and an MSD specialist took over the role of Deputy Chief of Party in June 2018 to support the team integrating MSD into the project's operations.

Implementation

The late shift to MSD caused some setbacks with some market actors. Some market actors were disappointed with the change in implementation approach, and disengaged with WIT for some time. For example, one wholesaler ended the relationship with WIT for six months, before WIT was able to re-engage. The main obstacle was convincing market actors to co-invest, as they were used to developing actors leading initiatives from start to end.

Eventually the market system approach resonated somewhat well with the private sector but not as well with government actors. There is appetite across the private sector to engage with programs that take a facilitative, MSD approach. After some initial hesitancy, and resistance to this change, some market actors engaged constructively with WIT, and spoke positively of the co-creation process. Many of the companies operating in the water sector in Jordan have decades of experience, and are well networked, and welcomed conversations with WIT that were more focused on barriers to doing business and creating opportunities for economic growth. However, some companies declined to speak to the review team because of poor experiences engaging with WIT; the review team was therefore not able to assess what had gone wrong. On the other hand, while WIT had some positive experiences with the private sector, WIT struggled to gain traction with public sector actors, who are more used to receiving direct funding support from development programs.

At the core of WIT's MSD approach was a co-creative investment fund. A key aspect of WIT's MSD approach was the rollout of an Investment Fund, the primary vehicle that WIT used to engage with market actors, and especially the private sector. Through the innovation fund, WIT issued public solicitations for market actors to respond to, so that they could pitch ideas and funding requests to WIT to support the rollout of new models. Each public solicitation issued by WIT was designed to meet the objectives of the Activity, so that applications were in line with WIT's strategic goals. Over the course of its implementation, WIT issued two open solicitations that attracted an average of 30 applicants for each. Four grantees were approved for funding at the end of each round. A key aspect of the innovation fund was the highly co-creative approach that WIT adopted. During each round of solicitation, WIT worked hand-in-hand with the applicants with the greatest potential to shape their proposal further. In some situations, WIT approached market actors encouraging them to apply to the public solicitation.

WIT had a three-pronged strategy to support the adoption of water-saving practices. Although WIT's portfolio of interventions is multi-faceted, the adoption of water saving technologies among households and farmers was promoted with a three-pronged approach:

- **Affordability and customer care**: The price of water saving technologies was subsidized to up to 70% through the investment fund to promote the immediate uptake of new products by farmers and households. Suppliers' ability to provide better customer care and after sale support was strengthened.
- **Awareness and marketing**: Demonstration sites were established to prove to local communities the impact of water saving technologies, and partnerships with local organizations were set up to improve awareness of water saving.
- **Financial services**: Revolving loans and lending products were designed to support customers to buy water technologies.

The need to meet short-term water targets influenced several of WIT's activities. Ambitious water saving targets shaped WIT's intervention portfolio and engagement with market actors. Intervention strategies were designed to encourage a rapid uptake of water saving technologies by households and farmers, including through subsidizing the retail cost of equipment. In addition, some interventions were introduced specifically to meet these targets, such as the range of activities aimed at rehabilitating dams and other key water infrastructure around Jordan.

Results

Water technology providers adopted a more customer focused approach. Conversations with several WIT partners have indicated that there has been a shift in how market actors now engage with customers. This shift appears to be sustainable and likely to outlive WIT. For example, one manufacturer and seller of irrigation equipment (such as pipes, fittings, emitters and sprinklers) who serves large farmers and retailers, commented that they have strengthened their communication with customers to be more systematic and structured, and will continue to do so. A wholesaler of various irrigation equipment also claimed that it changed how it communicates with farmers, and plans to continue learning how their customers think and behave to ensure that their services are better tailored to their needs. However, this was not reflected during interviews with farmers, who had not noticed a change in behavior at the provider level yet.

Sustained sales of water technologies is uncertain. Key to WIT's strategy was to subsidize the price of water technologies, with the hope that farmers would experience the value of the technologies and be encouraged to continue investing. However, there is limited evidence that there is a positive return on investment for farmers and households to invest in water saving technologies at the current retail price of equipment and given the low price of water. Some of WIT's most recent work has shown that there is growing evidence that improved irrigation improves productivity but this has not been packaged into a "business case for farmers" yet. The same applies to households. This raises questions on whether there will be a significant positive and sustainable increase in adoption once WIT ends.

The adoption of financial services to support water-saving technologies brought mixed results. One of the success stories of WIT was the successful rollout of the revolving loan program for households. Collaboration with local community-based organizations successfully supported the disbursement of revolving loans to households to purchase water saving technologies, and the integration of these loan programs with technology providers was noted as a success by WIT's partners. Demand from households for revolving loans has been high, especially to build water harvesting equipment. On the other hand, engagement with banks and more traditional financial services providers didn't yield significant results, as WIT struggled to make the case for their involvement. Feedback from one of WIT's bank partners indicated that before developing a new loan product, demand must be stimulated at the source. Banks are also in need of greater guarantees for return on investment of water saving technologies to de-risk their loans. Rather than lending directly to farmers and households, financial institutions' preference was to extend loans to suppliers, and for these to be channeled to consumers alongside the sale of products.

5. CONCLUSIONS

5.1 Agriculture and water use

Seventy five percent of Jordan's estimated 499 MCM agricultural water use in 2017 was concentrated among 13 crops. In order of water use these crops are olives, tomatoes, dates, clover, peaches, potatoes, grapes, oranges, apricots, lemons, bananas, sweet melons and maize. By focusing on these highest water use crops, this assessment aims to identify findings and conclusions that can lead to high impact recommendations for USAID.

Olives and tomatoes are each unique and important in the context of this study. The top two crops in Jordan in irrigated water use, olives and tomatoes combined to use an estimated 35 percent of Jordan's agricultural water in 2017.

Olive production in Jordan uses nearly twice as much water as tomato production. They also are cultivated on 30 percent of Jordan's agricultural land and are the top agricultural water user in seven out of Jordan's 12 governorates. Olives are by far the most commonly cultivated crop in Jordan, with nearly three quarters of Jordan's 81,812 farmers cultivating olives with nearly half of them cultivated on small farms under 30 dunam. Part of olives' widespread appeal is their hardiness: they are able to produce even without irrigation and in fact over half of Jordan's production is unirrigated. Annually Jordan is close to self-sufficient in olive production, which is primarily used to produce olive oil. Jordan's government has recognized the importance of olives and periodically banned imports of olive oil as well as sponsored events to promote their health benefits.

Tomatoes are Jordan's second highest user of agricultural water. Unlike olives they are nearly entirely irrigated, almost exclusively with drip irrigation. Their production is concentrated in the Jordan Valley and has increased by nearly 50 percent in the past two decades. Tomatoes are Jordan's largest agricultural export, with the majority destined for markets in the Middle East. Some farmers however are shifting away from tomatoes. Their perishability means they need to be sold quickly after harvest and gluts on the market can lead to low prices at harvest time.

Dates, clover and bananas are the three highest water usage crops per unit of land. Each uses more than one cubic meter of water per dunam cultivated and each is completely irrigated in Jordan. Date production expanded from just over two thousand dunam in 1997 to thirty-two thousand dunam in 2017. Imports more than double exports indicating potential for further growth. Clover crop area has more than doubled between 1997 and 2017 and it is entirely irrigated. This contrasts with Israel where clover is entirely rainfed. Finally, bananas have seen a steep decline in area under production between 2007 and 2017 and rank 11th in their total water use.

Jordan's external agricultural trade is characterized by low prices. Most of Jordan's exports are to lower priced Middle Eastern markets. Jordan earns less on its exports of tomatoes and peaches, its top two exports among key crops, than Turkey which targets Eastern European markets. But the price gap between what is earned by Jordan for its agricultural exports and what can be earned through access to the EU export market is wider. For example, while Jordan earned an average of 0.50 USD for its tomato exports, Morocco earned USD 1.30 for its tomato exports to France and the United Kingdom. Jordan's exporters are said to currently lack the ability to meet the EU's strict trackability and phytosanitary standards and therefore lose out on these higher value markets. In addition to low export prices, border closings with Syria and Iraq and COVID19 induced trade restrictions lead to oversupply on the domestic market and low prices.

Estimates of agricultural water use vary. This assessment estimates agricultural water use in 2017 to be 499 MCM. The MWI measured water used by irrigation at 545 MCM in 2017, and another study used remote sensing to estimate that 691 MCM of agricultural water was used in 2017. Given that illegal abstraction of groundwater is reported to occur in Jordan, the actual amount of agricultural water use is likely to be higher than the MWI figure and the total estimated for this report. For the purposes of this assessment, what is most important is not the total water usage by the agricultural sector but instead the relative water use of different crops. We do not find evidence that these comparisons cannot be made. Nevertheless, consensus on an accurate measure for water use will be important in tracking progress over time in addressing Jordan's water scarcity problems in agriculture.

Irrigated agriculture is constrained by water shortages, contamination and high electricity prices. Farmers respond to water shortages by irrigating less, cultivating less land or purchasing water, which negatively affects yields, revenue and profitability. Salinity largely from over abstracted wells is common and poses similar problems by reducing the per unit effectiveness of applied water if not treated. Turbidity damages irrigation equipment if not filtered. Both problems can be managed but add to farmers costs of production, reducing profitability. Similarly, electricity costs associated with agriculture, including pumping irrigation water, add significantly to the costs of production.

Traditional water conserving practices are common. Most notably farmers irrigate at night to reduce evaporation. Some also follow irrigation schedules designed to optimize water usage. These appear to have been mostly traditional knowledge or learned from neighbors rather than through extensions.

Capital and knowhow, not awareness constrain adoption of new water conserving technologies. One of the key findings from this assessment was that most farmers knew about some water conserving technologies they were not using. They did not use them however mostly because of their cost but also because they did not know how to use them. Extension services are not widespread and few farmers interviewed said that their input suppliers offered technical services.

Knowledge of the water savings effectiveness of water conserving technologies is scarce. One implication is that many farmers had heard about smart irrigation systems and expressed interest in them, but were constrained by their cost. However, according to one estimate these technologies save 10 to 20 percent of irrigated water. This estimate is lower than estimates for other water savings technologies and practices, including more affordable ones (see Table 13). This limited knowledge on the actual water savings potential of technologies constrains the government, the private sector and NGOs from making rational water conservation technology and practice recommendations. And it limits farmers' ability to make sound technology adoption decisions for their farms. Furthermore, it may reduce confidence in promotion of water conserving technologies if results from expensive technology adoption are not consistent with expectations.

There is the potential for Jordan to save significant water in agriculture. A recent study produced a conservative estimate showing that if Jordan was able to replicate Israel's water use efficiency it could reduce its water use by 33 percent for the 14 crops included in that study. The estimated water savings would be greatest for clover, olives and tomatoes.

5.2 Non-agricultural services water use

The challenges for increasing adoption of water saving technologies are the cost and the limited awareness of their water savings benefits. Some businesses do not consider long term cost savings through water savings in deciding whether or not to purchase different technologies. Others may want to evaluate this information but do not know where to find it. Furthermore, water savings technologies are viewed as costly, especially when compared to an unknown or unconsidered cost savings. The result is that many businesses are not adopting water conserving technologies even though it may very well be profitable for them.

> "The best way to tackle the water conservation is by adopting and applying water demand management that includes non-revenue water as a main component. New resources are very limited and it became more costly over time. We need to shift our way of thinking"
>
> - Senior manager of a water utility

Water conservation must be based on a thorough understanding of water balance. Many businesses lack an understanding of their water use and do not have internal protocols to track and manage water use. The result is that many businesses do not know how they use their water and consequently how they could save more water.

In general, there is limited promotion of water conservation for the non-agricultural service businesses. Technology sellers market their products on price rather than water conservation potential and long-term cost savings. National and regional water conservation promotions focus on household rather than business water use. The result is that adoption of water saving technologies and practices is not as common as it could be given the potential for cost savings.

A coordinated planning process across sectors focusing on water conservation is essential to make significant progress on water conservation. Setting targets for water conservation in each sector after understanding the demand and the current use in each sector can steer better the planning, implementation and monitoring and evaluation. This, however, requires better data on water use. There is also an opportunity to better incentivize and raise awareness around water savings through targeted tariff and sales tax relief.

5.3 WIT Activity market system development

Program design

A contracting mechanism that offers implementation flexibility is needed for MSD programs. An MSD activity requires flexibility, as the intervention portfolio must be adapted as implementation progresses and an implementer learns what works, what doesn't, and what other constraints have emerged that require intervention. Contracting arrangements that hold accountable implementers against the delivery of outcomes and impacts (such as cooperative agreements as in the case of WIT, or CPFF term or Time and Materials), rather than deliverables (Fixed price or CPFF completion), allow for the flexibility that an MSD implementer needs.

Staffing changes were made to support the implementation of the MSD approach. The right steps were taken to support WIT's team transition to an MSD approach, such as supporting the existing staff through formal training, and recruiting an MSD advisor to support the Activity through implementation. However, the MSD approach requires implementers to 1) engage with market actors outside of the traditional core value chain actors and 2) adopt a disruptive, entrepreneurial approach to project design and implementation. The existing team, with deep knowledge of water systems could have been supported with additional resources to constructively challenge the current implementation approach and intervention design, and bring a fresh perspective. Engaging with market actors to promote the adoption of new business models, products and policies requires team members who are versed in speaking the language of the private sector, can open those doors rapidly and who can build trust. Supporting the existing team with private sector and policy engagement specialists could have supported WIT during dialogues with prospective market actors and troubleshooting constraints.

While WIT identified ways to engage with the private sector and leverage their incentives, it struggled to engage with public sector actors. In a resource-constrained environment, influencing the behavior of any market actor, and supporting their adoption of new practices, requires negotiations that leverage specific incentives to change. The interplay of these incentives is different across different types of market actors. For example, commercial incentives are the main driver for private sector companies, and shaping the business case for change for companies requires an understanding of their business model, and the commercial viability of a new practice. For the public sector, on the other hand, incentives are different. They can be political, social and economic, and facilitating change requires engagement and trust building that is more strategic and sustained. The historical reliance of the public sector on donor funding also means that engaging with government counterparts is more challenging. It is difficult to succeed with a strategy specifically designed to engage with public sector actors that accounts for these issues.

Because of the focus on short-term water saving targets, WIT designed activities to specifically achieve quick water saving results. These either affected the sustainability of some initiatives, or took resources and attention away from targeting systemic constraints more crucial to the sustainable adoption of water saving technologies. For example, WIT took the lead in establishing and running demonstration sites, and developing advertising campaigns (such as the distribution of leaflets) to promote water-saving technologies among farmers and households. Leading on these activities meant that the ownership of these activities often remained with WIT, and their cost was not fully built into companies' long-term business models. Subsidizing the cost of water saving technologies also allowed WIT to meet sales and water saving targets immediately, taking the Activity's focus away from decreasing the cost of these technologies from the source, and building the business case for water saving technologies.

Implementation

WIT did not significantly engage in co-creation activities with companies until after they had applied for funding via the Investment Fund. Additionally, a big part of WIT's co-creation support helped applicants through the application process and negotiated co-investment terms. This "hands off" approach was driven by WIT's desire to let companies drive the innovation process by their own knowledge and experience, rather than being "pushed" into a way of doing business that may have not necessarily resonated with them. While this approach is empowering for market actors and maximizes the ownership of any new initiative, it can also have some shortcomings.

- Disruption and innovation can sometimes be driven by a fresh perspective, and the challenge and knowledge that an external party can bring to an organization.
- Engaging with market actors exclusively via an innovation fund can exclude more disruptive organizations that have less experience working with donors and limited understanding of how to apply to an open solicitation.

WIT has done the hard work of shifting the private sector's mindset towards a facilitative approach. MSD projects working in new countries, new sectors, or both, have the difficult job of engaging with market actors that are less used to a facilitative MSD approach, and who might be resistant to this. Building this trust with market actors takes some time, and can sometimes set projects back by up to 12 months. Future MSD projects in the water sector in Jordan will be able to build on WIT's successes and the trust built with market actors, without having to start from scratch. WIT also proved that there is appetite for market actors working in the water sector to co-invest and try new models, which is encouraging for future MSD Activities in this space.

The business case for water saving is emerging, but must be strengthened. To sustainably increase sales of water saving technologies, consumers must have the incentive to invest in new products, and see the return on investment. WIT has shown that the adoption of water saving technologies can bring some returns to farmers (both in terms of yield and quality). WIT has also shown households are looking for products that improve their ability to be independent from an unreliable public water network, and costly water deliveries. Conversations with companies operating in the services sector have also shown that water-saving is a key priority to them, and hotels, restaurants and retailers are looking for ways to decrease their water consumption, and have done so already for years. These lessons should be a starting point for future work in this space so that the incentives of all consumers (households, farmers, services) are quantified and leveraged more effectively.

The business case for water-saving requires a system approach. The high cost of water saving technologies, and the low cost of water means that the return on investment for consumers (both farmers and households) to invest in water saving technologies is in question. Strengthening the business case must require decreasing the cost of water technologies, as well as engaging with policymakers and regulators to incentivize more rational water consumption.

For financial services to work, there must be demand and a business case. In the water market system, financial services allow consumers to buy water saving technologies that they may not have the cash flow to afford but expect to save money with in the future A return on investment is therefore crucial to ensure that consumers see the value in taking a loan, and to decrease the loan risk from the financial services providers' perspective.

6. RECOMMENDATIONS

6.1 Agricultural water use

Recommendation 1 – Prioritize impact water savings crops

Finalize a list of key water savings crops with institutional consensus. Using this assessment as a starting point, USAID should work with government, private sector NGO partners to create a list of priority crops (or crop groupings) with the greatest real-world potential for water savings. These crops should then be the focus of USAID's work and partners should be encouraged to have the same focus. For example, government research and extension work could focus on water conserving technologies for these crops. These priority crops may be selected at the national and subnational level too with local experts. Criteria for finalizing the list of priority crops for water savings can include:

- Current water use
- Potential water use reduction
- Availability, affordability, known effectiveness and suitability of appropriate water conservation technology and practices.
- Applicability of technologies and practices to other crops

Recommendation 2 - Learn from Israel's experience

Learn from Israel's experience - As this assessment notes, for many of the same crops and in many of the same agro-climatic conditions, Israel uses its agricultural water more efficiently than Jordan. While some of these lessons have been captured broadly for the developing world, they should be captured specifically for Jordan.[50] Focusing on the priority crops identified above, USAID should commission and disseminate a study with Jordanian and Israeli experts to

[50] Abraham, Danielle, Thierry Ngoga, Jonathan Said, and Merav Yachin. 2019. "How Israel became a world leader in agriculture and water: Insights from today's developing countries". Tony Blair Institute for Global Change. Available at: https://institute.global/advisory/how-israel-became-world-leader-agriculture-and-water

document practical lessons learned and recommendations for Jordan from Israel's experience in agricultural water conservation.

Recommendation 3 – Build knowledge on water saving technologies

Assemble, commission and disseminate knowledge on water-saving technology effectiveness - There is limited information on the effectiveness of different water conserving technologies in agriculture in Jordan. The information that does exist often has a wide range of estimates. As a result, there does not seem to be consensus on the best practices and technologies for water conservation of different crops in different conditions. USAID could provide Jordan's agricultural sector a public good by:

- Assembling and validating existing research and expert estimations, including those from Israel from recommendation 2.
- Commissioning new research to test untested technologies and practices.
- Helping to disseminate the results through public events and online.

Recommendation 4 – Expand to agricultural water governance and productivity support

While it was not a focus of this assessment, governance in agricultural water appears to be a significant issue.[51] Farmers complained about lack of coordination between the different bodies charged with managing water, about irregular and unpredictable scheduling of water access from the KAC and about other farmers using water illegally. The later issue affects incentives for adoption of water conserving technologies and practices as well as accurate measurement of water use.

In addition to water conservation in agriculture, USAID should also focus on water productivity in its programming. That is, increasing crop yields per unit of water. Farmers are reluctant to invest in water saving technologies because of their cost. This reluctance is understandable given the low prices on export markets and high costs of production due to energy costs. If farming is more profitable, then farmers will be better able to invest in water saving technologies.

6.2 Non-agricultural services water use

Recommendation 1 – Water auditing and accounting practices

Introduce water auditing and accounting concepts at the business and governance level. Water auditing allows businesses, utilities and governments to better understand the water balance including water supply, demand and waste. Water accounting adds analysis of water governance. Companies should have access to water auditing training and reference materials to allow them to better track their own water use. Water utilities and government agencies should receive training on water accounting to allow them to better manage water use.

Recommendation 2 – Water-savings knowledge platform

Initiate water conservation knowledge sharing platform for different stakeholders. An accessible shared platform where different water conservation stakeholders can share information and experiences is crucial to support water conservation efforts. The platform could include training and reference materials for water auditing and simple cost benefit analysis, information on the water savings of different technologies, best practices for water conservation

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[51] Gilmont, Michael. Steve Rayner, Erica Harper, Lara Nassar, Nadav Tal, Mike Simpson, and Hilmi Salem, 2017. "Decoupling National Water Needs for Water Supplies: Insights and Potential for Countries in the Jordan Basin". *The Wana Institute.* Available at: http://wanainstitute.org/en/publication/decoupling-national-water-needs-national-water-supplies-insights-and-potential-countries

and water use data. The platform should be based on the market analysis to provide value to different actors.

Recommendation 3 – Water savings promotional campaign

Conduct Public – private promotional campaign targets for businesses to show the competitive advantages of water conservation. There are water conservation awareness campaigns for households but not for businesses. As a result, business awareness of the potential profitability of water savings investments is not as high as it could be. A public private promotional campaign could be launched to raise awareness of the potential profitability of investing in water savings technologies and practices. This could feature testimonials from some businesses on the cutting edge of water conservation.

Recommendation 4 – Water savings incentives regulator review

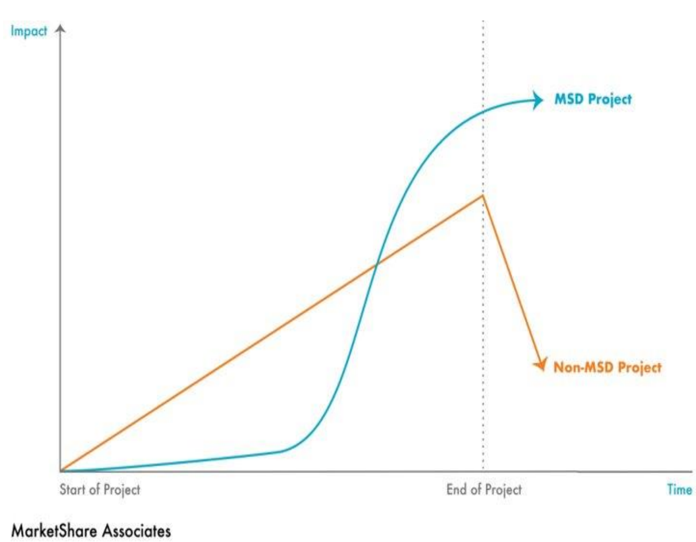
Review water conservation governance and incentives. This review should look at the coordination of water management and how that can be improved. It should also address the need for sector and geography-based water user and conservation targets, how these might be implemented and the capacity of government and water utilities to set and monitor progress against these targets. Additionally, there should be a review of the feasibility of incentivizing water conservation technology adoption across different sectors through tariff and sales tax incentives programs.

6.3 WIT Activity market system development

Recommendation 1 – Setting targets

Targets should be set lower in the first two years of implementation, to give MSD projects the flexibility to test different ideas and business models, and to learn, adapt, and scale-up. MSD projects tend to spend the first two years of implementation co-creating new models with partners, testing their feasibility, adapting them by embedding additional services, and learning what works and what doesn't. Testing, adapting and scaling-up is particularly valuable when working with the private sector, as companies need first-hand evidence on the viability of their business models before deciding whether it deserves more investment and can be scaled-up. This adaptive approach to testing, probing, scaling-up requires targets that do not put pressure on the implementer to take a more hands-on approach during implementation, taking ownership away from the implementer. Moving too quickly may also not allow implementers and their partners to fully test the viability of a new model, running the risk of pushing for the adoption of new practices that are not sustainable in the long run. Targets should therefore be set so that they start slowly for the first few years of implementation, and rapidly scale-up during the second half of the Activity's life to follow the traditional "hockey stick" often used across MSD Activities (see figure 2).

Figure 2: Market systems development "hockey stick"



Targets should include indicators that reward implementers for addressing systemic barriers, not just water-saving goals. Although achieving water-savings during the lifetime of WIT is an important goal, programs should be rewarded for addressing systemic barriers that will support the continued adoption of water saving technologies in the long run. Possible indicators could include:

- Decrease in the average cost of water saving technologies.
- # of farmers showing increases in yields with the adoption of efficient water technologies
- # of households showing a positive return on investment from the adoption of water-saving technologies.

Recommendation 2 – Implementation

Include a policy component. Engagement with government actors and policymakers requires an approach different to the one generally used with private sector actors and community-based organizations. For public sector actors, incentives can be political, social, and economic. Facilitating change requires engagement and trust building that is more strategic and sustained. A policy component should be included that is designed to target public sector market actors and institutions directly.

Build the business case for water saving technologies from the start. The costs and benefits of adopting water saving technologies should be mapped out and quantified (where this is possible) from the start of implementation. Then strategies should be systematically designed to target cost drivers, strengthen revenue drivers, and leverage incentives that support the sustainable adoption of water saving technologies. Behavior change communication campaigns should also be designed to support adoption, leveraging the incentives identified by the business case for change.

Build a project team that is multidisciplinary. To follow the MSD approach, an Activity needs the ability to diagnose issues and successfully engage and build trust with market actors beyond the core value chain. This requires a team with a diverse skill set with the following core skills: private sector engagement, business planning and pricing, business model innovation, policy and advocacy, regulation, water management, agriculture, behavior change communication, financial services.

Take a more proactive approach to partner engagement and co-creation. Innovation with MSD projects is often the outcome of semi-structured co-creation processes where projects become thought partners and advisors to market actors. Future programs should continue building relationships with market actors and take a more flexible approach to co-creation, doing this outside of the structured Investment Fund open solicitation process. This would, however, require a more flexible procurement process that allows for partnerships with market actors and the disbursement of funds without the need of a public solicitation. Future MSD Activities should also take a more proactive approach to deal making by identifying market actors with the will and skill to engage in partnerships and directly pitching innovative ideas to them. These ideas can then be tested with the support of USAID who can buy-down some of the risk.

Recommendation 3 – Intervention portfolio

Integrate financial services products into the rest of the portfolio. Financial services products on their own do not make water technologies more affordable. Instead, they spread the cost out allowing households and farmers to afford expensive products. Financial services are therefore an enabler for the adoption of water saving technology, and work best if they are fully embedded into the sale process. Before rolling out financial products, there therefore must be demand, and the return on investment for consumers must have been proven. When this occurs, MSD activities should then aim to facilitate partnerships between financial services providers and water technology wholesalers to integrate loan products into the buying process.

Marketing and customer outreach activities should be cost and embedded into water saving technology models. Any marketing activity that is crucial to supporting water technologies adoption at scale by consumers must be costed and incorporated into the business model of wholesalers and retailers. This will ensure that business models are successful, and that sales strategies outlive the lifetime of a future MSD Activity.

ANNEXES (See separate attachment)