Increasing Irrigation Efficiency in Jordan: Demand and Supply Side Constraints and Opportunities

Prepared by the International Water Management Institute for Mercy Corps' "Water Innovation Technologies" Project

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Summary

This report provides evidence for improving irrigation efficiency in Jordan. We examine on-farm irrigation practices and water management, barriers and challenges to repairing and maintaining irrigation infrastructure, and farmers' beliefs about the linkages between groundwater depletion and agriculture. Based on this evidence, we identify farmer and farm characteristics as entry points for effecting changes.

Our results suggest that farmers in Jordan face challenges in repairing and maintaining their irrigation equipment, and in accessing professional advice on irrigation. As such, developing value chains and linking farmers to markets will help to increase irrigation efficiency. However, these investments are not likely to have adequate impacts on Jordan's groundwater problems unless the challenges for increasing irrigation efficiency on the demand-side are addressed. This means changing the practices of over-irrigation and sensitizing owners and managers to the role that agriculture has had on groundwater depletion in Jordan.

Our *findings on the supply side* include:

- **Access to and the supply of credit do not appear to be major barriers to replacing irrigation technologies or systems.** Most respondents categorically stated that they have no challenges in accessing credit. This is not surprising given the landscape in Jordan of acquiring credit through the Agricultural Credit Corporation, and the fact that many farms are owned by affluent individuals.
- **There is evidence to suggest that there may be a price story around the repair and maintenance of irrigation devices.** A large share of respondents in the study reported that parts for repairing and maintaining irrigation systems are expensive. A large share also reported that technical support for repairing and maintaining the system is expensive and not readily available.

Our results suggest that the *bigger challenges for increasing irrigation efficiency are on the demand-side*.

- **Farms are over-irrigating, or 'mis-irrigating'**. Many farms reported irrigating their trees daily or a few times a week. A significant share of managers also reported examining the soil, using their own judgment, and irrigating 'when they felt the need' to as ways to determine the timing and duration of irrigation. These practices are likely to result in lower yields due to potential over-irrigation or mis-irrigation.
- **Farmers have a limited understanding of (or the desire to understand) the externalities of groundwater use.** Farmers generally do not believe that agricultural activities have contributed to groundwater issues, and that falling groundwater levels affect farm incomes. They also have a limited understanding of how each farm affects other farms' operations as they all continue to pump and withdraw groundwater.

Recommendations

We relate our evidence-based recommendations to the three outcomes of the WIT project.

Outcome 1: Water Conserved

- **Educate farmers through a 'lead farmer' approach.**
  Survey evidence suggests the need for better information programs that correct mis-conceptions on irrigation practices, and for programs that educate farmers about the potential problems for farm production and profits due to over-irrigation.
  Unfortunately, the vast majority of farmers also categorically stated that they do not want any irrigation-related advice. This creates major barriers for how such information can be distributed, and how readily it will be taken up when it is distributed.
  Fortunately, managers of WIT farms that are larger than 600 *dunums* prefer the Ministry of Agriculture (and to a lesser extent the Ministry of water and irrigation) as an avenue for receiving irrigation advice when they do receive it. This may create an opportunity for the Ministry of Agriculture/WIT to introduce much needed information on correcting irrigation practices by using the larger WIT farms as 'leaders', or 'early adopters', who then share information with smaller farms. Since a vast majority of respondents stated that other farmers are their preferred source for receiving irrigation advice, a 'lead

farmer' approach may be feasible in the Jordan context to disseminate information about proper irrigation practices for not only conserving water but also improving yields.

- **Facilitate the supply of repair and maintenance services and parts.**
  Since farmers report challenges with availability and affordability, and since appropriately maintained and repaired irrigation systems operate more efficiently, efforts to improve maintenance and repair services could pay dividends not only for the farmers' bottom line, but may also reduce total water use in the country.

Outcome 2: Improved Access to Finance for Water Conservation Technology Adoption

- **Making access to credit easier or cheaper may not be the best place for the public sector to put its efforts.**
  As noted above, access to and the supply of credit do not appear to be major barriers to replacing irrigation technologies or systems, since most respondents categorically stated that they have no challenges in accessing credit.

Outcome 3: Strengthened Institutions to Support Water Conservation

- **Sensitize farmers to the externalities of groundwater use through a 'lead farmer' approach.**
  Farmers' lack of understanding about the externalities associated with agricultural groundwater use is problematic since it likely dampens their motivations for changing their pumping behaviors and related investment decisions. These perceptions clearly need to be corrected in order for strengthened governmental and non-governmental institutions to effectively deliver and administer water networks and supplies. This is another opportunity for the Ministry of Agriculture/WIT to work with lead farmers. Once they are sensitized to these externalities, large WIT farms can more effectively be inspired to seek out new technologies. Moreover, they will be better placed to share their understanding of the externalities as well as their experiences and knowledge about the new technologies with other farmers.

1 Introduction

The problems of groundwater-based farming in Jordan are well known. In recent years, there have been serious declines in both the quantity and quality of groundwater available for agriculture. This has not only increased pumping costs, and consequently the costs of production, but has also affected the quality of agricultural outputs and thus revenues. These deteriorations in water levels and quality threaten the profitability (short-term) and survival (long-term) of high-value agriculture in Jordan. Thus, improving irrigation efficiency in the face of increasing costs of irrigation is a *necessary* condition for reducing both pumping costs (and thus maintaining farmers' net incomes) and the over-abstraction of groundwater (though it may not be *sufficient*; Hussein, 2018).

Traditionally, much of the focus on improving irrigation efficiency has been on the supply side, with efforts made to increase the availability of and access to attractive loans, and to develop value-chains for irrigation infrastructure and equipment in order to increase the connectivity between farmers and suppliers. Less attention has been paid to the demand side, specifically to understanding behaviors pertaining to on-farm irrigation practices and water management. Even less attention has been paid to understanding farmers' beliefs about groundwater over-abstraction and its linkages to agriculture. Such demand-side factors affect not only farmers' decisions to purchase better irrigation infrastructure and to adopt expert advice, but also their incentives to change their on-farm irrigation practices and water management. In addition, hardly any attention has been paid to mapping farmer and farm characteristics to behaviors (as different behaviors are likely to work for different types of farmers and farms). Specifically, the size of the farm, whether the owners and managers are the same individuals, and the age of the existing irrigation system may determine behaviors pertaining to changing practices.

This report provides evidence for improving on-farm irrigation practices and water management, for reducing barriers and challenges to the repair and maintenance of irrigation infrastructure, and for changing farmer beliefs about the linkages between groundwater depletion and agriculture. We use farmer and farm characteristics to identify entry points for effecting changes.

In this report, we use the following terminology:

- WIT-farms: Farms that are equal or greater than 200 *dunums* in area
- Non-WIT farms: Farms that are less than 200 *dunums* in area
- WIT-large farms: Farms that are equal to or greater than 600 *dunums* in area
- WIT-small farms: Farms that are equal or greater than 200 *dunums*, and less than 600 *dunums* in area
- Owner: person who owns the farm
- Manager: person who supervises the day-to-day operations of the farm
- Worker: person who performs labor or tasks on the farm but is not the owner or the manager
- WIT-new system: Farms equal or greater than 200 *dunums* in area that have undertaken major repairs, maintenance or replacements of their irrigation systems in the last 10 years (2009-2019).
- WIT old-system: Farms equal or greater than 200 *dunums* in area that have not undertaken any major repairs, maintenance or replacements of their irrigation systems in the last 10 years (2009-2019).

2 Study design and sampling

We randomly selected 414 farms in Azraq (210 farms) and Mafraq (204 farms) for interviews. Of these 414, there were 215 WIT farms and 199 non-WIT farms. Details of the study design and sampling strategy can be found in Appendix 1. The sample is representative of all farms in Azraq and Mafraq.

3 Data

3.1 Questionnaire

Based on a set of detailed key informant interviews with WIT Mercy Corp staff, and two detailed focus group discussions with farmer groups in Azraq and Mafraq (WIT project sites), we designed a questionnaire for survey purposes.

In all cases, we interviewed either the manager or the owner-manager, and collected data on the following characteristics (the questionnaire is attached in Appendix 2).

- Farm, farm owner and farm managers' characteristics; farm management practices (Sections 1, 2, 3, 4, 5)
- Division of irrigation-related tasks on the farm, and on-farm water management practices (Sections 5, 8)
- Beliefs about groundwater use and linkages with agriculture (Section 6)
- Practices and need for expert advice on irrigation practices and technologies (Sections 7, 8)
- Purchase, repair and maintenance of irrigation technology and equipment (Sections 7, 8)

3.2 Description of farms

WIT farms are significantly larger than non-WIT farms. The average size of all farms is 353 *dunums*; the average size of the WIT farms (farms with area 200 *dunums* or greater) is 605 *dunums* and the average size of non-WIT farm is 80 *dunums* (Table 1). About 90% of all farms are cultivated by the owners and their employees, and the remaining 10% farms are rented out.

Some farms do not have any metered wells. While 86.5% of the farms reported at least one metered well, 13.5% of the farms reported not having any metered well (Table 1)**.** Among the farms that have metered well connections, WIT farms have more than non-WIT farms, indicating that larger farms likely have more metered well connections.

A larger number of non-WIT farm owners are also managers. While 52% of WIT farm owners are also the farm managers, 62% of non-WIT farm owners also manage the farms (Table 1). More than 95% of the farms are privately owned, with single private ownership more common among non-WIT farms and multiple private ownership more common among WIT farms (Table 1).

WIT and non-WIT farms cultivate similar crops. More than 75% of farms cultivate olives, followed by grapes (35%), pomegranate (22%), and vegetables (17%); other perennials include palm, pears, peaches, and fodder trees (Figure 1). However, 32% of WIT farms cultivate almonds, compared to only 12% of non-WIT farms.

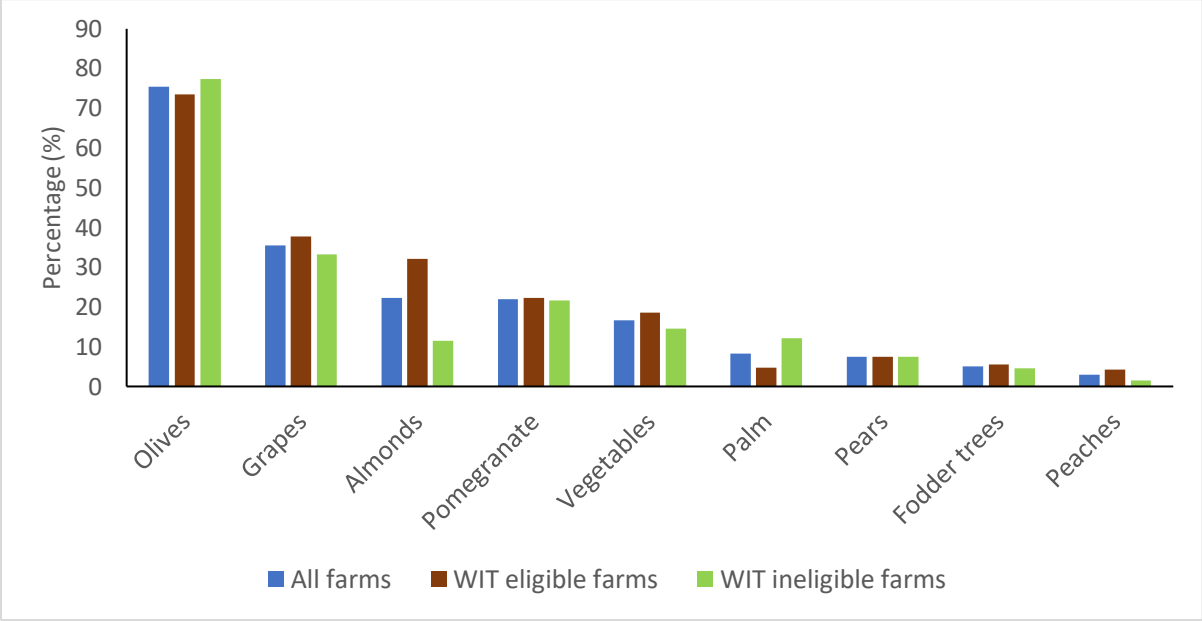


Figure 1: Major crops grown in 2018 in Azraq and Mafraq

3.3 Farm owners' and managers' characteristics

Almost all owners are older literate males, especially for WIT-farms. About 99% of all owners are males in their mid-fifties (Table 2). All WIT farm owners are male, but 2.5% of the non-WIT farm owners are female (Table 2). Owners of more than 96% of the farms are educated, with 38% attaining a diploma or higher education (Table 2). A significantly higher share of WIT-farm owners completed a diploma, indicating that more educated owners were likely to own larger farms (Table 2).

Fewer WIT-farm owners reside in the local community compared to non-WIT farms. More than 52% of all owners reside either on the farm or in the local community; however, 57% of WIT farm owners reside outside the local community (primarily Amman), compared to 38% of non-WIT farm owners (Table 2).

The primary occupation of most farm owners is cultivating their farms. This is especially the case for WIT-farms. Twenty-eight percent of all owners also work in non-agricultural business, while 10% work as salaried employees, and about 9% do not work at all or are retired

(Table 2). The share of the WIT farm owners cultivating their own farm is greater (57%) than that for non-WIT farm owners (48%) (Table 2).

Managers who are not owners are educated middle-aged males. Non-owner managers are mostly in their mid-forties and more than 93% are educated, with 42% attaining a diploma or above. There are no differences in the education levels WIT and non-WIT farm managers. More than 67% of non-owner managers are Jordanian, 28% are of Egyptian origin, and the rest (5%) are of Syrian, Sudanese, or Iraqi origin.

While most non-owner managers reside locally, non-WIT farm managers are more likely to do so. More than 83% of all non-owner managers reside either on the farm or in the local community. The share of these managers residing locally is significantly higher among non-WIT farms (87%) compared to WIT farms (81%) (Table 3). Consequently, 19% of the WIT farm non-owner managers resided elsewhere (primarily Amman), compared to 13% for non-WIT farms.

Many non-owner managers managed more than one farm. This is especially the case for those managing non-WIT farms. The primary occupation of 47% of all non-owner farm managers is cultivating just one farm, while 43% *also* work on other farms. Some non-owner managers also work as non-agricultural entrepreneurs and salaried employees outside the farm. A greater share of WIT-farm non-owner managers only work on one farm (55%) compared to non-WIT farm non-owner managers (36%), indicating that non-owner managers of larger farms were less likely to engage in other opportunities (including managing more than one farm).

3.4 Farm management practices

Farm management practices depend on farm size and the number of workers, with WIT farms having more workers and managers, and meeting more regularly with workers to coordinate activities. WIT farms are larger, and consequently have more workers. WIT farms reported an average of 8 permanent salaried workers working on the farm, as compared to 3 for non-WIT farms (Table 4a). WIT farms also reported hiring around 101 daily wage workers in the past 12 months, as compared to 61 for non-WIT farms. While 74% of WIT farms reported daily meetings between managers and workers, only 61% of non-WIT farms reported the same. While

only 4% of WIT farms reported meetings between managers and workers to be twice a month or less, 10% of non-WIT farms reported the same.

Managers and workers on WIT-large farms meet less often than on WIT-small farms. While almost 17% of WIT-large farms reported that managers meet with workers a few times a week, only 6% of WIT-small farms reported the same (Table 4b), indicating that regular meetings occur less frequently on very large farms.

WIT-small farms have more family workers than WIT-large farms. While WIT-small farms reported 2 family members working on the farm, WIT-large farms reported less than 1 such person on average (Table 4b), indicating that that family labor is more likely used on smaller farms.

4 Results

These results are organized into four sections for the ease of the reader:

- Division of irrigation-related tasks on the farm, and on-farm water management practices
- Beliefs about groundwater use and linkages with agriculture
- Practices and need for expert advice on irrigation practices and technologies
- Purchase, repair and maintenance of irrigation technology and equipment

4.1 Division of irrigation-related tasks on the farm, and on-farm water management practices

Managers make irrigation-related decisions. Keeping in mind that 57% of farm managers are owners and 43% are non-owners, we find that 44% of farm decisions about the hours and duration of groundwater pumping are made by owner managers, and 30% are made by non-owner managers (Table 5). Owner managers make 44% of the decisions about the need for repairs and maintenance of irrigation devices, while non-owner managers make 26%. Owner managers make 49%, and non-owner managers make 29% of the decisions about when devices need repair and maintenance. Similarly, 49% of the decisions about the irrigation plans for the farms are made by owner managers, while 29% are made by non-owner managers. Slightly more

of the decisions about the need to replace irrigation devices are made by both owner managers (51%) and non-owner managers (31%). Finally, owner managers make 55% of the decisions about purchasing pesticides and fertilizers, while 23% non-owner managers make such decisions.

Salaried workers are responsible for physically intensive activities on all farms. Salaried workers have primary responsibility for operating the pumps on the 49% of the farms, while they are responsible for irrigating the farms on 57%, and for applying fertilizers and pesticides on 40% (Table 5).

A vast majority of all farms use drip irrigation systems, with more WIT farms reporting drip use for a greater number of years. Ninety-three percent of WIT farms and 86% of non-WIT farms reported using drip irrigation; and WIT farms reported drip system use for four more years than non-WIT farms (15 years compared to 11 years; Table 6). More non-WIT farms reported using other methods of irrigation than WIT farms. Among WIT farms, 7% of WIT-old system farms reported using surface runoff irrigation; none of the WIT-new system farms reported doing so.

The use of drip irrigation kits is high. Eighty-nine percent of all farms reported using such devices (Table 6); but the use of devices such a pressured/pressure-compensating pipes and smart panels is limited. This is equally true for WIT-new system farms and WIT-old system farms.

WIT farms irrigate more frequently than non-WIT farms. Twenty-seven percent of WIT farms reported irrigating the farm daily, compared to 13% of non-WIT farms (Table 6). About 54% of WIT farms and 45% of non-WIT farms reported irrigating the farm a few times a week. In contrast, almost 28% of non-WIT farms reported irrigating weekly, compared to 16% of WIT farms. Around 14% of non-WIT farms reported irrigating a few times a month or less frequently, as compared to 2% of WIT farms. WIT-new system farms reported irrigating less frequently; almost 61% of them reported irrigating a few times a week, while 34% of WIT-old system farms reported irrigating daily.

WIT farms and non-WIT farms use a variety of methods to determine the timing and duration of irrigation. While 71% of WIT farms and 63% of non-WIT farms reported following the crop's irrigation calendar, other common methods for determining the timing of irrigation include examining the soil moisture and irrigating when the manager 'felt the crop needed water' (Table 6). Common practices for determining the duration of irrigation are using personal judgment and observing of the moisture content of the soil, rather than following expert opinion.

4.2 Beliefs about groundwater use and linkages with agriculture

Overall, managers believe that the chances of groundwater levels falling in the governorate in the next five years is low. On a scale of 0-10, with an increment of one unit representing 10%, WIT farms believe that there is only a 50% chance of groundwater levels in their governorate falling in the next 5 years (Table 7). Non-WIT farms believe that there is a 47% of this happening (Table 7). This is similar for farms where owners and managers were the same and different individuals.

Overall, managers do not believe that their farming activities will affect groundwater issues in the next 5 years. WIT farms believe that the chance of farming activities affecting groundwater issues in the next five years is 54%, while non-WIT farm managers believe those chances are 47% (Table 7). This is similar for farms where owners and managers are the same and different individuals.

The understanding that each farm affects every other farm's groundwater pumping cost (as pumping by all farms leads to falling groundwater levels, which increases everyone's pumping cost) is rather low. WIT farm managers believe that the probability that other farms' use of groundwater has affected the cost of pumping on their farm is only 48%, while non-WIT farm managers believe that the probability is 44% (Table 7). This is similar for farms where owners and managers are the same and different individuals.

Both WIT and non-WIT farms do not believe that the probability of their farm incomes being lower in the next five years due to groundwater issues is very high. WIT-farm

managers believe that there is a 49% chance while non-WIT farm managers believed that there is a 53% chance (Table 7). This is similar for farms where owners and managers are the same and different individuals.

However, both WIT and non-WIT farms believe that the probability is rather high that new irrigation systems will reduce groundwater use and pumping costs. For reducing groundwater use, WIT farm managers think the probability is 72%, while non-WIT farm managers think the probability is 78% (Table 7). For reducing pumping costs, WIT farm managers think the probability is 68%, while non-WIT farm managers think the probability is 76% (Table 7).

4.3 Practices and need for expert advice on irrigation practices and technologies

Less than half of farm managers met with irrigation experts in the previous five years, and less than half of managers reported wanting any irrigation-related information. Forty six percent of farm managers reported meeting with an irrigation expert at least once in the previous five years (Table 8). Those who did meet with these experts received information an average of 10 times over the five years. The fact that so many managers did not seek out advice could follow from the fact that 46% reported not needing any irrigation advice at all (Table 8 and Figure 2). This does not mean that farm managers in general do not want advice. Indeed, 28% expressed interest in receiving information on improved irrigation methods. This is particularly the case for WIT-small farms. Just over 31% of managers of these farms want information on irrigation methods, compared to 20% of managers of WIT-large farms. Other information that managers wish to receive includes irrigation system design (16%), water quality, soil type and plant requirements (15%), and irrigation management (12%).

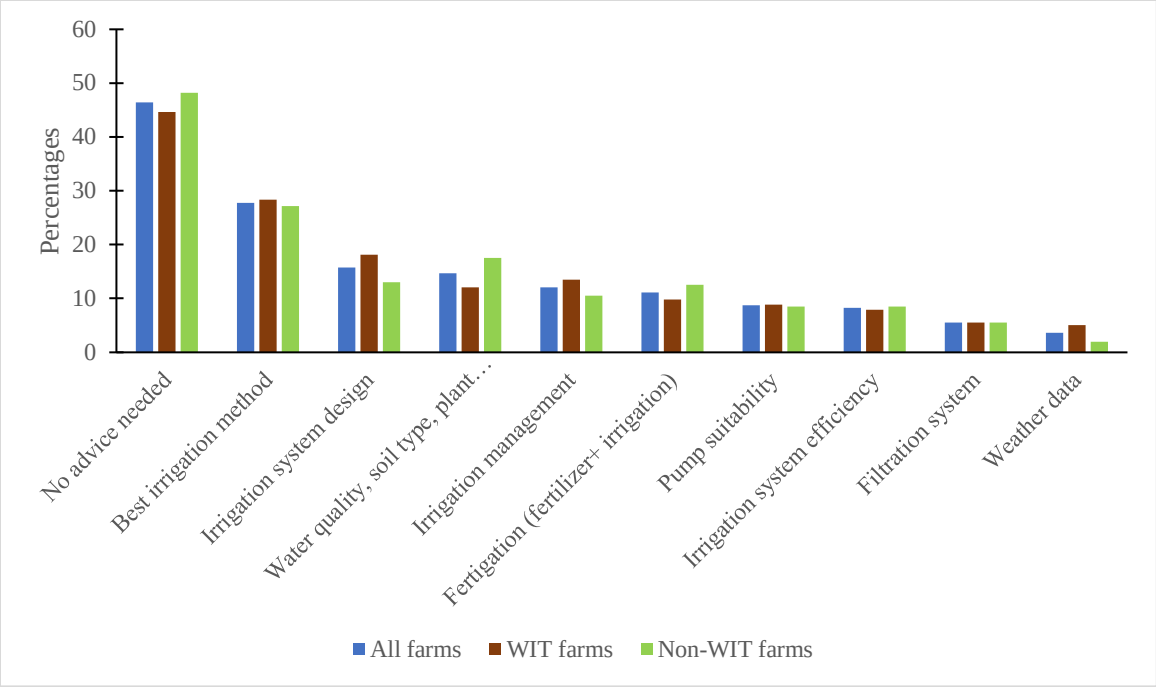


Figure 2: Type if irrigation information managers wished to receive

When seeking advice on irrigation, farm managers mostly turn to fellow farmers and neighbors. Half of non-WIT farm managers turn to this source, while 42% of WIT farms do (Table 8 and Figure 3). WIT farm managers also seek advice from private irrigation companies (45%) and other government agencies (23%), with the latter driven mostly by WIT-small farms (27% vs. 13% of WIT-large farms). Non-WIT farm managers turn more to the Ministry of Agriculture (36%) and Ministry of Water and Irrigation (23%).

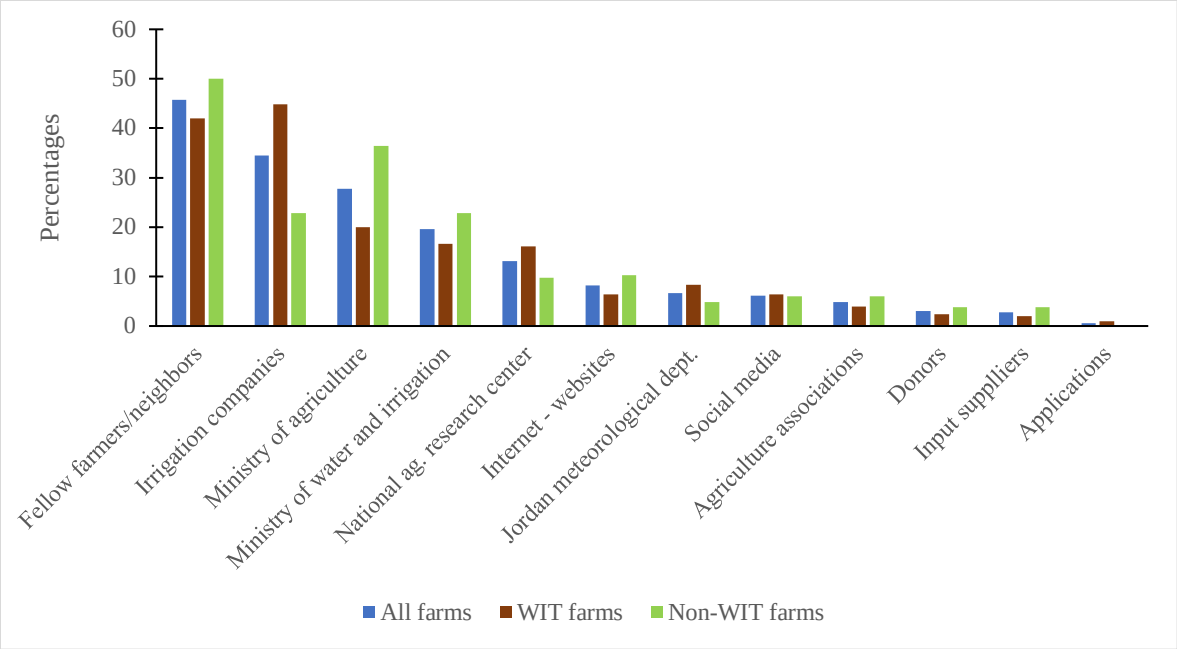


Figure 3: Preferred entity to provide irrigation information

When they do receive irrigation information, farm managers prefer to receive it through social media. Forty five percent of WIT farm managers prefer social media, while 41% of non-WIT farms do, though this difference is not statistically significant (Figure 4). This is followed for all managers by websites (25%) and TV (16%). Although 10% of all managers favor receiving information through events and printed materials, managers of WIT-small farms are particularly receptive (14%). Similarly, while less than 5% of all managers prefer to receive information through SMS, nearly 12% of managers of WIT-large farms do.

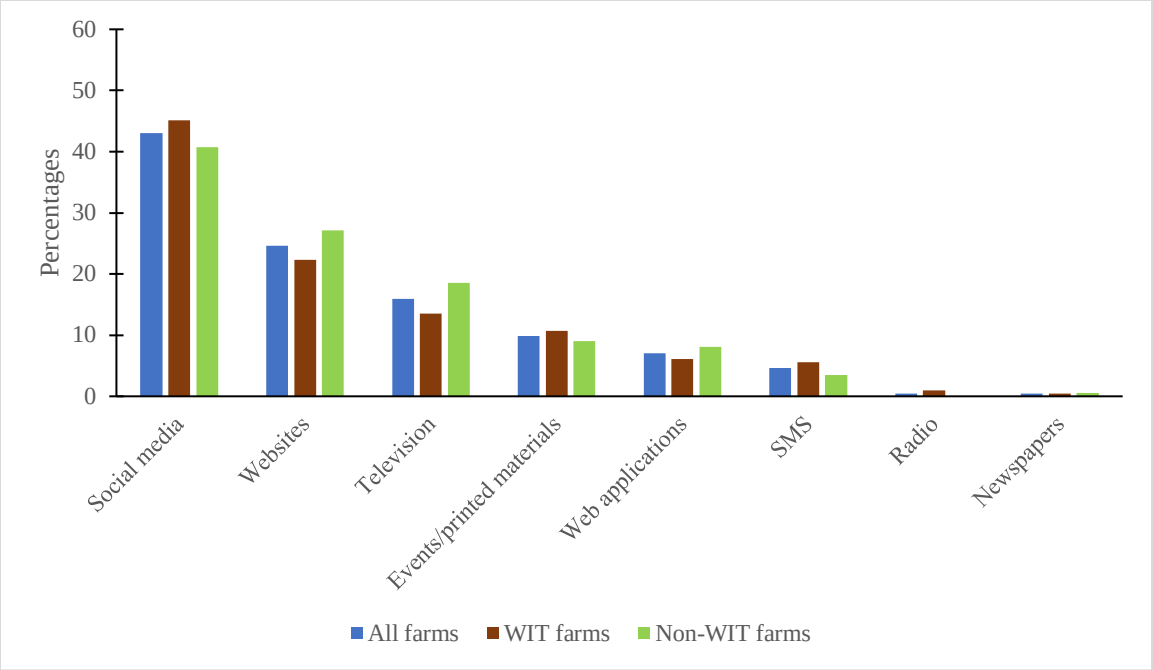


Figure 4: Preferred channel to receive irrigation information

4.4 Purchase, repair and maintenance of irrigation technology and equipment

For purchases of irrigation equipment, a majority of farm managers consults with experts, and most buy from wholesalers in Amman. Sixty three percent of all farm managers consult with experts before purchasing irrigation equipment (Table 9). Amman is the typical location where these purchases take place. While 79% of non-WIT farms acquire their equipment in the capital city, an even greater share (87%) of WIT farms do so. WIT-small farms are even more inclined to purchase equipment in Amman (91%) than were WIT-large farms (67%).

Wholesalers account for the lion's share of suppliers for all farms. Seventy-two percent of all farms source irrigation equipment from wholesalers (Table 9). Wholesalers make up 81% of irrigation equipment suppliers for WIT-large farms. This is considerably greater than the 67% of WIT-small farms that rely on wholesalers. These smaller farms also turn to retailers (12%), international traders (11%) and irrigation equipment companies (8%). Non-WIT farms also turn to retailers (18%) as their primary alternative to wholesalers for sourcing equipment.

WIT farms are more inclined to think about product quality, rather than affordability and trustworthiness. Although all managers care about product quality (34%), affordability (25%) and trustworthiness (23%) when choosing a seller, WIT farm managers were more inclined to care about product quality (42%) than affordability (21%) and trustworthiness (22%) (Table 9). This is especially the case for WIT-small farms, where 46% of managers reported that the quality of the products on offer is the primary reason for choosing the supplier, compared to 32% for WIT-large farms. This emphasis on quality over affordability by WIT managers compared to non-WIT managers may be associated with the finding that the former tend to take the equipment back to the supplier for repairs more than the latter do (47% vs. 38%).

Access to credit does not appear to be a problem and the Agricultural Credit Corporation is a main source of credit. Only 15% of all farms received loans in the previous five years in order to purchase irrigation equipment; and when they did so, they took out an average of two loans over this time-period (Table 10). Most (82%) managers reported that they face no challenges related to acquiring credit. This is especially the case for WIT-large farms (92%), though 81% of WIT-small and 80% of non-WIT farms also do not encounter problems (Table 10). In the few cases where managers reported encountering problems, high interest rates (7%) and difficulty in contacting credit providers (3%) were cited. The main source of loans for all farms is the Agricultural Credit Corporation (71%). WIT-large farms also rely on commercial banks, while WIT-small and non-WIT farms rely on other sources (Table 10).

For repair and maintenance of irrigation equipment, farm managers largely respond to the conditions of their irrigation equipment and use their own judgement when making decisions. Fewer than 10% of farm managers follow their seller's schedule (5%) or use the advice of experts (3%) in determining the need for repair and maintenance (Table 11). They mainly respond to the conditions of the irrigation equipment (79%) or use their own judgement for scheduling maintenance (21%).

Availability and affordability of parts and technical support are important challenges for repair and maintenance. Over three quarters of managers reported challenges with accessing technical support and parts. Only 23% of managers stated that they encounter no problems with technical support, while only 25% are challenge-free in terms of finding parts.

Both price and availability are challenges for technical support. Just over half of managers have difficulty with affordability, while 48% have difficulty with availability. The price of technical support is more of a problem for WIT-old systems than WIT-new systems. Sixty-six percent of the former reported affordability problems, while 49% of the latter did so (30% and 19%).

High prices are the main challenge when it comes to parts for repair. Seventy-one percent of all managers reported affordability problems. This is more of a challenge for WIT farms (75%) than for non-WIT farms (67%). Although the order of magnitude is not as large for prices, the lack of availability of parts affects nearly 20% of all farms, and impacts non-WIT farms (23%) more than WIT farms (13%).

5 Recommendations

Our results suggest that farmers in Jordan face challenges in repairing and maintaining their irrigation equipment, and in accessing professional advice on irrigation. As such, developing value chains and linking farmers to markets will help to increase irrigation efficiency. However, these investments are not likely to have adequate impacts on Jordan's groundwater problems unless the challenges for increasing irrigation efficiency on the demand-side are addressed. This means changing the practices of over-irrigation and sensitizing owners and managers to the role that agriculture has had on groundwater depletion in Jordan.

Our findings on the supply side include:

- **Access to and the supply of credit do not appear to be major barriers to replacing irrigation technologies or systems.** Most respondents categorically stated that they have no challenges in accessing credit. This is not surprising given the landscape in Jordan of acquiring credit through the Agricultural Credit Corporation, and the fact that many farms are owned by affluent individuals.
- **There is evidence to suggest that there may be a price story around the repair and maintenance of irrigation devices.** A large share of respondents in the study reported that parts for repairing and maintaining irrigation systems are expensive. A large share also

reported that technical support for repairing and maintaining the system is expensive and not readily available.

Our results suggest that the bigger challenges for increasing irrigation efficiency are on the demand-side.

- **Farms are over-irrigating, or 'mis-irrigating'**. Many farms reported irrigating their trees daily or a few times a week. A significant share of managers also reported examining the soil, using their own judgment, and irrigating 'when they felt the need' to as ways to determine the timing and duration of irrigation. These practices are likely to result in lower yields due to potential over-irrigation or mis-irrigation.
- **Farmers have a limited understanding of (or the desire to understand) the externalities of groundwater use.** Farmers generally do not believe that agricultural activities have contributed to groundwater issues, and that falling groundwater levels affect farm incomes. They also have a limited understanding of how each farm affects other farms' operations as they all continue to pump and withdraw groundwater.

Recommendations:

We relate our evidence-based recommendations to the three outcomes of the WIT project.

Outcome 1: Water Conserved

- **Educate farmers through a 'lead farmer' approach.**
  Survey evidence suggests the need for better information programs that correct mis-conceptions on irrigation practices, and for programs that educate farmers about the potential problems for farm production and profits due to over-irrigation.
  Unfortunately, the vast majority of farmers also categorically stated that they do not want any irrigation-related advice. This creates major barriers for how such information can be distributed, and how readily it will be taken up when it is distributed.
  Fortunately, managers of WIT farms that are larger than 600 *dunums* prefer the Ministry of Agriculture (and to a lesser extent the Ministry of water and irrigation) as an avenue for receiving irrigation advice when they do receive it. This may create an opportunity for the Ministry of Agriculture/WIT to introduce much needed information on correcting

irrigation practices by using the larger WIT farms as 'leaders', or 'early adopters', who then share information with smaller farms. Since a vast majority of respondents stated that other farmers are their preferred source for receiving irrigation advice, a 'lead farmer' approach may be feasible in the Jordan context to disseminate information about proper irrigation practices for not only conserving water but also improving yields.

- **Facilitate the supply of repair and maintenance services and parts.**
  Since farmers report challenges with availability and affordability, and since appropriately maintained and repaired irrigation systems operate more efficiently, efforts to improve maintenance and repair services could pay dividends not only for the farmers' bottom line, but may also reduce total water use in the country.

Outcome 2: Improved Access to Finance for Water Conservation Technology Adoption

- **Making access to credit easier or cheaper may not be the best place for the public sector to put its efforts.**
  As noted above, access to and the supply of credit do not appear to be major barriers to replacing irrigation technologies or systems, since most respondents categorically stated that they have no challenges in accessing credit.

Outcome 3: Strengthened Institutions to Support Water Conservation

- **Sensitize farmers to the externalities of groundwater use through a 'lead farmer' approach.**
  Farmers' lack of understanding about the externalities associated with agricultural groundwater use is problematic since it likely dampens their motivations for changing their pumping behaviors and related investment decisions. These perceptions clearly need to be corrected in order for strengthened governmental and non-governmental institutions to effectively deliver and administer water networks and supplies. This is another opportunity for the Ministry of Agriculture/WIT to work with lead farmers. Once they are sensitized to these externalities, large WIT farms can more effectively be inspired to seek

out new technologies. Moreover, they will be better placed to share their understanding of the externalities as well as their experiences and knowledge about the new technologies with other farmers.

Table 1: Farm characteristics

	All farms	WIT farms	Non-WIT farms	p-value
	1	*2*	*3*	*4*
Farm characteristics				
Farm area (*dunums*)	352.7	605.0	80.2	0.00
	(23.7)	(38.1)	(3.8)	
Age of the farm under current owner	16.6	15.8	17.6	0.12
	-0.6	-0.8	-0.9	
Farm is WIT eligible (>200 *dunums*) (%)	51.9	-	-	
	(2.3)			
Farm is cultivated by the owner/employees (%)	89.6	88.4	91.0	0.39
	(1.5)	(2.2)	(2.0)	
Farm is rented out or contract farming (%)	10.4	11.6	9.0	0.39
	(1.5)	(2.2)	(2.0)	
Farm has one or more metered well (%)	86.5	88.8	83.9	0.14
	(1.6)	(2.0)	(2.6)	
Number of metered wells on the farm	1.2	1.3	1.0	0.00
	(0.0)	(0.1)	(0.0)	
Owner is the manager of the farm (%)	56.8	52.1	61.8	0.05
	(2.4)	(3.4)	(3.5)	
Private owner, single (%)	55.1	50.7	59.8	0.06
	(2.4)	(3.4)	(3.4)	
Private owner, multiple (%)	39.9	45.6	33.7	0.01
	(2.4)	(3.4)	(3.4)	
Government or other owner (%)	5.1	3.7	6.5	0.19
	(1.1)	(1.3)	(1.7)	
Number of observations	414	215	199	

Notes: Point estimates are means. Standard errors are in parentheses.

Table 2: Farm owners' characteristics

	All farms	WIT farms	Non-WIT farms	p-value
	1	*2*	*3*	*4*
Demographics				
Age	56.0	54.6	57.4	0.05
	(0.7)	(1.0)	(1.0)	
Owner is male (%)	98.8	100.0	97.5	0.02
	(0.5)	(0.0)	(1.1)	
Owner is educated (% at least primary)†	96.5	96.9	96.0	0.64
	(1.0)	(1.2)	(1.5)	
Highest education level completed				
Primary or less (%)	19.1	16.3	22.1	0.13
	(1.9)	(2.5)	(2.9)	
Secondary (%)	8.7	5.6	12.1	0.02
	(1.4)	(1.6)	(2.3)	
High school (%)	24.2	25.6	22.6	0.48
	(2.1)	(3.0)	(3.0)	
Diploma or above (%)	37.7	43.3	31.7	0.01
	(2.4)	(3.4)	(3.3)	
Residency status				
Resides on the farm (%)	14.3	13.0	15.6	0.46
	(1.7)	(2.3)	(2.6)	
Resides in the local community (%)	38.2	30.2	46.7	0.00
	(2.4)	(3.1)	(3.5)	
Resides elsewhere (%)	47.6	56.7	37.7	0.00
	(2.4)	(3.2)	(3.3)	
Occupation status				
Cultivates the farm (%)	52.9	57.2	48.2	0.07
	(2.4)	(3.4)	(3.4)	
Non-agricultural business (%)	28.0	27.4	28.6	0.79
	(2.2)	(3.0)	(3.1)	
Salaried employee (%)	10.4	8.8	12.1	0.28
	(1.5)	(1.9)	(2.3)	
Retired/does not work (%)	8.7	6.5	11.1	0.10
	(1.4)	(1.7)	(2.2)	
Observations	414	215	199	

Notes: Point estimates are means. Standard errors are in parentheses. † 10.4% of the farms report not knowing the education level of the owner.

Table 3: Farm manager's characteristics, if owner is not the manager

	All farms	WIT farms	Non-WIT farms	p-value
	1	*2*	*3*	*4*
Demographics				
Age	42.2	41.6	43.1	0.43
	(0.8)	(1.0)	(1.5)	
Manager is male (%)	100.0	100.0	100.0	
	-	-	-	
Years in-charge of the current farm	8.8	9.7	7.5	0.04
	(0.5)	(0.7)	(0.7)	
Manager is educated (%)	93.7	92.1	95.9	0.28
	(1.8)	(2.7)	(2.3)	
Highest education level completed				
Primary or less (%)	24.6	25.2	23.7	0.81
	(3.2)	(4.3)	(4.9)	
Secondary (%)	6.7	4.9	9.2	0.27
	(1.9)	(2.1)	(3.4)	
High school (%)	24.6	24.3	25.0	0.91
	(3.2)	(4.3)	(5.0)	
Diploma or above (%)	41.9	43.7	39.5	0.57
	(3.7)	(4.9)	(5.7)	
Nationality				
Jordanian (%)	67.0	68.9	64.5	0.53
	(3.5)	(4.5)	(5.6)	
Egyptian (%)	28.5	29.1	27.6	0.83
	(3.4)	(4.4)	(5.2)	
Other (Syrian, Sudanese, Iraqi etc.) (%)	0.0	0.0	0.1	0.08
	(0.0)	(0.0)	(0.0)	
Residency status				
Resides on the farm (%)	52.5	46.6	60.5	0.06
	(3.8)	(5.0)	(5.6)	
Resides in the local community (%)	57.0	66.0	44.7	0.00
	(3.6)	(4.6)	(5.7)	
Resides elsewhere (%)	16.8	19.4	13.2	0.26
	(2.8)	(3.9)	(3.8)	
Occupation status				
Manages/Cultivates other farm (%)	42.5	36.9	50.0	0.08
	(3.7)	(4.8)	(5.8)	
Non-agricultural business (%)	4.5	1.9	7.9	0.08
	(1.5)	(1.4)	(3.1)	
Salaried employee (%)	6.1	5.8	6.6	0.84
	(1.8)	(2.3)	(2.9)	
No other occupation (%)	46.9	55.3	35.5	0.01
	(3.7)	(4.9)	(5.5)	
Observations	179	103	76	

Notes: Point estimates are means. Standard errors are in parentheses.

Table 4a: Farm management practices

	All farms	WIT farms	Non-WIT farms	p-value
	1	*2*	*3*	*4*
In the last 12 months				
Number of salaried workers worked on the farm	5.5	7.9	2.9	0.00
	(0.5)	(0.7)	(0.7)	
Number of family workers worked on the farm	1.6	1.7	1.5	0.48
	(0.1)	(0.2)	(0.2)	
Number of daily wage workers worked on the farm	70.1	101.0	36.7	0.00
	(8.9)	(15.6)	(7.4)	
How often do all workers meet with the farm manager?				
Daily (%)	68.1	74.4	61.3	0.00
	(2.1)	(2.8)	(3.3)	
Once a week (%)	11.1	11.2	11.1	0.97
	(1.5)	(2.1)	(2.2)	
Few days a week (%)	10.6	9.3	12.1	0.37
	(1.5)	(2.0)	(2.3)	
Twice a month or less frequently (%)	7.0	4.2	10.1	0.02
	(1.2)	(1.3)	(2.1)	
Never (%)	3.1	0.9	5.5	0.01
	(0.8)	(0.7)	(1.6)	
Observations	414	215	199	

Notes: Point estimates are means. Standard errors are in parentheses.

Table 4b: Farm management practices in WIT farms (N=215)

	All farms	WIT-large farms	WIT-small farms	p-value
	1	*2*	*3*	*4*
In the last 12 months				
Number of salaried workers worked on the farm	7.9	10.4	7.0	0.14
	(0.7)	(2.0)	(0.6)	
Number of family workers worked on the farm	1.7	0.8	2.1	0.00
	(0.2)	(0.3)	(0.2)	
Number of daily wage workers worked on the farm	101.0	119.6	94.0	0.49
	(15.6)	(32.5)	(17.5)	
How often do all workers meet with the farm manager?				
Daily (%)	74.4	67.8	76.9	0.19
	(2.8)	(5.9)	(3.1)	
Once a week (%)	11.2	10.2	11.5	0.77
	(2.1)	(3.9)	(2.6)	
Few days a week (%)	9.3	16.9	6.4	0.05
	(2.0)	(5.0)	(1.9)	
Twice a month or less frequently (%)	4.2	3.4	4.5	0.70
	(1.3)	(2.4)	(1.6)	
Never (%)	0.9	1.7	0.6	0.56
	(0.7)	(1.7)	(0.6)	
Observations	215	59	156	

Notes: Point estimates are means. Standard errors are in parentheses. WIT-small farms are 200-600 dunums. WIT-large farms are 600+ dunums.

Table 5: Division of labor for different farm activities (N=414)

Activities	Owner (also the manager)	Owner (not the manager)	Manager (not the owner)	Salaried worker	Daily wage worker	Family member
Pump water out of the well	22.2	3.6	20.8	48.8	1.4	3.1
	(2.0)	(0.9)	(2.0)	(2.5)	(0.6)	(0.9)
Determine groundwater pumping hours & duration	44.2	7.0	30.2	15.5	0.7	2.4
	(2.4)	(1.2)	(2.3)	(1.8)	(0.4)	(0.8)
Conduct repair and maintenance of irrigation devices	44.0	8.0	26.3	15.0	4.3	2.4
	(2.4)	(1.3)	(2.2)	(1.8)	(1.0)	(0.8)
Determine if repair and maintenance of irrig. device is needed	48.8	8.9	29.2	10.1	0.5	2.4
	(2.5)	(1.4)	(2.2)	(1.5)	(0.3)	(0.8)
Determine the irrigation plan for the farm	48.8	8.5	30.9	9.9	0.0	1.9
	(2.5)	(1.3)	(2.3)	(1.5)	0.0	(0.7)
Irrigate the farm	18.1	1.2	18.4	56.5	2.2	3.6
	(1.9)	(0.5)	(1.9)	(2.4)	(0.7)	(0.9)
Replace irrigation devices and equipment	47.6	10.4	25.8	11.8	2.2	2.2
	(2.4)	(1.5)	(2.2)	(1.6)	(0.7)	(0.7)
Determine if irrigation devices/ equipment need replace	50.7	8.7	30.7	8.0	0.2	1.7
	(2.5)	(1.4)	(2.3)	(1.3)	(0.2)	(0.6)
Apply fertilizers and pesticides	28.7	2.4	23.7	39.9	2.4	2.9
	(2.2)	(0.8)	(2.1)	(2.4)	(0.8)	(0.8)
Purchase fertilizers and pesticides	54.1	18.4	22.9	1.7	0.7	2.2
	(2.4)	(1.9)	(2.1)	(0.6)	(0.4)	(0.7)

Notes: Point estimates are means. Standard errors are in parentheses. Row percentages add up to 100.

Table 6: Water management and irrigation choices

	All farms	WIT farms	Non-WIT farms	p-value	WIT - new system	WIT - old system	p-value
	1	*2*	*3*	*4*	*5*	*6*	*7*
Currently irrigation methods							
Drip irrigation (%)	89.9	93.0	86.4	0.03	96.0	86.2	0.03
	(1.5)	(1.7)	(2.4)		(1.6)	(4.2)	
Surface runoff (%)	3.4	2.3	4.5	0.22	0.0	7.7	0.02
	(0.9)	(1.0)	(1.5)		-	(3.2)	
Sprinkler irrigation (%)	1.4	2.3	0.5	0.11	2.0	3.1	0.66
	(0.6)	(1.0)	(0.5)		(1.1)	(2.2)	
Other: e.g. furrow, open tube, foliar etc. (%)	5.3	2.3	8.5	0.01	2.0	3.1	0.66
	(1.1)	(1.0)	(2.0)		(1.2)	(2.2)	
Devices/Gadgets used for irrigation system							
Drip irrigation kits (%)	88.6	90.7	86.4	0.18	90.0	92.3	0.58
	(1.6)	(2.0)	(2.4)		(2.5)	(3.4)	
Pressured/pressure-compensating pipes (%)	14.0	12.6	15.6	0.38	13.3	10.8	0.59
	(1.7)	(2.3)	(2.5)		(2.8)	(3.9)	
Smart panel (%)	1.0	0.9	1.0	0.94	1.3	0.0	0.16
	(0.5)	(0.7)	(0.7)		(0.9)	(0.0)	
No. of years the irrig tech are in use (%)	12.8	14.5	10.9	0.00	14.7	14.1	0.63
	(0.5)	(0.7)	(0.6)		(0.8)	(1.1)	
Frequency of irrigation							
Daily (%)	20.3	27.0	13.1	0.00	24.0	33.8	0.15
	(1.9)	(3.0)	(2.3)		(3.5)	(5.5)	
Few times a week (%)	50.0	54.4	45.2	0.06	60.7	40.0	0.00
	(2.4)	(3.4)	(3.5)		(3.9)	(6.2)	

Weekly (%)	21.7	16.3	27.6	0.01	13.3	23.1	0.10
	(1.9)	(2.3)	(3.0)		(2.5)	(5.1)	
Few times a month or less frequently (%)	8.0	2.3	14.1	0.00	2.0	3.1	0.66
	(1.3)	(1.0)	(2.5)		(1.1)	(2.1)	
How do you determine the timing of irrigation?							
Examine the soil moisture (%)	24.4	21.4	27.6	0.14	21.3	21.5	0.97
	(2.1)	(2.8)	(3.2)		(3.3)	(5.2)	
Follow crop's irrigation calendar (%)	66.9	70.7	62.8	0.09	70.0	72.3	0.73
	(2.3)	(3.1)	(3.4)		(3.8)	(5.6)	
Irrigate when we feel the need (%)	28.0	27.0	29.1	0.62	29.3	21.5	0.22
	(2.2)	(3.0)	(3.2)		(3.7)	(5.1)	
Use moister probes (%)	2.2	2.8	1.5	0.37	2.7	3.1	0.87
	(0.7)	(1.1)	(0.9)		(1.3)	(2.2)	
How do you determine the duration of irrigation?							
Stop irrigating when soil looks wet enough (%)	58.2	59.1	57.3	0.71	57.3	63.1	0.43
	(2.4)	(3.4)	(3.5)		(4.0)	(6.1)	
Use own judgement (%)	56.0	54.9	57.3	0.62	58.0	47.7	0.17
	(2.4)	(3.4)	(3.5)		(4.0)	(6.3)	
Follow expert's advice (%)	6.8	7.9	5.5	0.33	8.7	6.2	0.51
	(1.2)	(1.8)	(1.6)		(2.3)	(3.0)	
Observations	414	215	199		150	65	

Notes: Point estimates are means. Standard errors are in parentheses.

Table 7: Beliefs about groundwater uses, current levels, and future scenarios

	All farms	WIT farms	Non-WIT farms	p-value	Farm owner is manager	Farm owner is not manager	p-value
	1	*2*	*3*	*4*	*5*	*6*	*7*
In the last 5 years							
Droughts have affected the groundwater levels (0 to 10)	5.7	5.5	6.0	0.08	5.8	5.7	0.94
	(0.2)	(0.2)	(0.2)		(0.2)	(0.2)	
In the next 5 years, groundwater levels in my governorate							
Will rapidly fall (0 to 10)	4.9	5.0	4.7	0.42	4.6	5.1	0.15
	(0.2)	(0.2)	(0.2)		(0.2)	(0.3)	
Will be affected by farming activities (0 to 10)	5.1	5.4	4.7	0.05	4.9	5.4	0.16
	(0.2)	(0.2)	(0.2)		(0.2)	(0.2)	
Other farms' use of groundwater							
Is more than my farm's groundwater use (0 to 10)	5.9	5.7	6.2	0.13	5.8	6.1	0.27
	(0.2)	(0.2)	(0.2)		(0.2)	(0.2)	
Has increased the cost of groundwater pumping for my farm (0 to 10)	4.6	4.8	4.4	0.24	4.2	5.1	0.01
	(0.2)	(0.2)	(0.3)		(0.2)	(0.3)	
Thinking about my farm							
My farm income will be lower in the next five years due to groundwater issues (0 to 10)	5.1	4.9	5.3	0.32	5.0	5.2	0.52
	(0.2)	(0.2)	(0.2)		(0.2)	(0.3)	
New irrigation systems would help reduce the use of groundwater on my farm (0 to 10)	7.5	7.2	7.8	0.03	7.6	7.3	0.28
	(0.1)	(0.2)	(0.2)		(0.2)	(0.2)	
New irrigation systems would help reduce the cost of pumping groundwater on my farm (0 to 10)	7.2	6.8	7.6	0.00	7.3	7.0	0.32
	(0.1)	(0.2)	(0.2)		(0.2)	(0.2)	
Observations	414	215	199		235	179	

Notes: Point estimates are means. Standard errors are in parentheses.

Table 8: Information needs

	All farms	WIT farms	Non-WIT farms	p-value	WIT - large farm	WIT - small farm	p-value
	1	*2*	*3*	*4*	*5*	*6*	*7*
Irrigation expert advice							
Ever met with an irrigation expert in the last 5 years (%)	46.4	47.9	44.7	0.52	40.7	50.6	0.19
	(2.4)	(3.4)	(3.4)		(6.5)	(4.0)	
Number of times met with irrigation expert in the last 5 years	10.1	10.3	9.9	0.89	11.2	10.0	0.81
	(1.4)	(2.0)	(1.8)		(4.4)	(2.2)	
Type of information needed or wish to receive							
Best irrigation method (%)	27.8	28.4	27.1	0.78	20.3	31.4	0.09
	(2.2)	(3.1)	(3.2)		(5.3)	(3.7)	
Irrigation system design (%)	15.7	18.1	13.1	0.15	16.9	18.6	0.78
	(1.8)	(2.6)	(2.4)		(4.9)	(3.1)	
Irrigation management (%)	12.1	13.5	10.6	0.36	10.2	14.7	0.35
	(1.6)	(2.3)	(2.2)		(3.9)	(2.8)	
Water quality, soil type, plant requirements (%)	14.7	12.1	17.6	0.12	15.3	10.9	0.41
	(1.7)	(2.2)	(2.7)		(4.7)	(2.5)	
No irrigation advice needed (%)	46.4	44.7	48.2	0.47	47.5	43.6	0.61
	(2.5)	(3.4)	(3.6)		(6.3)	(4.0)	
Preferred entity to provide irrigation advice							
Fellow farmers/Neighbors (%)	45.8	42.0	50.0	0.11	42.9	41.6	0.87
	(2.5)	(3.4)	(3.7)		(6.7)	(4.0)	
Private irrigation companies (%)	34.4	44.9	22.8	0.00	44.6	45.0	0.97
	(2.4)	(3.4)	(3.1)		(6.7)	(4.0)	

Ministry of agriculture (%)	27.8	20.0	36.4	0.00	25.0	18.1	0.30
	(2.3)	(2.8)	(3.6)		(5.8)	(3.2)	
Ministry of water and irrigation (%)	19.5	16.6	22.8	0.12	23.2	14.1	0.15
	(2.0)	(2.6)	(3.1)		(5.6)	(2.9)	
Other government agencies (%)	19.0	22.9	14.7	0.04	12.5	26.8	0.01
	(1.9)	(2.8)	(2.5)		(4.3)	(3.4)	
Preferred media to receive irrigation information							
Social media: Facebook, WhatsApp (%)	43.0	45.1	40.7	0.37	39.0	47.4	0.26
	(2.4)	(3.4)	(3.5)		(6.4)	(4.0)	
Websites (%)	24.6	22.3	27.1	0.26	27.1	20.5	0.32
	(2.1)	(2.8)	(3.2)		(5.7)	(3.3)	
TV (%)	15.9	13.5	18.6	0.16	15.3	12.8	0.65
	(1.8)	(2.3)	(2.8)		(4.8)	(2.7)	
Events, Printed materials (%)	9.9	10.7	9.0	0.57	3.4	13.5	0.01
	(1.5)	(2.1)	(2.0)		(2.4)	(2.7)	
Web applications (%)	7.0	6.0	8.0	0.43	6.8	5.8	0.79
	(1.2)	(1.6)	(1.9)		(3.3)	(1.9)	
SMS (%)	4.6	5.6	3.5	0.31	11.9	3.2	0.05
	(1.0)	(1.5)	(1.3)		(4.0)	(1.4)	
Observations	414	215	199		59	156	

Notes: Point estimates are means. Standard errors are in parentheses. WIT small farms are 200-600 dunums. WIT large farms are 600+ dunums.

Table 9: Irrigation equipment purchases and repair

	All farms	WIT farms	Non-WIT farms	p-value	WIT - large farms	WIT - small farms	p-value
	1	*2*	*3*	*4*	*5*	*6*	*7*
Purchases							
Consult with irrigation expert before purchase (%)	62.6	63.3	61.8	0.76	64.4	62.8	0.83
	(2.4)	(3.3)	(3.5)		(6.3)	(3.9)	
Primary place of purchase							
Stores in Amman (%)	83.3	87.0	79.4	0.04	76.3	91.0	0.02
	(1.8)	(2.3)	(2.9)		(5.6)	(2.3)	
Local shops (%)	9.7	6.5	13.1	0.03	10.2	5.1	0.25
	(1.5)	(1.7)	(2.4)		(4.0)	(1.8)	
Type of seller							
Wholesaler (%)	72.2	71.2	73.4	0.62	81.4	67.3	0.03
	(2.2)	(3.1)	(3.1)		(5.1)	(3.8)	
Retailer (%)	14.5	11.2	18.1	0.05	8.5	12.2	0.41
	(1.7)	(2.1)	(2.7)		(3.7)	(2.6)	
International trader (%)	6.0	8.8	3.0	0.01	3.4	10.9	0.03
	(1.2)	(1.9)	(1.2)		(2.4)	(2.5)	
Factory/Company (%)	4.8	6.5	3.0	0.09	1.7	8.3	0.02
	(1.0)	(1.7)	(1.2)		(1.7)	(2.2)	
Reasons for choosing the seller							
The seller provides quality products (%)	33.8	41.9	25.1	0.00	32.2	45.5	0.07
	(2.3)	(3.3)	(3.0)		(6.1)	(3.9)	
Affordable (%)	24.6	20.9	28.6	0.07	16.9	22.4	0.36
	(2.1)	(2.8)	(3.2)		(4.9)	(3.4)	
Trustworthy seller (%)	23.4	21.9	25.1	0.43	28.8	19.2	0.16
	(2.1)	(2.8)	(3.1)		(6.0)	(3.1)	
No other options (%)	5.3	4.2	6.5	0.29	6.8	3.2	0.32
	(1.1)	(1.4)	(1.7)		(3.2)	(1.4)	
Repair							
Repair the equipment in the same place where purchased (%)	43.0	47.4	38.2	0.06	52.5	45.5	0.36
	(2.4)	(3.4)	(3.4)		(6.6)	(4.0)	
Observations	414	215	199		59	156	

Notes: Point estimates are means. Standard errors are in parentheses. WIT small farms are 200-600 dunums. WIT large farms are 600+ dunums.

Table 10: Loans to purchase irrigation equipment

	All farms	WIT farms	Non-WIT farms	p-value	WIT - large farms	WIT - small farms	p-value
	1	*2*	*3*	*4*	*5*	*6*	*7*
Loans to purchase the equipment							
Received a loan in the last 5 years (%)	15.0	16.3	13.6	0.44	13.6	17.3	0.49
	(1.8)	(2.5)	(2.4)		(4.5)	(3.0)	
Number of loans received in the last 5 years	2.0	2.4	1.6	0.21	1.8	2.6	0.34
	(0.3)	(0.6)	(0.2)		(0.3)	(0.8)	
Major challenges faced to secure a loan							
No challenges (%)	82.1	83.7	80.4	0.38	91.5	80.8	0.03
	(1.9)	(2.5)	(2.8)		(3.6)	(3.1)	
Very high interest rates (%)	6.5	6.5	6.5	0.99	5.1	7.1	0.58
	(1.2)	(1.7)	(1.8)		(2.8)	(2.1)	
Difficult to contact credit providers (%)	3.1	3.3	3.0	0.89	1.7	3.8	0.35
	(0.8)	(1.2)	(1.2)		(1.7)	(1.5)	
Primary loan provider (N=62)							
Agricultural credit corporation (%)	71.0	77.1	63.0	0.23	87.5	74.1	0.37
	(5.9)	(7.1)	(9.4)		(12.5)	(8.6)	
Commercial bank (%)	6.5	5.7	7.4	0.79	12.5	3.7	0.47
	(3.2)	(4.0)	(5.2)		(12.5)	(3.7)	
Private lender (%)	4.8	2.9	7.4	0.44	0.0	3.7	0.32
	(2.8)	(2.9)	(5.1)		-	(3.7)	
Other sources (Islamic bank, co-operative etc.) (%)	17.7	14.3	22.2	0.43	0.0	18.5	0.02
	(4.9)	(5.8)	(8.1)		-	(7.4)	
Observations	414	215	199		59	156	

Notes: Point estimates are means. Standard errors are in parentheses. WIT small farms are 200-600 dunums. WIT large farms are 600+ dunums.

Table 11: Repair and maintenance of irrigation technologies

	All farms	WIT farms	Non-WIT farms	p-value	WIT - new system	WIT - old system	p-value
	1	*2*	*3*	*4*	*5*	*6*	*7*
How do you determine repair/maintenance need for irrigation equipment?							
Examine the condition of the equipment (%)	79.0	80.9	76.9	0.31	80.0	83.1	0.59
	(2.0)	(2.7)	(3.0)		(3.3)	(4.6)	
Use expert advice (%)	3.1	4.2	2.0	0.20	4.7	3.1	0.56
	(0.9)	(1.4)	(1.0)		(1.7)	(2.2)	
Farm manager's judgement (%)	21.0	21.4	20.6	0.84	21.3	21.5	0.97
	(2.0)	(2.8)	(2.8)		(3.3)	(5.2)	
Follow seller's schedule for repair (%)	5.1	5.6	4.5	0.62	6.7	3.1	0.23
	(1.1)	(1.6)	(1.5)		(2.0)	(2.1)	
Challenges with technical support for repair and maintenance							
Support not available (%)	48.1	46.0	50.3	0.39	44.7	49.2	0.54
	(2.4)	(3.4)	(3.5)		(4.1)	(6.3)	
Support not affordable (%)	50.2	54.0	46.2	0.12	48.7	66.2	0.02
	(2.5)	(3.4)	(3.6)		(4.1)	(6.0)	
Support neither available nor affordable (%)	22.5	23.7	21.1	0.52	18.7	35.4	0.01
	(2.0)	(2.9)	(2.9)		(3.2)	(6.0)	
Technical support is not a problem (%)	23.4	23.3	23.6	0.93	25.3	18.5	0.25
	(2.1)	(2.9)	(3.0)		(3.5)	(4.8)	
Challenges with parts for repair and maintenance							
Parts not available (%)	19.3	16.3	22.6	0.10	14.7	20.0	0.36
	(1.9)	(2.5)	(3.0)		(2.8)	(4.9)	
Parts not affordable (%)	71.0	74.9	66.8	0.07	74.0	76.9	0.65
	(2.2)	(2.9)	(3.4)		(3.6)	(5.3)	
Parts neither available nor affordable (%)	15.9	13.0	19.1	0.09	11.3	16.9	0.30
	(1.8)	(2.2)	(2.8)		(2.5)	(4.5)	
Finding required parts is not a problem (%)	24.9	21.4	28.6	0.09	22.7	18.5	0.48
	(1.8)	(2.2)	(2.8)		(2.5)	(4.5)	
Observations	411	214	197		150	64	

Notes: Point estimates are means. Standard errors are in parentheses.

Appendix 1: Sampling strategy

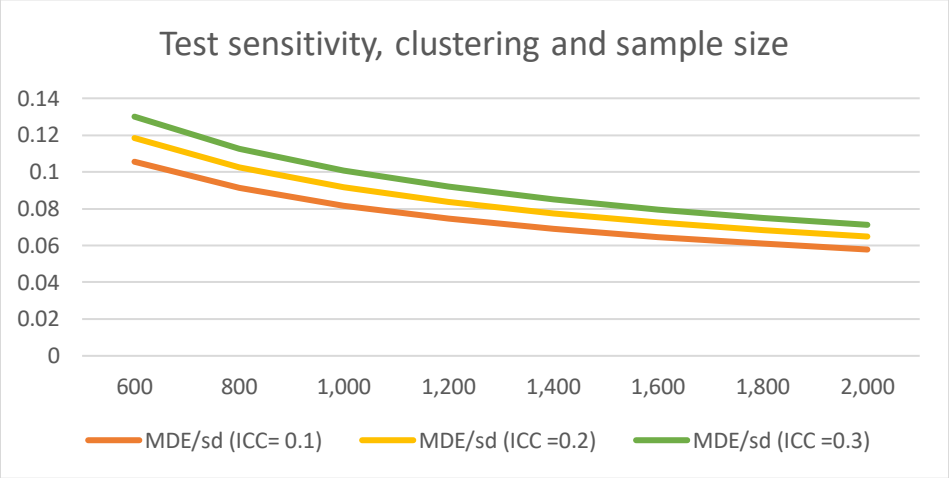
Power calculations for determining the number of farms to be interviewed in Azraq and Mafraq were conducted. Various intra-cluster correlation coefficients were used, to account for the fact that two farms within Azraq are likely to be more similar than one farm in Azraq and one farm in Mafraq. The results are presented in Table A1 and Figure A1.

As the intra-cluster correlation becomes higher, a given sample size yields a less sensitive test. For a given intra-cluster correlation, a higher sample size (with the sample equally split between Azraq and Mafraq) yield a more sensitive test. Based on these results, a sample size of 400 farms (with 200 each from Azraq and Mafraq) would be sufficient to detect changes in the probability of how adoption of water-saving technology is likely to be influenced by farmer, farm, informational and supply chain characteristics.

Table A1: Determining Sample Size

No. of clusters (towns)	Farms per cluster (#)	Sample size	MDE/sd (ICC= 0.1)	MDE/sd (ICC =0.2)	MDE/sd (ICC =0.3)
2	300	600	0.105514	0.118405	0.1300236
2	400	800	0.091378	0.102542	0.1126037
2	500	1,000	0.081731	0.091716	0.1007158
2	600	1,200	0.07461	0.083725	0.0919405
2	700	1,400	0.069075	0.077514	0.0851204
2	800	1,600	0.064614	0.072508	0.0796228
2	900	1,800	0.060919	0.068361	0.0750691
2	1000	2,000	0.057793	0.064853	0.0712168

Figure A1: Test Sensitivity and Sample Size



A two-step process was used to select the required number of sample farms. First, the list of all registered farms in Mafraq and Azraq was obtained from Mercy Corps Jordan. The list contained a total of 870 farms, 505 farms from Mafraq and 365 farms from Azraq. With help from Mercy Corps, farms that are eligible for water innovations technology (WIT) interventions – farms with total farm area of 200 dunum or more—were identified. Table A2 presents the distribution of number of farms by governorate and by WIT eligibility.

Table A2: Sampling plan

Eligibility	Mafraq farms		Azraq farms		All farms	
	Population	Sample	Population	Sample	Population	Sample
WIT (eligible) farms	333	153	134	62	467	215
Non-WIT (eligible) farms	172	79	231	106	403	185

All farms	**505**	**232**	**365**	**168**	**870**	**400**

Table A2 presents details of the sampling plan. The farm population is provided under column "Population". In total, there were 467 WIT farms and 403 non-WIT farms. In Mafraq, there were more WIT farms (333) than non-WIT farms (172) but the ratio was opposite in Azraq, where there were more non-WIT farms (231) than WIT farms (134). To make sure the study sample was representative of all farm types, population-proportional-to-the-size (PPS) random sampling was used to select a total of 400 farms out of 870 farms. The proportion of farms to be selected, 45.9% of 870 farms, was calculated. Then, 45.9% of the farms were selected from each of the four categories – WIT farms and non-WIT farms from both Mafraq and Azraq. The number of farms to be sampled for the study is reported under the column "Sample", with 58% of the sample farms located in Mafraq and remaining 42% were located Azraq; and with 54% of farms WIT and remaining 46% non-WIT farms.

Table A3. Distribution of final sample of farms by WIT eligibility

Eligibility	Mafraq farms		Azraq farms		All farms	
	Population	Sample	Population	Sample	Population	Sample
WIT eligible farms						
Number	333	137	134	78	467	215
Share (%)	65.9	67.2	36.7	37.1	53.7	51.9
WIT ineligible farms						
Number	172	67	231	132	403	199

Share (%)	34.1	32.8	63.3	62.9	46.3	48.1
All farms	**505**	**204**	**365**	**210**	**870**	**414**

While implementing the survey, IPSOS interviewed 137 WIT and 67 non-WIT farms in Mafraq, and 78 WIT and 132 non-WIT farms in Azraq. Even though the plan was to select 400 farms in total (215 WIT eligible and 185 WIT ineligible farms), we oversampled 15 ineligible farms giving a final sample size of 414 farms (215 WIT eligible and 199 WIT ineligible farms). Share of selected farms in each of the four categories – WIT eligible and ineligible across Mafraq and Azraq – are presented below the number of farms in Table 2. The final sample is not exactly proportional to the population of the four categories of the farms, but it is very close to being proportional to the population size.

Appendix 2: Questionnaire

INFORMED CONSENT

INTERVIEWER: PLEASE READ THE PARAGRAPH BELOW TO THE RESPONDENT

This paragraph MUST be read before each interview. At the beginning of the interview, take time to introduce yourself and the aim of the questionnaire to establish trust with the respondent. If necessary, please answer the questions the respondent may have. Clearly ask if the respondent agrees to answer the questionnaire.

My name is _____.I work for IPSOS and we have been contracted by Mercy Corp to do a survey to develop better irrigation supply chains in Mafraq and Zarqa. I will ask you a few questions about your irrigation practices and farm, so that we can identify current challenges you face. Understanding these challenges will help Mercy Corp design better services for you and your farm. The total time of the interview will be about 30 minutes. All your answers will be kept private, your name and the exact location where you live will not appear in any data that is made public. The information you provide will only be used to understand the irrigation challenges in Mafraq and Zarqa, so that Mercy Corp can use this information to better serve these communities. You may skip any question during the interview, and you have an option to discontinue the interview at any time.

[S1_Q1] Do you agree to participate in this survey? |__| 1=Yes 0=No

ENUMERATOR IDENTIFICATION

[S2_Q1] Enumerator Name _____

[S2_Q2] Supervisor Name _____

[S2_Q3] Date…… |__|__| / |__|__| *Day / Month*

[S2_Q4] Time at the beginning of the interview…….. |__|__| : |__|__|

24 H Format: For example, 14:30 for 2:30 pm, 18:00 for 6:00 pm

SECTION 2. FARM IDENTIFICATION INFORMATION

[S2_Q5] Governorate |___| 1. Zarqa 2. Mafraq

[S2_Q6] District name ……

[S2_Q6a] District code: |___|

[S2_Q7] Sub-district name ……

[S2_Q7a] Sub-district code: |___|

[S2_Q8] Locality: ……..

[S2_Q9] Urban/Rural: |___| 1. Rural 2. Urban

[S2_Q10] GPS coordinates: Latitude: |___||___||___| Longitude: |___||____||____|

[S2_Q11] Owner Name: ……

[S2_Q12] Contact phone number: |__|__|__|__|__| |__|__|__|__|__| |__|__|__|__|__|

[S2_Q13] UNIQUE ID NUMBER |___|___|___|___|

SECTION 3. FARM CHARACTERISTICS:

S3_Q1	S3_Q2	S3_Q3	S3_Q4	S3_Q5	S3_Q6	S3_Q7
Area of the farm (*Dunums*)	How long has this farm been in operation under current owner?	What is the texture of the soil of your farm?	Slope of your farm	Total number of metered wells on the farm	Type of farm ownership	Status of farm operation
[1, 2500]	Number of years (Note: -8 if Don't know)	1. Clayey 2. Sandy 3. Loamy 4. Silty 5. Other, specify	1. Flat land 2. Slightly sloped 3. Heavily sloped 4. Terraced farming 4. Other: _____	Number [0-99]	1. Private owner, single 2. Private owners, multiple 3. Government owned 4. Co-operative owned 5. Other, specify	1. Cultivated by the owner/ employees 2. Rented/Leased out 3. Contract farming 4. Share-cropping

	S3_Q8	S3_Q9	S3_Q10
Crop code	Crops grown in the last 12 months (Check all that apply)	Area cultivated (2018) *Dunums* [Enter -9 if Don't know]	Number of trees (2018)
		[1, 2500]	[1, 5000]
1. Olives			
2. Almonds			
3. Pears			
4. Peaches			
5. Grapes			
6. Vegetables			
7. Fodder trees			

SECTION 4: OWNER AND MANAGER CHARACTERISTICS

S4_Q1	S4_Q2	S4_Q3	S4_Q4	S4_Q5	S4_Q6	S4_Q7
Age of the owner	Sex of the owner	Education of owner: Highest grade completed	Residence of the owner	What is the owner's primary occupation?	How often does the owner inspect the farm's operations?	Is the owner also the manager of the farm? (*Manager is person who supervises day-to-day farm)*
(years) [15, 150]	1. Male 2. Female	1. None 2. Primary school 3. Secondary school 4. High school 5. Diploma 6. BA/BS 7. Masters or higher 8. Don't know	1. Resides on the farm 2. Resides in the same Governate as the farm 2. Resides in Amman 3. Resides in another Governate (but not in Amman) 4. Resides overseas 5. Other: _____	1. Cultivating this farm 2. Cultivating another farm in the same governate 3. Cultivating another farm in another governate 4. Non-agricultural business 5. Salaried employee 6. Other, specify: _____	1. Daily 2. Few days a week 3. Once in a week 3. Once in every two weeks 4. Once a month 5. Rarely 6. Never	1. Yes>>Go to Section 5 2. No >> Go to S4_Q8

S4_Q8	S4_Q9	S4_Q10	S4_Q11	S4_Q12	S4_Q13	S4_Q14
Age of manager	Sex of manager	Education of manager: Highest grade completed	Nationality of manager	Number of years current manager has been in-charge of the farm operations	What other occupation is the manager involved in?	Residence of the manager
(years) [15, 150]	1. Male 2. Female	1. None 2. Primary school 3. Secondary school 4. High school 5. Diploma 6. BA/BS 7. Masters or higher 8. Don't know	1. Jordanian 2. Syrian 3. Egyptian 4. Other, specify	(years) [1 to 99]	1. Managing/cultivating other farm 2. Other non-Agricultural business 3. No other occupation 4. Other, specify: _____	1. On this farm 2. On another farm in same Governate 3. Not on any farm, but in same governate 4. Outside governate 5. Other, specify: _____

SECTION 5. FARM MANAGEMENT PRACTICES

S5_Q1 In the last 12 months, how many salaried long-term workers worked on the farm? _____ [0, 999]

S5_Q2 In the last 12 months, how many workers on the farm were part of the family, and hence did not get paid a salary? _____ [0, 999]

S5_Q3 In the last 12 months, how many short-term daily wage workers cultivated the farm? _____ [0, 999]

Please indicate who was primarily responsible for performing the following tasks on the farm over the last 12 months (check only one per row):

		Owner	Manager	Salaried Worker	Daily Wage Worker	Family member
S5_Q4	1. Pumping water out of the well					
S5_Q5	2. Determining groundwater pumping hours and duration					
S5_Q6	3. Conducting repair and maintenance of irrigation devices					
S5_Q7	4. Determining whether repair and maintenance of irrigation equipment is needed					
S5_Q8	5. Determining the irrigation plan for the farm					
S5_Q9	6. Irrigating the farm					
S5_Q10	7. Replacing irrigation devices and equipment					
S5_Q11	8. Determining whether irrigation devices and equipment need replacement					
S5_Q12	9. Applying fertilizers and pesticides					

S5_Q13	10. Purchasing fertilizers and pesticides					

S5_Q14 How often do all workers on the farm meet with the manager of the farm?

1. Daily

2. Once a week

3. Few days a week

4. Once a fortnight/ twice a month

5. Once a month

6. Once a year

7. never

SECTION 6.1: BELIEFS

We will now ask you to share your perceptions on the groundwater situation in your governorate

Please hold these 10 stones in your hand, and use them to answer the Questions I am about to ask you, by putting them down on the ground.

You may put down on the ground as many stones as you feel in order to answer the Question according to your opinion.

Let us practice a few Questions. For example:

Do you think the sun will rise tomorrow morning?

We know that the sun rises every day; so in this case, you would put all 10 stones on the ground.

Do you think two suns will rise tomorrow morning?

We know that two suns will certainly not rise tomorrow; so in this case you would not put down any stones.

Do you think Brazil would win the next FIFA World Cup?

This event may or may not occur.

If you feel that Brazil is less likely to win, then you may put down 2 or 3 stones. If you feel it is very likely to win, you may put down 7 or 8 stones.

Please think about the last 5 years, and answer the following questions :		# stones [0, 10]
S6_Q1	Droughts have affected the groundwater levels	|__|__|

S6_Q2	The groundwater levels have been affected by farming activities	|__|__|
	Please think about the next 5 years, and answer the following Questions	# stones [0, 10]
S6_Q3	Groundwater levels in my governorate will rapidly fall over the next 5 years	|__|__|
S6_Q4	The groundwater levels in my governorate will be affected by farming activities	|__|__|
	Now think about the other farms in your governorate, and answer the following Questions	# stones [0, 10]
S6_Q5	Other farms use more groundwater than my farm	|__|__|
S6_Q6	Other farms' use of ground water has increased the cost of groundwater pumping for my farm	|__|__|
	Now think about your farm, and answer the following Questions	# stones [0, 10]
S6_Q7	The incomes from my farm will be lower in the next five years due to groundwater issues	|__|__|
S6_Q8	New irrigation systems would help reduce the use of groundwater on my farm	|__|__|
S6_Q9	New irrigation systems would help reduce the cost of pumping groundwater on my farm	|__|__|

SECTION 6.2. Eliciting individual discount rates/time preferences

S6_Q10. Think about an NGO that is going to provide you monetary gift that **you can only use for repair or maintenance of your irrigation equipment**. Suppose, the NGO has pledged to provide you at least 3000 JD to maximum of 3500 JD depending on when you choose to receive the transfer **over the period of next 8 weeks**. Which of the following transfer methods would you choose?

1. Receive 3000 JD today, nothing later **(Total 3000 JD)**
2. Receive 1500 JD today, 1600 JD in 4 weeks, nothing in 8 weeks **(Total 3100 JD)**
3. Receive nothing today, but 3200 JD in 4 weeks **(Total 3200 JD)**
4. Receive nothing today, 2000 JD in 4 weeks and 1300 JD in 8 weeks **(Total 3300 JD)**
5. Receive nothing today, nothing in 4 weeks, but 3500 JD in 8 weeks **(Total 3500 JD)**

S6_Q11. Now, suppose the same NGO is going to provide you monetary gift, but **now you can use in any way you like**. Again, the gift amount will be at least 3000 JD to maximum of 3500 JD depending on when you choose to receive the transfer **over the period of next 8 weeks**. Which of the following transfer methods would you choose?

1. Receive 3000 JD today, nothing later **(Total 3000 JD)**
2. Receive 1500 JD today, 1600 JD in 4 weeks, nothing in 8 weeks **(Total 3100 JD)**
3. Receive nothing today, but 3200 JD in 4 weeks **(Total 3200 JD)**
4. Receive nothing today, 2000 JD in 4 weeks and 1300 JD in 8 weeks **(Total 3300 JD)**
5. Receive nothing today, nothing in 4 weeks, but 3500 JD in 8 weeks **(Total 3500 JD)**

SECTION 7: SUPPLY CHAIN FACTORS

S7_Q1	S7_Q2	S7_Q2b	S7_Q2c
In the last 5 years, how many times have you met with an irrigation expert? (In your farm or in the irrigation office)	In general, what is your preferred entity to provide you information about irrigation? (*Choose up to three in order of preference*)	What kind of information do you need/would you like to receive about irrigation? (*Choose up to three in order of preference*)	What is your preferred media/communication channel to receive general information about irrigation? *(Choose up to five options)*
Number of times [0-99] (If never met with an irrigation expert, enter 0)	1. Ministry of Agriculture 2. Ministry of Water and Irrigation 3. National Agricultural Center for Research 4. Jordan Meteorological Department 5. Private sector - Irrigation companies 6. Input (fertilizers, pesticide) suppliers 7. Agriculture associations 8. Donors 9. Fellow farmers/neighbors 10. Social media platforms 11. Internet – websites 12. Applications 13. Others (Specify)	1. Irrigation system design 2. Irrigation management 3. Best irrigation method 4. Water quality, soil type, plants requirements 5. Fertigation (fertilizer plus irrigation) 6. Irrigation system efficiency 7. Pump suitability to your network 8. Filtration system 9. Weather data for irrigation management	1. Radio (specify radio channel) 2. Television (specify TV channel) 3. Newspapers (specify newspaper) 4. SMS 5. Web applications (specify application) 6. Websites (specify website) 7. Events 8. Printed materials (e.g. brochure) 9. Social media (e.g. Facebook (specify Facebook page), WhatsApp) 10. Other (specify)

S7_Q3	S7_Q4	S7_Q5	S7_Q6
Do you consult with any irrigation expert before purchasing irrigation equipment?	Where do you primarily purchase new irrigation equipment or repair parts? [choose only one]	How would you describe the seller you purchase equipment from? [choose only one]	Why do you purchase your equipment from this seller? (Select the primary reason)
1. Yes 2. No	1. Local shop in the same governate 2. From stores in Amman 3. Purchase machinery from wholesalers 4. Not applicable	1. Small supplier/retailer 2. Wholesaler 3. International trader 4. Other, specify 5. Not applicable, never purchased an equipment >> S7_q7	1. No other options available 2. The seller provides Quality equipment and parts 3. The seller offers after-sales services 4. The price is affordable 5. The seller is trustworthy 6. The seller is located nearby 7. Other, specify: _____

S7_Q7	S7_Q8	S7_Q9		S7_Q10	S7_Q11
In the last 5 years, how many loans did you receive for purchasing irrigation equipment?	What was the agency that you applied most frequently to, for a loan? [choose only one]	What was the major challenge faced while securing a loan for purchasing irrigation equipment?		Do you repair your irrigation equipment in the same place where you purchase it?	How often do you repair/maintain your irrigation systems/ (check only one option)
Number [0-99] (note: if never applied enter -8) IF 0 or -8 >> S7_Q9	1. Commercial bank 2. Agricultural credit corporation 3. Co-operative organization/institution 4. Micro-finance bank 5. Private lender 6. Friend/Relative 7. Other, specify: _____	1. No challenges 2. Credit providers are not easy to contact 3. Interest rates are very high 4. Credit providers are reluctant to make loans for irrigation		1. Yes 2. No >>Next section	1. Every 6 months 2. Annually 3. Bi-annually 4. Once in 5 years 5. Never, until it stops working

SECTION 8: WATER MANAGEMENT AND IRRIGATION CHOICES

S8_Q1	S8_Q2	S8_Q3		S8_Q4	S8_Q5	S8_Q6
What irrigation method are you using currently? [Primary method]	Which of the following devices/gadgets do you use for your irrigation system? [Check all that apply]	How long have you been using these types of technologies?		How often do you irrigate your crops/trees?	How do you determine THE TIMING of irrigation for your crops/trees? [Check all that apply]	How do you determine THE DURATION of irrigation? [Check all that apply]
1. Surface runoff 2. Furrow irrigation 3. Sprinkler irrigation 4. Drip irrigation 5. Open Tube irrigation 6. Foliar irrigation 7. Other, specify 8. No irrigation used >> S8_Q4	1. Drip irrigation kits e.g. pipes and drippers 2. Smart panel 3. Affixed flow meter 4. Pressured pipeline 5. Pressure compensating pipes 6.Other, specify	Years [1-99]	Months [1-12]	1. Daily 2. Few times a week 3. Weekly 4. Few times a month 5. Monthly 6. Bi-Monthly 7. Once a year 8. We never irrigate >> S8_Q10	1. We examine the soil and irrigate 2. We follow the crop's irrigation calendar 3. We use moisture probes 4. Irrigate when feel the need to	1. We use auto-stop smart panel 2. Stop when the soil looks wet enough 3. Follow expert's advice, varies by crop 4. We use our judgement

S8_Q7	S8_Q8	S8_Q9	S8_Q10	S8_Q11	S8_Q12
How do you determine whether your irrigation technologies need repairing/maintaining? (check all that apply)	Which of the following describes best the challenges with technical support for repair and maintenance of your irrigation system?	Which of the following describes best the challenges with parts for repair and maintenance of your irrigation system?	In the last 10 years, how many years have you had water scarcity problems that were so serious that you had to reduce cultivation activities?	What did you do to manage water scarcity? (Check all that apply)	What were the outcomes/consequences of water scarcity you faced? (Check all that apply)
1. We examine the condition of the equipment to determine if repairs are required 2. We ask an expert to come and inspect the equipment 3. We rely on the judgment of the manager of the farm 4. We follow a schedule that the sellers of the equipment provided 5. Other, specify: _____	1. Technical support not available 2. Technical support not affordable 3. Technical support neither available nor affordable 4. Technical support is not a problem at all	1. Parts not available 2. Parts not affordable 3. Parts neither available nor affordable 4. Finding reS8_Quired parts is not a problem at all	Number [0-10] (If never had water scarcity problem, enter 0) IF 0 >> Section 9	1. Reduced cultivated area 2. Switched to drought tolerant crops 3. Removed/Pruned trees 4. Adopted water saving technologies 5. Did nothing	1. Loss of agricultural production 2. Loss of income 3. Loss of farm assets 4. Loss of trees/crops 5. Family member migrated 6. Nothing happened

SECTION 9: WILLINGNESS TO ADOPT EFFICIENT IRRIGATION TECHNOLOGIES

S9_Q1 In the last 10 years, did you make any major replacements of your irrigation systems?

For example, did you completely replace your drip systems, or purchase new filters and membranes?

1. Yes

2. No

Using the stones that were provided to you, please answer the following questions that pertain to hypothetical situations.

We are simply interested in your opinion, and there is no right or wrong answer

Your answers will help us understand how financing can help with improving the adoption of irrigation technologies.

I would be willing to make a major replacement of my irrigation system if:

S9_Q3 If the government removed taxes on the products (import, sales), but offered no loans |___|

S9_Q4 if the government provided an interest-free loan but did not remove the tax on the products |___|

S9_Q5 in the next 5 years, even if the prices of the products, availability of loans, and rates of interest did not change |___|