WATER INNOVATION TECHNOLOGIES PROJECT (WIT)

ECONOMICS OF WATER SAVINGS UNDER THE WATER INNOVATION TECHNOLOGIES PROJECT

FINAL REPORT

PREPARED FOR MERCY CORPS – JORDAN

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Executive Summary

The Water Innovations Technologies (WIT) project is a five-year project funded by the United States Agency for International Development (USAID) and implemented by Mercy Corps with the primary purpose of increasing water savings in Jordan. The research conducted here leveraged relevant data, information, and studies already completed as part of WIT to 1) estimate the cost-effectiveness of investment in each WIT activity in terms of promoting the adoption of water saving approaches (WSAs) by households, farmers and communities; and 2) assess the motivations for and costs/benefits of WSAs adopted as part of WIT to both private (i.e., suppliers, farmers and households) and public actors (i.e., USAID and Mercy Corps).

Methods

In addition to a literature review, four distinct analyses were conducted:

1. **Activity-based cost analysis**. WIT expenditures were categorized and summed based on the degree to which they supported WIT activities to increase water savings (e.g., directly, indirectly).
2. **Water savings analysis**. Data on water savings collected during WIT were used to estimate total water saved during WIT and under two additional scenarios.
3. **Cost-effectiveness analysis**. Costs and water savings for each activity were compared to assess the cost per unit of water saved.
4. **Incentives and return on investment analysis**. Data from WIT knowledge, attitude and practices endline surveys first were used to evaluate participant motivations for adoption and then were combined with other data to estimate participant return on investment (ROI).

As there was a need to complete this research before the end of the WIT project, it should be noted that data (and results) represent WIT progress through September 2021.

With input from Mercy Corps staff, WIT activities to increase water savings in Jordan were grouped into eight categories:

Agriculture

- **Demonstration sites (Ag – Demos).** Demonstration sites where water saving technologies (WSTs) were installed early on in the project.
- **Investment fund (Ag – Fund).** Provided technical and cost-share support to suppliers to help them promote WSTs to farmers as part of the market system development (MSD) approach.
- **Supplier incentives (Ag – Incentives).** Incentivized farmer adoption of WSTs through suppliers who signed a water savings compensation agreement and were compensated for each cubic meter of water saved by farmers after WST adoption.

Household

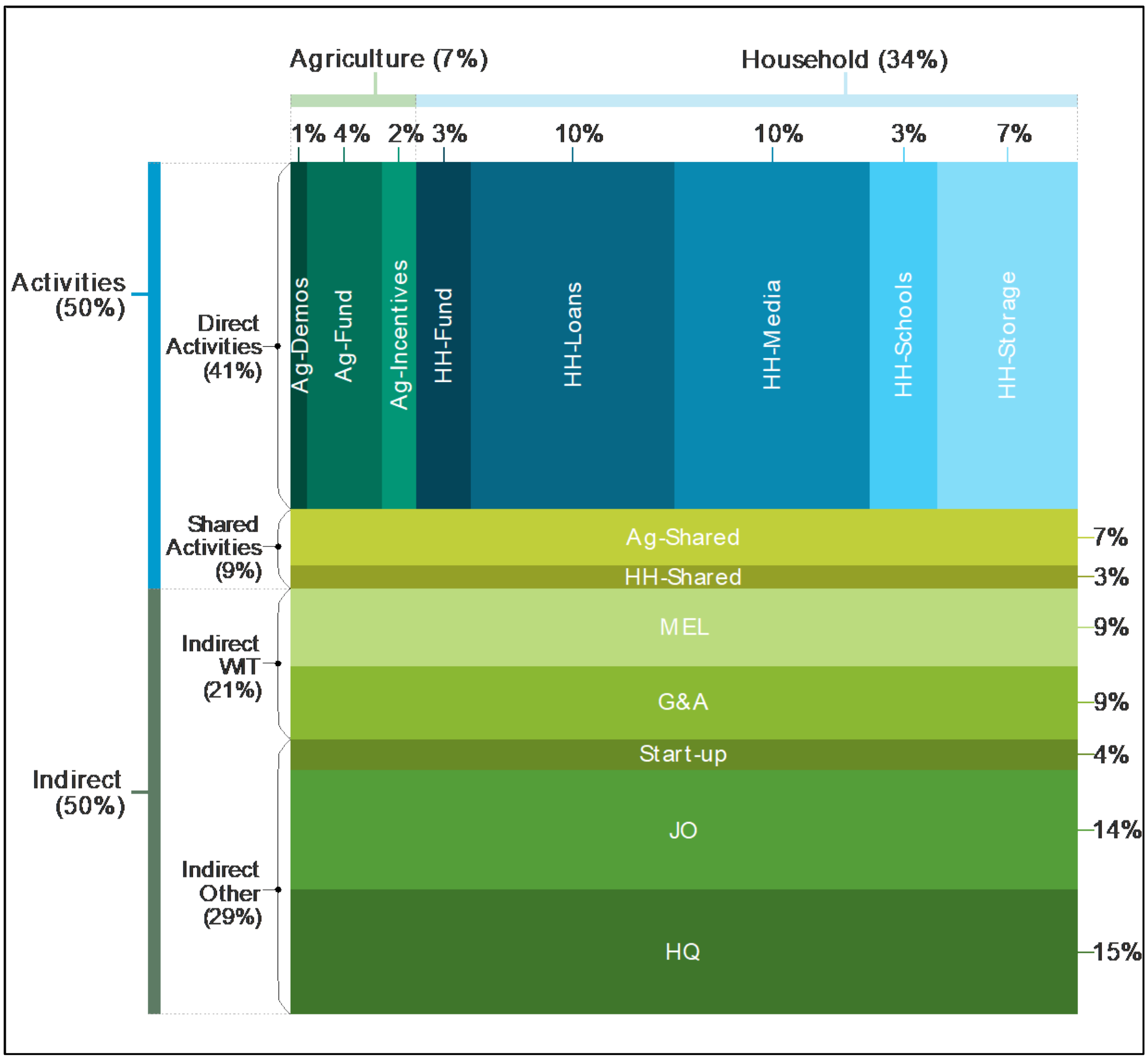
- **Investment fund (HH – Fund).** Provided technical and cost-share support to suppliers to help them expand sales networks and improve promotion of WSTs/WSDs to households.
- **Revolving loan fund (HH – Loans).** Facilitated household adoption of WSTs/WSDs by providing loan capital to community-based organizations that, in turn, dispersed loans to households.
- **Social media and outreach campaign (HH – Media).** Raised public awareness and promoted WSA adoption though social media, training and awareness sessions and community participation.
- **Schools (HH – Schools).** Installed WSTs in schools.

– **Communal storage projects (HH – Storage).** Rehabilitated existing dams used to store water for local community use.

ACTIVITY-BASED COSTS

Cost categories were developed with the help of WIT staff and line items expenditures were assigned to these categories. Key variables used to categorize costs included GL code, employee ID and sub-grant number. In addition, in cases where categorization was not obvious, WIT staff apportioned personnel time by employee and other line items across the appropriate cost categories. Activity costs (both direct and shared) supported WIT activities to increase water savings, while indirect costs provided broader project support but did not directly contribute to water savings. In total, activity and indirect costs each represented 50% of total project costs. (Figure ES1).

Figure ES1. Distribution of Costs by Category



WATER SAVINGS

After cleaning, the water savings data were summed by activity and then used to estimate water savings under three scenarios — a baseline, which represented water savings during WIT and two scenarios that also included projected future water savings: 1) length of life (LoL) — through the assumed length of life of the WSAs adopted; and 2) continued adoption for an additional two years by new farmers and continued use and replacement of WSAs by previous adopters. A period of two years was chosen as a timeframe over which continued adoption could reasonably be attributed to WIT activities rather than to other or future efforts aimed at generating water savings in Jordan.

These additional scenarios were assessed because water savings do not stop simply because the WIT project ends. For agriculture, drip irrigation systems, if maintained properly, should continue to function for several more years at minimal cost. For households, the majority of WSAs adopted have long lifespans (50+ years) if properly maintained.

Agricultural water savings were estimated to be 17.6 MCM and 65.2 MCM, for the WIT baseline and LoL scenario, respectively (Table ES1). Similarly, household water savings were estimated to be 1.2 MCM and 11.0 MCM, respectively. Differences in the results of the Baseline and LoL scenario highlight the importance of accounting for future water savings when evaluating project outcomes and also suggests that the majority of water savings will occur after the end of the WIT project.[1]

Table ES1. Estimated Water Savings

	Water Savings (MCM)		
WIT Activity	**Baseline**	**Projected to LoL**	**Projected Total**
Ag- Demos	1.0	0.9	2.0
Ag- Fund	12.4	32.6	45.0
Ag - Incentives	2.7	8.4	11.1
Sub-Total - Ag	17.6	47.5	65.2
HH - Fund	0.1	0.6	0.6
HH - Loans	0.0	0.5	0.5
HH - Media	0.9	7.3	8.2
HH - Schools	0.0	0.2	0.2
HH - Storage	0.2	1.3	1.5
Sub-Total - HH	1.2	9.8	11.0
Total	**18.8**	**57.3**	**76.2**

Additionally, because technical support was provided to irrigation equipment suppliers to help them promote WSTs to farmers as part of the MSD programming, adoptions of WSTs by farmers should continue beyond the completion of the WIT project. Total agricultural water savings were estimated to be 184 MCM if adoptions continued for an additional two years after the WIT project ends. The substantial difference between baseline and projected water savings highlights the need to consider both future water

[1] Assumptions made in calculating projected water savings are detailed in the report, however, it is important to note that external variables (e.g., climate change, etc.) that have the potential to affect water supply/availability and/or influence water user behavior were not considered.

savings from WSA adoption during WIT as well as future adoptions (and associated water savings) as a direct result of WIT.

Cost Effectiveness

Cost-effectiveness analysis compares a project to the status quo — or another project, however, in the case of WIT, there is no counterfactual — by estimating the cost per unit gain. For the WIT project, this "unit gain" was defined as one cubic meter of water. The cost-effectiveness of WIT activities was assessed by dividing the cost of each activity by the volume of water savings from that activity to estimate the cost per cubic meter of water (m^3) saved.

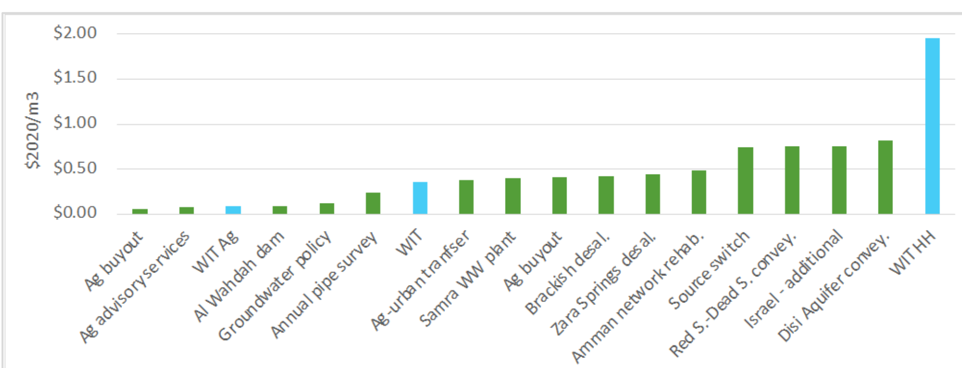
As seen in Table ES2, the agriculture investment fund and household loan fund were the most and least cost-effective activities, with total costs of \$0.08/m^3 and \$13.37/m^3, respectively. The cost-effectiveness of all WIT activities (calculated as a weighted average) was \$0.36/m^3.

Table ES2. Cost-Effectiveness by Activity and Cost Type

Activity	Activity Costs (\$/m^3)	Indirect Costs (\$/m^3)	Total Costs (\$/m^3)
Ag	\$0.05	\$0.03	\$0.09
Demos	\$0.23	\$0.14	\$0.37
Fund	\$0.05	\$0.03	\$0.08
Incentives	\$0.09	\$0.05	\$0.14
HH	\$0.92	\$1.04	\$1.96
Fund	\$1.29	\$1.47	\$2.76
Loans	\$6.26	\$7.11	\$13.37
Media	\$0.37	\$0.41	\$0.78
Schools	\$5.65	\$6.42	\$12.08
Storage	\$1.44	\$1.63	\$3.07
Total	**\$0.18**	**\$0.18**	**\$0.36**

Assessing the cost-effectiveness of WIT activities is useful for informing possible future efforts in Jordan (and elsewhere), but it also raises the question of how the cost-effectiveness of WIT activities compares to other alternatives. Figure ES2 compares costs per cubic meter from alternatives found in the literature to WIT activities (highlighted in blue). Given that agriculture accounts for over 50% of total water use in Jordan, WIT activities (and agricultural activities in particular) appear to be cost-effective strategies compared to other alternatives.

Figures ES2. Cost-Effectiveness by WIT Activity



Incentives & Return on Investment

While the majority of farmers adopting WSTs were motivated by a desire to save water for the future, when results were broken out by governorate, a different pattern emerged — 100% of survey respondents from Mafraq said saving water for future use was a motivation, while only 59% of Azraq respondents felt similarly. In contrast, 71% of Azraq respondents said a primary motivation was to use saved water elsewhere on their farm, whereas this motivation was selected by only 7% of Mafraq respondents. These differences highlight that not all agricultural water "saved" may actually stay in the ground for future use. For households, although WSA adopters cited multiple motivating factors, religion appeared to play an outsized role across all governorates surveyed.

The ROI for farms adopting WSTs was estimated to be approximately 450%. Even assuming a conservative length of life for the WSTs (i.e., three years instead of eight), the expected ROI was still positive. These results suggest that even if a farmer pays the full cost of WST installation, over the lifespan of the WST the resulting cost-savings would be very likely to outweigh the initial cost of installation. On-farm WST adoption not only appears to generally support cost-savings, but also positive ROIs, suggesting that farmers should adopt WSTs even if their only motivation is financial.

For households, rainwater harvesting (RWH) systems, particularly lower cost ones, produced positive ROIs in governorates with higher average annual rainfall; however, they were unlikely to produce positive ROIs in drier governorates such as Mafraq and Azraq. Low flush toilets, toilet bags, and low flow showerheads also produced positive ROIs in select governorates, primarily as a result of their low costs compared to other WSAs rather than the volume of water savings.

Conclusions & Recommendations

The findings of this effort suggest that a) funding water saving projects in Jordan, particularly with an MSD component, may be less expensive than other alternatives; and 2) WSA adoption often has a positive ROI for the adopter even if they bear the full cost of adoption, and, therefore, should be strongly encouraged as part of government policy and donor funding. Subsidizing WSA adoption also would likely be cost-effective, as the cost of other, more expensive, alternatives could potentially be avoided. Recommendations for similar efforts in the future include:

- In order to accurately measure cost-effectiveness by activity (and also account for indirect costs), cost categories and methods for assigning expenditures to these categories should be established at the start of a project and used consistently throughout.
- Calculations of water savings from a project should incorporate some estimate of future water savings (a suggested timeframe would be the LoL of the WST adopted).
- Given that farms are businesses, efforts to increase on-farm WST adoption should include information on the potential cost-savings and ROI of adoption.
- For households, the effectiveness of future outreach efforts may be enhanced if the messaging were to be placed in a religious context and/or if religious institutions were taken on as partners.
- Future efforts to increase WSA adoption by households should consider strategic marketing of RWH systems, with a focus on areas with higher average annual rainfall — and include information on the potential long-term financial benefits of adoption.
- If regular maintenance is not a part of the adopters' knowledge when a WST/WSD is adopted, then total potential water savings may not be realized. Providing technical assistance/training on care and maintenance may be an important aspect of supporting long-term use.

- Future household efforts might consider a more limited set of WSTs/WSDs, and, in particular those with the largest potential for water savings (e.g., RWH systems) and also potentially provide mechanisms to support adoption as up-front costs are typically higher (e.g., discounted pricing).
- Based on limitations encountered as part of this effort, if cost-effectiveness and return on investment are considered relevant indicators for future projects, it is recommended that increased coordination occurs to standardize data collection and tracking methods and ensure consistency of terminology, IDs, etc. used across multiple data sets and organizations.

Contents

Tables

Figures

Acronyms

Ag	Agriculture
CBA	Cost-benefit analysis
CC	Cross-cutting
Demo	Demonstration sites
FY	Fiscal year
G&A	General and administrative
GL	General ledger
GW	Greywater
HH	Household
HQ	Headquarters
ID	Identification
id:rc	Interdisciplinary Research Consultants
IF	Investment fund
Improved-GR	Improved glass-fiber reinforced
IWMI	International Water Management Institute
JOD	Jordanian dinar
KAP	Knowledge, attitude and practices
LoL	Length of life
m	million
m^3	Cubic meter
MCM	Million cubic meters
MEL	Monitoring, evaluation and learning
MENA	Middle East-North Africa
MSD	Market Systems Development
NICRA	Negotiated Indirect Cost Rate Agreement
PC	Pressure compensating
RIM	Residual Imputation Method
ROI	Return on investment
RSS	Royal Scientific Society
RWH	Rainwater harvesting
USAID	United States Agency for International Development
USD	United States dollars
WAJ	Water Authority of Jordan
WIT	Water Innovations Technologies
WSA	Water saving approach
WSD	Water saving device
WSP	Water saving practice
WST	Water saving technology
$	United States dollars

1. Introduction

The Water Innovations Technologies (WIT) project is a five-year project funded by the United States Agency for International Development (USAID) and implemented by Mercy Corps. The project's theory of change is

> "if barriers to the adoption of water-saving technologies are systematically broken down at multiple levels, with different groups of water users and market actors through enhancing knowledge, forming partnerships and providing advisory services, in addition to improving access to finance and strengthening institutions that support water-saving, then adoption of water-saving technologies by farmers, households, and communities will increase leading to the sustainable management of water and natural resources". (Mercy Corps 2020)

The primary purpose of WIT was to increase water savings in Jordan, with a goal of saving 18.5 million cubic meters (MCM) of water, through efforts targeting:

- increased adoption of water saving approaches (WSAs) by farmers, households, and communities;
- improved access to finance for water conservation technologies; and
- strengthened institutions to further support water conservation.

The WIT project also represented one of the first large-scale applications of a Market Systems Development (MSD) approach to water conservation by the United States Agency for International Development (USAID) and Mercy Corps. An MSD approach is one that works through both public and private sector actors "to address the underlying systemic constraints that hinder target populations' access to, and participation in, the market" (Mercy Corps 2017). The fundamental basis for this approach is that local actors are more connected with the local population and, because of this, can reach more people and help change both behavior and the market system beyond the lifespan of the project. WIT activities focused on: 1) providing farmers and households both with increased information on the benefits of WSAs; 2) increasing market demand for WSAs; and 3) building the capacity of market actors to market, sell and finance these types of goods.

The focus of this research was to leverage relevant data, information and studies already carried out by Mercy Corps as part of WIT to conduct a study of the costs and benefits associated with WSA adoption as a result of the WIT project. While this effort would have ideally covered the entire life of the project, there was a need to complete the analysis before the end of the project, which is anticipated to be March 2022. For this reason, data (and results) represent WIT progress through September 2021. This cutoff point was selected as it was the end of the fiscal year (FY) and ensured that information/data used in this effort had been reviewed and finalized by WIT.

After summarizing the key findings from the literature review, this report outlines the conceptual framework and methodological approach used. The next four sections then cover the methods for and results of four distinct analyses conducted as part of this research: 1) activity-based cost analysis; 2) water savings analysis; 3) cost-effectiveness analysis; and 4) incentive evaluation and return on investment analysis. The report concludes with a section on findings, conclusions and recommendations that could potentially improve outcomes of similar water conservation projects and interventions in the future.

2. Literature Review

A brief and focused external literature review was conducted to understand both the broader water landscape in Jordan and similar efforts to conserve water through water saving technologies (WSTs) and/or other methods in the Middle East-North Africa (MENA) region.

2.1. Water Supply & Demand in Jordan

The Hashemite Kingdom of Jordan is one of the most water scarce countries in the world, ranking between third and thirty-third on the global scale depending on the water scarcity measure employed (Tetra Tech 2018). The majority of the rainfall the country receives (a long-term annual average of roughly 8,200 MCM) evaporates, with less than 6% remaining to flow into surface water or infiltrate into groundwater aquifers (Al-Shibli, Maher, and Thompson 2017). Jordan has fifteen surface water basins that drain into three different water bodies: the Dead Sea, the Red Sea, and desert mudflats.

In 2017, the sustainable supply of water in Jordan was estimated to average around 875 MCM, while estimated water demand was 1,412 MCM (MoEnv 2020). While 65% of freshwater in Jordan comes from surface water, the majority of water use (60%) comes from groundwater (Al-Shibli, Maher, and Thompson 2017; Ministry of Water and Irrigation 2016b; 2016a). This is, in part, the result of transboundary agreements and changes to the surface water resources shared across borders that have constrained Jordan's access to the Jordan River and Yarmouk River supply over time. At present, Jordan receives only 100 MCM via the King Abdullah Canal (0.1% of the total Jordan River Basin withdrawal) as a result of international political treaties and diversions by Israel, availability of storage in the Basin, and extraordinary rates of loss through evaporation (Al-Shibli, Maher, and Thompson 2017; Comair, McKinney, and Siegel 2012; Courcier et al. 2005). Flow in the Yarmouk River is also limited, having been reduced by almost half between 1970 and 1990 due to dam construction in upstream Syria (Ministry of the Environment 2006).

Limited surface water resources and reliance on groundwater has placed extreme pressure on the twelve main groundwater basins in Jordan, with four of the aquifers experiencing groundwater abstraction above safe yields, six aquifers at safe yield levels, and only two aquifers remaining underexploited (El-Naser 2009; "National Water Strategy of Jordan, 2016-2025" 2016). Most wells are located in the Jordan Valley and the northern reaches of the Highlands — including the overexploited Yarmouk and Amman Zarqa basin, the Dead Sea basin, and Azraq (Molle et al. 2017). Similar to their surface water resources, Jordan also shares with Saudi Arabia the groundwater resources in the Disi aquifer, one of the country's largest aquifer (Muller, Muller-Itten, and Gorelick 2017). Groundwater declines of 0.9 to 3.5 meter (m) per year have been observed since 1995 in one of the most highly productive aquifers in the country, serving the Amman-Zarqa area, and average of approximately 1 m/year decline across groundwater aquifers (Goode et al. 2013; Ministry of Water and Irrigation 2019; Balasubramanya et al. 2020). Additionally, agricultural fertilizers and biocides, waste from oil refineries, and other pollution sources threaten the water quality in groundwater aquifers (Mohammad, Almomani, and Alhejoj 2015).

Contributing to the issues of water scarcity are observed trends in rainfall resulting from climate change and the pressures of rapid population growth. Declines in rainfall have been realized over the past century, and climate models predict that higher temperatures and longer, more frequent, and more intense droughts will manifest by 2100 (Hoerling et al. 2012; Rahman et al. 2015; Rajsekhar and Gorelick 2017). At the same time as water resources are becoming more constrained, population is expected to increase. Jordan's population has experienced distinct periods of massive population growth from several refugee crises including more recently the First Gulf War (1990-1991), the war in Iraq (2003), and the recent Syrian conflict (Zietlow, Michalscheck, and Weltin 2016; Tetra Tech 2018). In 2010 Jordan's population was 7.2 million, and by 2020 the population had grown to 10.8 million, including at least 1.1 million Syrians fleeing from the 2011 Syrian war (Courcier et al. 2005).

Under moderate population growth scenarios, without considering the possibility of another refugee crisis, Jordan's population could increase to 21.4 million by the end of the century; a 121% increase (Yoon et al. 2021). More aggressive population growth scenarios that include potential influxes from surrounding countries like Syria predict a population of 32 million by the end of the century (Yoon et al. 2021). These population projections, coupled with climate change, ongoing transboundary issues, and security concerns in the region, have made domestic and drinking water supply a priority in Jordan's current water strategy ("National Water Strategy of Jordan, 2016-2025" 2016).

Significant effort and funds, both domestic and international, have been allocated to address these issues. Primary strategies generally fall into four categories: 1) policy/regulatory changes; 2) construction of large infrastructure projects; 3) increased adoption of water saving technologies; and 4) increased utilization of non-conventional water resources.

2.2. Pathways for Addressing Water Supply Concerns

Investing in WSAs in the face of severe water scarcity is a logical approach. McKinsey (2009) outlines three high-level strategies for meeting future water needs: increase supply; increase productivity of water use; and reduce demand through change in water using activities. One challenge, however, is to identify which of these options, or a combination thereof, is most cost-effective given the geographic and socio-cultural context.

Several recent studies have focused on potential demand-side strategies specific to Jordan. First, Ramírez et al. (2011) concluded that pricing has the potential to influence agricultural water usage in Jordan, with 1) low water pricing discouraging water savings even if water savings is being promoted by other institutions; and 2) high water pricing incentivizing water savings even in the presence of other negative impacts. Another recent study (Klassert et al. 2015) modeled demand for piped and tanker water in Amman and concluded that increased tariffs on piped water would likely support water savings by 1) having households be more responsible for the full costs of piped water; and 2) reducing household demand for tanker water that is partially unregulated. Were this approach to be implemented in the future, the author noted it would be important to consider spatial and socioeconomic factors in order to ensure that potentially vulnerable communities were not disproportionately impacted.

To date, however, there has been relatively limited interest from Jordanian authorities to enact such changes. As noted in Bonn (2013), "the water question is often stylized as a national affair in Jordan, which leads to an attitude of 'yes to projects but no to political interference.'" That being said, it appears some recent government interventions have occurred. Examples include increasing groundwater tariffs and a campaign targeting water theft and groundwater licensing that eliminated access to the power grid for illegal farms and denied government services and official documents to individuals who had not paid their water bills (Harake 2019; Molle et al. 2017).

Still, water scarcity is often presented by authorities and the media as a supply-side issue in Jordan, noting factors such as climate change and an influx of refugees and, therefore, the primary pathway for addressing water scarcity is seen as enhancing supply (Klassert et al. 2015). This pathway aligns with development of large infrastructure projects focused on increasing supply (e.g., Disi Water Pipeline and Red Sea Desalination Projects).

Another potential supply-side strategy already being considered relates to management of water supply systems in Jordan (Ministry of Water and Irrigation 2016c). In 2013, it was estimated that water losses in the piped distribution systems exceed 50% in most of the country as a result of leakages, illegal connections and metering inaccuracies (Wildman 2013).

There appears to be a growing recognition that changes on the demand-side are also needed such as increased adoption of WSTs and non-conventional water resources. Water saving technologies have the potential to increase water savings across many sectors — in the literature, the primary focus has been on municipal water supply (including residential use) and agriculture.

Jordan already has identified wastewater reuse as a strategy to address the potential water supply gap, particularly in terms of providing supply to agriculture and other non-domestic uses. In Amman over 95% of wastewater is treated and recycled (Yoon et al. 2021). Jordan is a regional success story in terms of the use of treated wastewater for irrigation, which made up 14% of Jordan's total water "supply" and 25% of irrigation water usage in 2017, though this strategy relies on Jordan's unique geography with cities perched atop the Jordan Valley and its irrigated lands (Ministry of Water and Irrigation 2015). The use of rainwater harvesting systems, particularly pear-shaped wells, have also been proposed as a cost-effective way to improve water supply (Abdulla 2020).

Despite these efforts to increase efficiency and close the looming water supply gap, water distribution and use in Jordan is still highly inefficient and intermittent. With regards to adoption by households and farmers, a variety of sociocultural, informational and financial barriers exist that may be preventing adoption on a broader scale and campaigns and programs to raise awareness and reduce transaction costs are needed (Hagan and Jordan 2008; Ministry of Water and Irrigation 2016c).

2.3. Cost & Value of Water

Table 1 includes estimated the cost per cubic meter paid for water by various water users in Jordan. In some cases, the cost paid by water users is less than the cost of providing that water. Qtaishat et al. (2017) estimated that even with 100% efficiency in billing and collection (which does not currently occur), the tariff required to cover operations, maintenance and depreciation costs associated with supplying water for irrigated agriculture in the Jordan Valley would need to be approximately $0.10/m^3, however, current tariff rates for irrigation are less than $0.02/m^3.

Table 1. Estimates of Water Costs in Jordan

Water Costs	$2020/m^3	Reference
Use		
Irrigated agriculture	$0.02	Qtaishat et al. (2019)
Average residential household	$0.51-$0.61	WAJ (2016)
Non-residential	$1.98	WAJ (2016)
Supply		
From Israel	$0.65	Lieberman (2021)
From water tanker	$1.40-$14.00	Endline HH survey (2021)

Al-Karablieh (2012) used the Residual Imputation Method (RIM) to estimate the average value of water to industry/service sectors and agriculture. An additional value chain analysis was done for select crops to assess the allocation of water value from crop production to final use (i.e., consumer's table). Studies (Carpio, Ramirez, and Boonsaeng 2011; Chebaane et al. 2004) also have examined the costs of purchasing water use rights from farmers or providing assistance to farmers to reduce water use in Jordan as a method of water savings (Table 2). It is important to note that these studies were conducted at different times and that all estimates were modeled values.

Table 2. Estimates of the Value of Water in Jordan

Type	$2020/$m^3$	Reference
Permanent purchase of agricultural land	0.06	Chebaane et al. (2004)
Temporary leases of agricultural water for urban use	0.37	Capiro et al. (2011)
Permanent purchase of agricultural land	0.41	Capiro et al. (2011)
Production value to agriculture	0.73	Al-Karablieh (2012)

2.4. Cost-Effectiveness of Water Saving Approaches

To assess cost-effectiveness, McKinsey (2009) proposed the use of a "cost curve of incremental water availability," which is created by plotting the amount of water saved by each activity on the x-axis and the cost per unit on the y-axis. This approach is useful in that it recognizes that the most cost-effective strategy may only conserve a portion of the desired total.

Similarly, the report also puts forth a "payback curve," which considers the number of years it would take for capital expended on an activity to be recovered by the adopted or end user — this is particularly useful when comparing potential costs and benefits across public and private sectors and allows decision-makers and funders to better assess which approaches might be most attractive to adopters as well as whether incentives for certain approaches might be advisable. Cost-effectiveness measures also provide a method for comparing different types of WSAs (e.g., supply-side versus demand-side) — a critical component, however, when comparing cost-effectiveness is considering how both the quantity of water and value of costs are calculated and ensuring that methods are consistent. (McKinsey 2009)

To provide comparisons for the cost-effectiveness for WIT, a number of other studies were reviewed. Results from these are included in Table 3 and the most relevant also are compared to the cost-effectiveness of WIT activities in Section 6.4. Recognizing that costs for a given activity have the potential to vary substantially county-to-country, the focus has been limited to Jordan and the MENA region.

Table 3. Estimates of Cost-Effectiveness

Cost-Effectiveness	$2020/m^3	Reference
Permanent agriculture buyout	$0.06	Chebaane et al. 2004
Irrigation advisory services	$0.08	Chebaane et al. (2004)
Al Wahdah dam construction	$0.09	Aulong et al. (2008)
Groundwater policy	$0.12	Aulong et al. (2008)
Annual pipe survey	$0.24	AL-Washali et al. (2019)
Temporary ag-urban transer	$0.37	Capiro et al. (2011)
Upgrade Samra wastewater plant	$0.40	Aulong et al. (2008)
Permanent agriculture buyout	$0.41	Capiro et al. (2011)
Brackish water desalination	$0.42	Qtaishat et al. (2017)
Zara Springs desalination	$0.44	Aulong et al. (2008)
Amman network rehabilitation	$0.49	Aulong et al. (2008)
Irrigation water source switch	$0.74	Chebaane et al. 2004
Red Sea-Dead Sea conveyance	$0.75	Aulong et al. (2008)
Israel - additional above agreement	$0.75	Lieberman (2021)
Disi Aquifer conveyance	$0.82	Aulong et al. (2008)

2.5. Do Water Savings Lead to Water Conservation?

In water saving efforts utilizing WSTs, an important distinction is drawn between water use and water consumption. Water use is related to the water withdrawn for a specific end-use, but may include consumptive and non-consumptive activities. From the latter, water can often be recovered for other uses. Water consumption, on the other hand, specifically refers to the volume of water lost from the geographic scale of analysis and that is not available for use by others. Previous work implementing WSTs and other water productivity interventions have found that, without external governance controls, such water saving efforts often result in similar or even increased levels of water consumption.

This impact manifests because the water savings produced by these interventions does not necessarily keep water savings in the ground. Consider an example from the agricultural sector in which a farmer is entitled to or typically extracts a certain volume of groundwater for irrigation. After adopting a WST this farmer now is able to irrigate the same land with less water, but, rather than not extracting the now-surplus water, the farmer increases the land area he/she irrigates causing an overall net increase in water consumption. In such a situation the water saved through WST adoption is not saved for a public use, but rather for a private one. Impacts of this kind have been realized with irrigation efficiency projects from India, the United States, and China, among others. (Yu et al. 2021)

In the agricultural context, at least, economics have a part to play in whether WSTs result in greater water consumption as increased consumption typically occurs when the increased water efficiency results in increased revenue that is greater than any marginal costs associated with the WSTs, such that WSTs are often associated with increased farm incomes. It has been found that this relationship is particularly strong in water-stressed basins and when WSTs are subsidized. Without policy guidance or other external controls, adoption of WSTs by agricultural producers is unlikely to result in water savings for the public benefit. Projects that implemented WSTs alongside other interventions, such as quotas and land use restrictions, were more likely to result in reduced water consumption. Of the studies reviewed, total reduction in water consumption was primarily attributable to the other interventions rather than the WSTs (Perez-Blanco, Hrast-Essenfelder, and Perry 2020).

It appears important, therefore, to consider the intended goal of water savings efforts for a given project. If the intent is for conserved water to be used to support increased agricultural production, then WSTs may be an effective and useful strategy; however, if environmental or more public-facing (e.g., additional water supply for an increasing population) outcomes are desired, other interventions or clearly defined restrictions on how any water saved could be used should be considered.

No similar research was found on adoption of WSTs by households. That being said, even if water conserved by a household was simply used for other needs within the same household, in the Jordanian context, it could be argued that this is still a "public" benefit, although not an environmental one, given that per capita water availability in Jordan is only around 150 m^3/year, while the absolute scarcity threshold is 500 m^3/year (United Nations Development Programme 2006).

3. Conceptual Framework & Methodological Approach

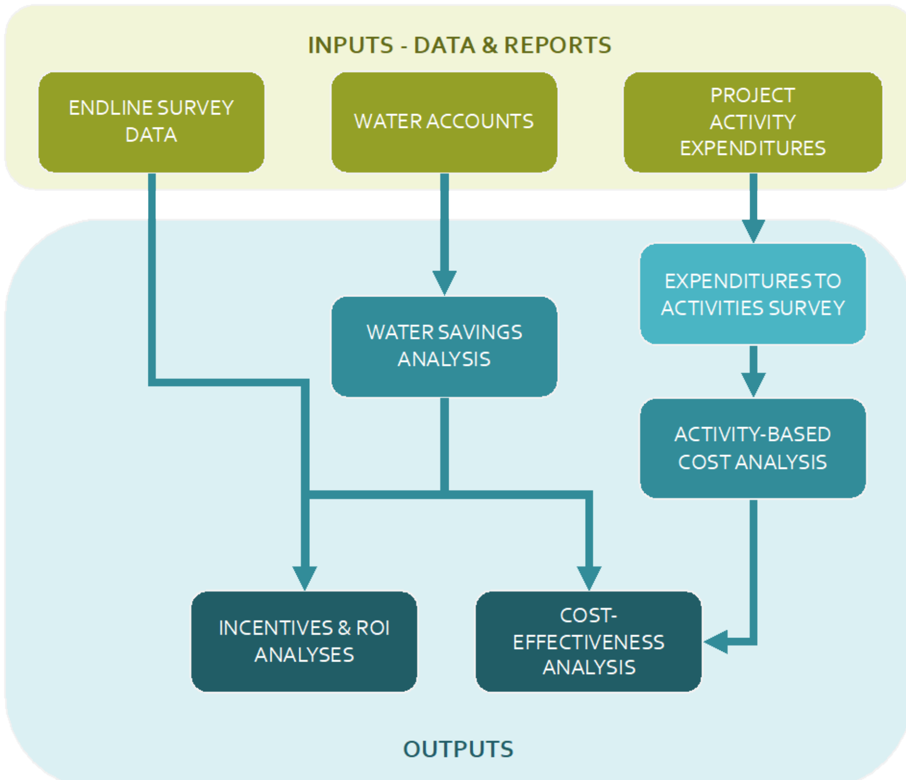
The two primary objectives of this study were to 1) estimate the cost-effectiveness of investment in each WIT activity in terms of promoting the adoption of WSAs by households, farmers and communities; and 2) assess the motivations for and costs/benefits of WSAs adopted as part of WIT to both private (i.e., suppliers, farmers, and households) and public actors (i.e., USAID and Mercy Corps).

As mentioned previously, four distinct analyses were conducted to meet those objectives:

1. **Activity-based cost analysis**. WIT expenditures (thru September 2021) were categorized and summed based on the degree to which they supported WIT activities (e.g., directly, indirectly).
2. **Water savings analysis**. Data on water savings collected during WIT were used to estimate total water saved during WIT and under two additional scenarios.
3. **Cost-effectiveness analysis**. Costs and water savings for each activity were compared to assess the cost per unit of water saved.
4. **Incentives and return on investment analysis**. Data from the knowledge, attitude and practices (KAP) endline surveys were used to first evaluate motivations for adoption of WSAs and then were combined with additional data from external sources to conduct a return on investment (ROI) analysis for participants.

Figure 1 provides a high-level representation of how key data sources from WIT were used to complete these analyses.

Figure 1. Conceptual Framework



3.1. WIT Focal Areas

As mentioned previously, the WIT project was a five-year project — beginning in March 2017 and ending in March 2022. It focused on increasing water savings in Jordan by improving knowledge of and access to water saving technologies (WSTs), water saving devices (WSDs) and water saving practices (WSPs), collectively referred to as WSAs. Activities targeted two water user groups: 1) farmers; and 2) households.

Project work was focused on the northern part of the country — the majority of agricultural activities took place in the governorates of Azraq and Mafraq, while household activities covered a broader area that included Mafraq, Ajloun, Azraq, Jerash, Irbid, and Amman.

3.2. WIT Activities

As the primary goal of this study was to assess cost by activity, it was first necessary to identify key WIT activities and group them such that it was possible to create a linkage between expenditures and activities. With input from Mercy Corps staff, WIT activities to increase water savings in Jordan were grouped into eight categories (abbreviations used throughout shown in parentheses).

Agriculture

- **Demonstration sites (Ag – Demos).** Demonstration sites where WSTs were installed early on in the project.
- **Investment fund (Ag – Fund).** Provided technical and cost-share support to irrigation equipment suppliers to help them promote WSTs to farmers as part of the MSD approach.

- **Supplier incentives (Ag – Incentives).** Incentivized farmer adoption of WSTs though suppliers who signed a water savings compensation agreement with the WIT project, though which suppliers were compensated for each cubic meter of water saved by farmers after WST adoption. Also known as "results-based package".

Household

- **Investment fund (HH – Fund).** Provided technical and cost-share support to suppliers to help them expand sales networks and improve promotion of WSTs/WSDs to households.
- **Revolving loan fund (HH – Loans).** Facilitated household adoption of WSTs/WSDs by providing loan capital to community-based organizations that, in turn, dispersed loans to households purchasing WSTs/WSDs.
- **Social media and outreach campaign (HH – Media).** Focused on raising public awareness on water conservation issues and options for WSAs though social media, training and awareness sessions and community participation.
- **Schools (HH – Schools).** Installed WSTs in schools.
- **Communal storage projects (HH – Storage).** Rehabilitated existing dams used to store water for local community use.

4. Activity-Based Cost Analysis

This section describes the data, methods and results for the activity-based cost analysis. Note that all values presented are in United States dollars as this is the currency in which line-item expenditures (also referred to as costs) were recorded in Mercy Corps' accounting system; however, personal communication indicates that most of the costs were paid in Jordanian dinar (JOD).

4.1. WIT Cost Data

A spreadsheet of all WIT project-related expenditures was obtained from Mercy Corps along with a table of General Ledger (GL) codes, which are used to identify the "type" of cost (e.g., salary, vehicle rent, subcontract, etc.). Over 17,000 individual line items were included in the spreadsheet, covering WIT project costs from March 2017 through September 2021.

While the spreadsheet contained a variety of information for each line-item cost, the key variables used to categorize costs by activity included Mercy Corps' activity or GL code, employee identification (ID) number, and sub-grant number.

4.2. Activity-Based Cost Analysis Methods

For the purposes of this analysis, at the highest level, costs were categorized as:

- **Activity costs.** Expenditures that directly supported or contributed to water savings.
- **Indirect costs.** Expenditures that provided broader project support, but did not directly contribute to water savings.

Activity costs were further broken down into direct and shared costs:

- **Direct activity costs.** Expenditures directly supporting WIT activities focused on increasing water savings. Examples included costs to install agricultural demonstration sites; costs to put on public awareness sessions; and construction costs for communal storage projects. Direct activity costs also included salaries for key personnel directly engaged in WIT activities.

- **Shared costs.** Expenditures that contributed directly to water savings, but supported multiple agriculture or household activities. An example was costs associated with irrigation supplier training workshops, the water savings benefits from which were realized through both the agricultural investment fund and supplier incentives activity groups.

Indirect costs also were categorized in more detail:

- **MEL.** Expenditures related to WIT monitoring, evaluation and learning (MEL) activities.
- **G&A.** The general and administrative (G&A) costs of the WIT project; costs that broadly supported WIT activities; and costs that could not be directly attributed to agricultural or household activities based on the information provided.
- **Start-up.** Expenditures during the first six months of WIT (i.e., March 2017 thru September 2017).
- **JO.** The administration, management and financial support costs rendered by the Mercy Corps' Jordan office to the WIT project.
- **HQ.** Mercy Corps' Negotiated Indirect Cost Rate Agreement (NICRA) costs for USAID projects, that go to support activities provided by Mercy Corps' global headquarters (HQ).

Finally, a limited number of line-item costs were removed from the analysis based on input from Mercy Corps' staff. These represented an insignificant portion of overall costs (i.e., approximately 0.4%) and were associated with a weather-station activity and the water audit activity in partnership with Miyahuna, which is not yet complete and, therefore, has not yet resulted in any water savings.

As mentioned previously, the key variables used to categorize costs by activity included GL code, employee ID and sub-grant number. In addition, a matrix of personnel as well as sub-grants and GL codes for which categorization was not easily determined was completed by key WIT staff who apportioned personnel time by employee and other line items across the direct activities. Using this information in various combinations allowed all line item costs to be attributed to a specific cost category.

4.3. Activity-Based Cost Analysis Results

In total, $27.3 million was allocated across the cost categories previously outlined. Costs (both direct and shared) related to agricultural and household activities accounted for 13% and 37% of total costs, respectively (Figure 2). An additional 21% of costs supported the WIT project more broadly and the remaining 29% supported activities at the Mercy Corps Jordan office and headquarters. A full breakdown of costs by category is presented in Table 4. Note that due to the rounding, values in Figure 2 and Table 4 may not sum to the totals reported therein.

Figure 2. Distribution of Costs by Category

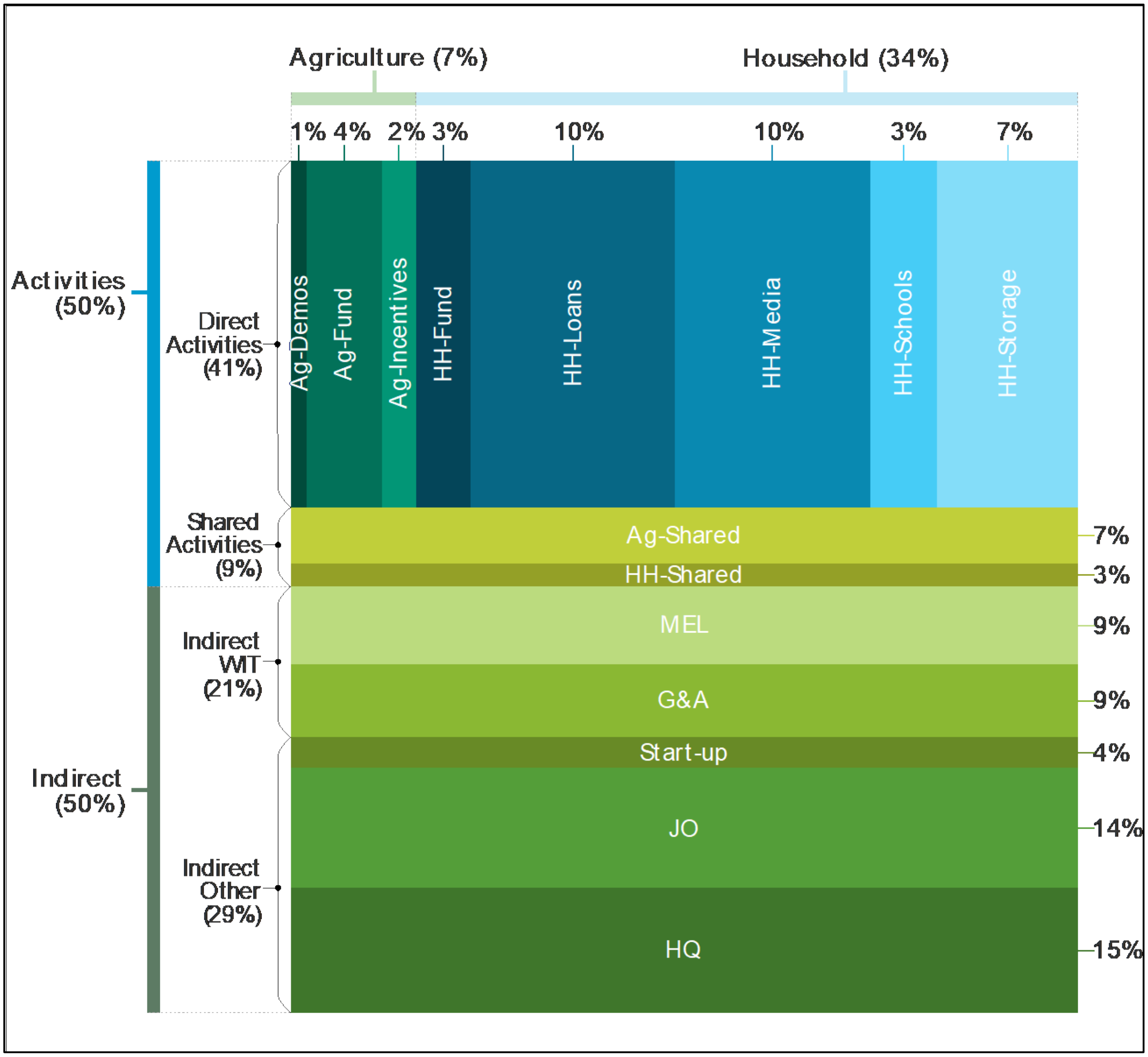
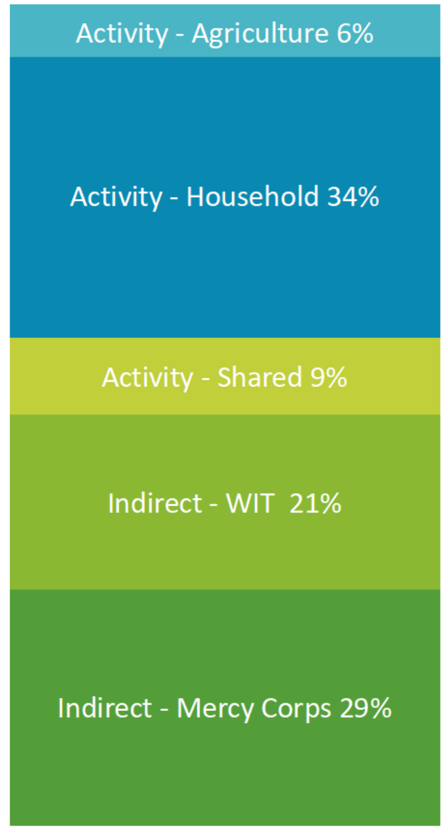


Table 4. Costs by Category

Direct Activity	USDm	% of Total
Ag - Demos	**$0.2**	**1%**
Ag - Fund	**$1.1**	**4%**
Ag - Incentives	**$0.5**	**2%**
HH - Fund	**$0.8**	**3%**
HH - Loans	**$2.9**	**10%**
HH - Media	**$2.8**	**10%**
HH - Schools	**$0.9**	**3%**
HH - Storage	**$2.0**	**7%**
Sub-Total	$11.1	41%
Shared Activity		
Ag - Shared	**$1.8**	**7%**
HH - Shared	**$0.8**	**3%**
Sub-Total	$2.6	9%
Indirect WIT		
MEL	**$2.5**	**9%**
G&A	**$2.4**	**9%**
Start-up	**$1.0**	**4%**
Sub-Total	$5.8	21%
Indirect Mercy Corps		
JO	**$3.8**	**14%**
HQ	**$4.0**	**15%**
Sub-Total	$7.8	29%
Total	$27.3	100%



5. WATER SAVINGS

This section describes the data and methods used to estimate water savings from the WIT project and also presents results.

When interpreting results presented here, it is important to note that estimates of future water savings (i.e., outside the WIT project baseline) do not account for external factors (e.g., climate change, trends in groundwater abstraction from other sectors, etc.) that have the potential to affect water supply/availability in Jordan and/or influence the behavior of water users.

5.1. Water Savings Scenarios

For the purposes of this analysis, water savings are calculated under a baseline and two projection scenarios:

1. **WIT Baseline.** Water savings during WIT from adoption of WSAs supported by WIT activities.
2. **WIT Length of Life.** Water savings from adoption of WSAs during WIT (through September 2021) and through the length of life of currently installed/adopted WSAs. Water savings under this scenario were estimated separately for agriculture and household activities. This scenario is perhaps most representative of the water savings supported by WIT as water savings do not stop when the project ends.

3. **WIT Adoptions.** Water savings from adoption or behavioral change occurring during WIT (through September 2021) and from new adoption after the end of the WIT. Water savings under this scenario were calculated only for agriculture activities as a result of the market system development component of WIT, which provided irrigation suppliers with the knowledge and ability to continue to effectively market and promote WST adoption.

5.2. Water Data

A series of files were obtained from Mercy Corps and International Water Management Institute (IWMI), which are describe in further detail below.

In order to provide water savings estimates across a broad range of households, farms and WSAs, IWMI developed and documented the methods used to estimate monthly water savings (e.g., IWMI 2020; 2019; 2018). In some cases, different methods had to be applied to different groupings (e.g., not all farmers agreed to have water meters installed on their farms, so proxy values had to be used as opposed to direct estimates). In addition, no direct water savings were tracked for households, either by IWMI or Interdisciplinary Research Consultants (id:rc), but rather, surveys and lab calculations were used to estimate average monthly water savings associated with adoption of a particular WSA. Additional details of actual calculations, assumptions, and methodological limitations are included in the IWMI and id:rc reports.

5.2.1. Agricultural Water Data

Two sources of agricultural water savings data were made available by Mercy Corps. The WIT baseline was developed using the data provided by IWMI, which had developed and implemented the plot level water monitoring effort and provided a full dataset in December 2021. The water savings data from WIT staff were made available later, in January 2022. Some agriculture activities, such as Ag – Incentives, were still ongoing at the time this analysis was conducted and, therefore, will have greater impact than results reported here.

1. **IWMI agriculture water accounts spreadsheet**. This spreadsheet provided monthly water savings and area under WST data by Farm ID number from January 2018-September 2021. Monthly water savings reports produced by IWMI were based on this spreadsheet and aligned with the values entered therein. Steps taken to clean and summarize the data are described next.

2. **WIT final farm water savings spreadsheet**. This spreadsheet provided quarterly water savings, total farm area, area in WSTs, area metered by IWMI, and crop by farmer name and Farm ID. Water savings for FY2018-FY2021 recorded in this spreadsheet were higher than water savings reported in the IWMI spreadsheet by 0.6 MCM (3%) (Table 5).

Note that both data sources include water savings from "early adopters" or farmers who adopted WSTs as an indirect effect of the WIT project and without incentive from WIT. This analysis, the aim of which was to complete a cost-effectiveness analysis by WIT activity, did not consider the "early adopters" as there was no way to allocate WIT expenditures to the water savings return from this group. While estimated total savings were the same between the two spreadsheets, the 3% difference in water savings between the two data sources emerged when water savings from early adopters were removed.

Table 5. Agricultural Water Savings by Activity & Data Source

WIT Activity	WIT Final (MCM)	IWMI (MCM)
Demos	1.3	1.0
Fund	13.4	12.4
Incentives	3.6	2.7
Early Adopters	3.3	3.9
Uncategorized	0.0	1.5
Total	**21.6**	**21.6**

Note: Although the delineation of water savings by WIT activity was more complete in the WIT final farm water savings spreadsheet, the IWMI agriculture water accounts spreadsheet provided water savings by farm by month, which was critical to the calculation of future water savings under the Length of Life and Adoption scenarios described in Section 5.1.

The IWMI agriculture water accounts spreadsheet provided monthly water savings by Farm ID number on one tab and area under WSTs by month on another tab. Some farms adopted WSTs on multiple treatment areas; given this, a Farm ID could represent total or partial adoption by a single farm. For farms with multiple treatment areas, the beginning of the Farm ID was the same, with the final alphanumeric combination typically identifying the crop (e.g., AM002OT and AM002ST represented two treatment plots on the same farm for olive and stone fruit crops, respectively). In the case of farms with multiple treatment areas, water savings were calculated by treatment area.

The water savings data first had to be organized by activity such that the appropriate costs from the expenditure data could be attributed to the correct volumes of water savings. Effort was made to attribute water savings and area under WSTs to the activities referenced in Section 3.2: Ag – Demos; Ag – Fund; and Ag – Incentives.

The water savings within each activity were further broken down by WST type (i.e., improved glass-fiber reinforced (improved-GR), pressure compensating (PC) systems (online and inline), and T-tape as the technologies have different lifespans, which were provided by the WIT team:

- PC systems – 7-10 years with 8 years used in the projections;
- Improved-GR systems – 3-7 years with 5 years used in the projections; and
- T-tape systems – 2-5 years with 3 years used in the projections.[2]

To complete this exercise, data on WIT activities and WST technology had to be reconciled between the water savings tab and the area under WST tab. There were some instances in which a Farm ID referenced on one tab did not appear on the other or the WIT activity or WST technology for a given Farm ID differed between tabs. Further communication with the WIT team allowed many of these issues,

[2] In-line PC drip irrigation systems have the drippers pre-inserted at fixed intervals. On-line PC drip irrigation systems typically have the pipe installed without drippers and then drippers are manually attached to the pipe.

particularly those in regard to the activity discrepancies, to be reconciled (remaining discrepancies, particularly in regard to missing Farm IDs, combined with minor differences in water savings recorded, form the basis of the difference in water savings by activity between the IWMI spreadsheet and the farm water savings FY18-FY22 spreadsheet spreadsheet). Some inconsistencies in technology type by Farm ID remained between tabs, however, because the focus of this analysis was on water savings and cost-effectiveness by activity, additional effort to reconcile these discrepancies was not made.

As water savings during WIT were provided by month, the lifespan of each WST was tracked from the month in which water savings were first recorded. For example, if a farm began using a T-tape system in March 2019, the assumed end of life for that WST would be March 2022.

5.2.2. Household Water Data

Two sources of information were available on household water savings:

1. **IWMI household water accounts spreadsheet.** The household water savings spreadsheet provided monthly water savings for most WIT household activities through September 2021, however, in contrast to the agricultural water savings data, some water savings were presented as annual totals (e.g., communal storage projects) and all water savings prior to October 2020 were presented as cumulative totals through the end of FY2020.[3]

   Tabs included water saving devices (WSDs) such as showerheads, faucets, etc.; reverse osmosis systems (RO); rainwater harvesting (RWH) systems; greywater (GW) systems; communal storage projects; schools; and WSPs. Water savings on the tabs for WSDs, RO systems, RWH systems and GW systems were further broken out by whether adoption occurred as a result of the revolving loan fund, sales or demonstrations. As mentioned previously, in order to align with expenditure data WSPs are presented as water savings under HH – Media.

   Data on water savings and WSA adoption was reorganized by activity to align with those outlined in Section 3.2: HH – Fund; HH – Loans; HH – Media; HH – Schools; and HH - Storage.

2. **id:rc KAP household end-line survey report**. The id:rc KAP end-line survey was a survey of households in the governorates of Mafraq, Irbid, Jerash, Ajloun, and Azraq focused on respondents' knowledge and perceptions of water issues in Jordan, particularly as they pertain to household water use and supply, and their adoptions of WSAs over the two years preceding 2021, including their motivations for and impacts of adoption. Although the timeframe covered by the survey encompasses years in which the WIT project was active, the survey was not specific to WIT project participants or actions taken as a direct result of WIT activities. The report, which analyzed and displayed survey results, extrapolated the adoption of WSAs and the associated water savings from the surveyed population to the whole populations of the surveyed governorates to provide an estimate of water savings resulting from WIT activities and outreach in the targeted governorates.

Given substantial differences in the estimated water savings from the two sources (i.e., IWMI and id:rc), particularly resulting from WSPs, the IWMI data was selected for use in the baseline analysis — namely because water savings coming from sources other than WSPs represented adoptions that occurred as a direct result of WIT, whereas it was more difficult to attribute estimated water savings from the KAP

[3] Methods used for the calculation of IWMI water savings can be found in "WIT Water Accounts Plan For Fiscal Year 2020 Calculation" (IWMI 2019).

survey to WIT activities directly. A sensitivity analysis was performed to assess how results might change if water savings estimates from the id:rc report are used instead.

5.3. Methods

This section describes the methods used to estimate water savings under the baseline and two scenarios previously described in Section 5.1. Sensitivity testing also was conducted to assess the degree to which results changed under different assumptions for key variables and results are included in Section 5.5.

5.3.1 WIT Baseline – Agriculture & Household

Following cleaning of the agriculture and household data, water savings were summed by WIT activity through September 2021 and reconciled to the IWMI water accounts monthly reports to estimate water savings for the WIT baseline.

5.3.2. WIT Length of Life – Agriculture

The steps used to estimate water savings under the WIT Length of Life (LoL) scenario for agriculture are as follows:

1. The month/year when water savings data first started being tracked on a farm was determined for each Farm ID. It also was determined whether and when WSTs were added to additional dunums[4] on an individual farm-plot.
2. The number of dunums under WSTs was projected based on the lifespan of the appropriate technology for each Farm ID and the date when WSTs were implemented or the treatment area under WSTs was increased. For example, if 10 dunums with a T-tape irrigation system came online in October 2018 and 20 dunums were added in October 2019, the projected values for dunums under WSTs for this row of data would be 30 dunums until October 2021 (3 years from October 2018) and 20 dunums until October 2022, after which the number of dunums under WSTs would drop to zero.
3. Water savings for each Farm ID were calculated using the FY2021 monthly values and projecting those values forward adjusted by the proportion of dunums under WSTs for that Farm ID in the future to the number of dunums of WSTs in that month of FY2021. For those Farm IDs with water savings data, but no corresponding entry on the area under WSTs tab, the water savings in FY2021 were replicated into the future until the lifespan of the technology from the date of implementation is reached, after which water savings dropped to zero.

   For example, using the example for area under water savings, if 600 m^3 of water is saved in January 2021 from the 30 dunums associated with the T-tape system and 1,000 m^3 in July 2021, then the projected values for January 2022 would be 600 m^3. By July 2022, 10 dunums have been retired because the lifespan of the T-tape had been reached, so only 667 m^3 of water would be saved in July 2022 (1000 m^3 * 20 dunums / 30 dunums).

The resulting projections are likely conservative as some farm-plots came online in FY2021 and therefore did not have a complete year of monthly data. As such, there was no baseline data for projecting water savings forward for certain plots in certain months. The estimates of water savings may be additionally conservative because of the finding, identified by IWMI (IWMI 2021), that water savings observed by farmers on treatment plots resulted in reduced water applied to control plots in subsequent months such that water savings appeared lower than they were in reality. Additionally, because this methodology relies

[4] Ten dunums equals one hectare.

on the FY2021 data so that the water savings associated with the total dunums under WSTs was appropriately represented, this methodology did not account for interannual variability due to different hydrologic conditions that may cause water savings per dunum to increase or decrease.

5.3.3. WIT Adoption – Agriculture

The steps used to estimate water savings under the WIT Adoption scenario for agriculture are as follows:

1. The average rate of WST adoption throughout WIT was calculated in dunums/month for plots adopted through the investment fund and/or supplier incentives —as new demonstration sites are unlikely to be developed.
2. The average water savings per dunum per month was calculated.
3. New dunums per month with WSTs installed were then calculated.
4. Dunums per month were then multiplied by average water savings per dunum per month and summed to calculate total annual water savings.
5. Continued adoptions of WSTs by new farmers occur for two years after the end of the WIT project.
6. In contrast to the LoL projections for currently installed WSTs, water savings were extrapolated over 20-years (through FY2041), at the recommendation of WIT staff. During this time, even though replacement of WSTs would be required, it was assumed that farmers, seeing the benefit of WSTs, would maintain or reinstall WSTs as they began to degrade or fail.

5.3.4. WIT Length of Life – Household (WSAs)

It was determined that, with the exception of tap aerators, which have a lifespan of approximately one year, the adopted technologies — including low flow devices, GW units, dry sanitation units, RO filtering systems, RWH tanks, and communal storage projects — should last longer than the timespan used for agricultural water savings projections (through FY2041). Therefore, water savings were projected over a 50-year timespan (through FY2071) using the following methods.

First, the cumulative number of WSA adoptions (and associated water savings) were calculated for each WIT activity/WSA combination through the end of September 2021 and then were assumed to stay constant going forward, with the exception of the WSD category, which was adjusted due to the short lifespan of tap aerators.

Next, water savings were projected forward by referencing the month in question in the FY2021 and replicating the water savings, adjusted by the proportional cumulative adoptions of each WIT activity/WSA in September 2021 relative to the month in question in FY2021. Water savings were also reduced by the calculated value for water savings produced by tap aerators for each month. For example, if there was a total of 10 reverse osmosis filtering systems adopted through December 2020 with water savings of 100 m^3 and 10 additional filters were adopted by September 2021, to project the water savings in December 2021 the following formula would have been used: 100 m^3 * (20 adoptions / 10 adoptions) to produce a total of 200 m^3 of water savings in December 2021.

5.3.5. WIT Length of Life – Household (Community Storage Projects)

For the projection of water savings from communal storage projects, which included construction/rehabilitation of large reservoirs/ponds, estimates of anticipated initial water savings from each project were sourced from a WIT quarterly report (Mercy Corps 2021, 2) as follows:

- Queen Rania Pond- Sakhra, Ajloun (completed FY2020): 21,000 m^3/year;
- Deir al Kahef Dam - Deir al Kahef, Mafraq (completed FY2021): 50,000 m^3/year;
- Buwaidah Dam Ramtha, Irbid (completed FY2021): 75,000 m^3/year; and

– Al Ghadeer Al Abiad Dam- Mafraq (to be completed FY2022-23): 50,000 m^3/year.

A percentage loss in total volumetric capacity of these reservoirs/pond due to sedimentation (after the initial year) of 1.55% per year was applied to projected water savings based on estimates from a study of the Mujib Dam reservoir in Central Jordan (El-Radaideh, Al-Taani, and Al Khateeb 2017). This value also is within the range of estimated reservoir storage capacity lost globally on an annual basis (i.e., 1-2%) (Iradukunda and Bwambale 2021).

5.3.6. Discounting

The benefits of a project such as WIT often occur over a different timeframe than that of the project investment. In the case of WIT, investments occurring from FY2018 through FY2021 will support water savings benefits beyond the life of the project. In cases where the timeframe differs, it would be incorrect to directly compare total investments to total benefits without accounting for when they actually occur. The Office of Management and Budget (2003) recommends that as part of any regulatory analysis benefits be estimated using both a 3% and 7% discount rate. For the purposes of this analysis, a 5% discount rate was used, which represents the midpoint between the recommended 3% and 7%.

5.4. Water Savings Results

Estimated water savings by activity are presented below for the baseline and additional scenarios considered.

5.4.1. Agricultural Water Savings

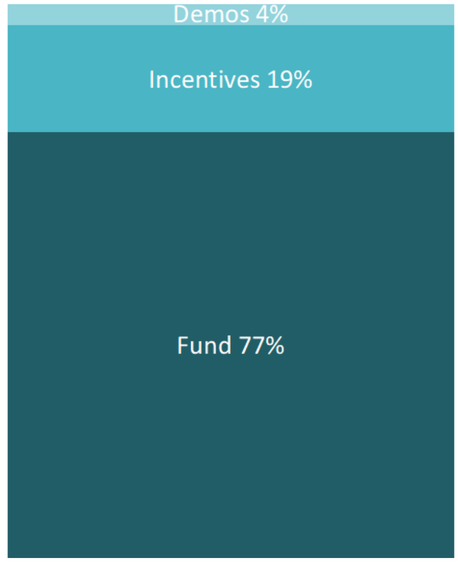
Agricultural water savings, as reported in the WIT Water Account Monthly reports and reconciled with calculations from the provided accounting spreadsheet, are detailed below (Baseline), alongside the estimated water savings for the two water saving scenarios (WIT LoL and WIT Adoption).

5.4.1.1. Agriculture – WIT Baseline

The WIT Water Account Monthly Report for September 2021 states that the total monitored area was 14,340 dunums across 89 farms (Amdar and Elmahdi 2021). Of this total, 13,403 dunums were associated with the activities tracked here — the remaining dunums fall outside of the activities by which expenditures were categorized and one discrepancy in area under WSTs that was updated based on correspondence with the WIT team (Farm ID AM008GT). The data also showed six additional farms that had adopted WSTs as part of the project, but for which water savings were no longer being recorded (presumably because the WSTs were no longer being used).

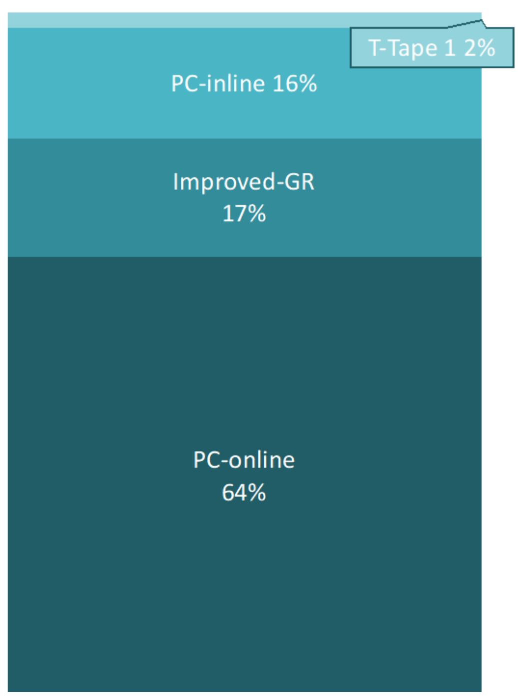
Of these 89 farms, 79 and 10 had adopted as a result of the investment fund and supplier incentives, respectively. It appeared that demonstration sites also were located on eight of these farms. The majority of dunums were adopted as part of the investment fund (i.e., 9,329 dunums), although it is important to note that the supplier incentive activity started later than the other WIT activities (Figure 3).

Figure 3. Distribution of Dunums by Adoption



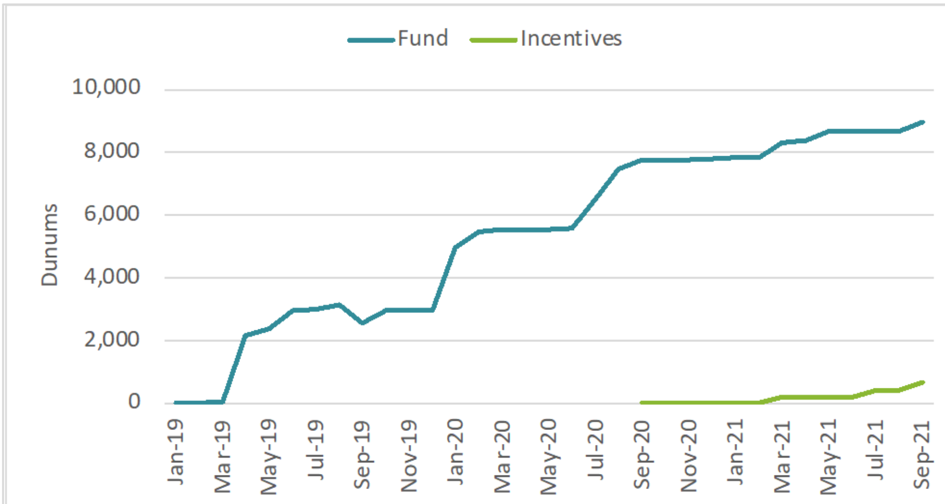
Across all farms, 149 unique treatment plots were included in the water accounting spreadsheet, treatment area tab. Given that a single farm could have multiple plots with different WSTs, adoption by WST is reported at the plot-level. The majority of plots adopted PC-online, with adoption of other technologies as follows: PC-inline, T-Tape, and Improved-GR. In terms of dunums covered by each WST, PC-online was installed on the majority of dunums, followed by Improved-GR, PC-inline and T-Tape (Figure 4).

Figure 4. Distribution of Dunums by WST



The average rate of adoption was 259 and 66 dunums per month, for farms adopting under the investment fund and supplier incentive activities, respectively (Figure 5).

Figure 5. Adoption by Activity



The majority of total water savings came from the investment fund (70%), although this result was not unexpected given that demonstration sites were developed primarily as an educational tool and water-savings from supplier incentives did not start until August 2020 (Table 6). It should be noted that the total value for all WIT agricultural activities displayed in Table 6 does not equal the sum of the three individual WIT activity rows nor does it match the values reported by IWMI. The total is greater than the sum of the individual WIT activities because there were some Farm IDs that were inconsistently assigned to an activity across tabs of the water accounting spreadsheet, in which case the water savings of these Farm IDs were not represented in the individual WIT activities and were instead labeled as "uncategorized" and incorporated into the overall total.

Table 6. Agricultural Water Savings by Activity

WIT Activity	Total (MCM)
Demos	1.0
Fund	12.4
Incentives	2.7
Uncategorized	1.5
Total	**17.6**

While the water accounting spreadsheet provided adoption area and water savings by WST, inconsistencies across tabs as to the WST adopted by Farm ID existed and limited effort was made to reconcile these discrepancies water savings by WIT activity. No attempt was made therefore to report out by type of technology.

Additionally, the IWMI monthly water savings reports provided information on WST adoption and water savings by crop. In the September 2021 report approximately 50% of agricultural water savings came from dunums in stone fruit. Other primary crops contributing to water savings included pomegranates (22%), olives (13%) and grapes (11%). (Amdar and Elmahdi 2021)

5.4.1.2. Agriculture – WIT Length of Life

Continued water savings from WSTs installed during WIT through their anticipated length of life also were calculated and combined with water savings during WIT (as calculated by IWMI) to estimate total water savings as a direct result of WIT activities. Total water savings generated by WIT, including realized and estimated values for currently installed WSTs, sum to over 65 MCM (Table 7).

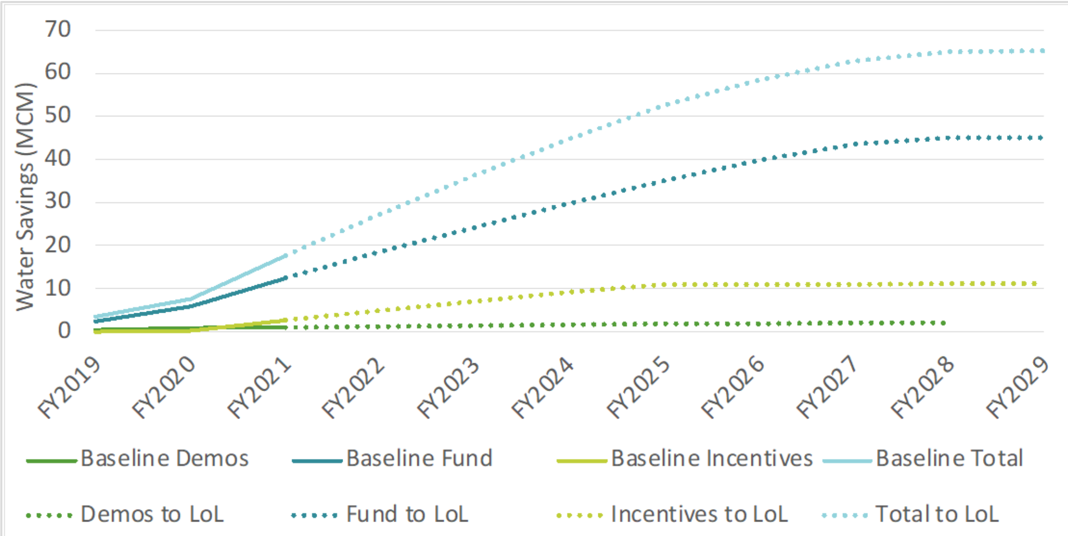
Table 7. Projected Agricultural Water Savings

	Water Savings (MCM)		
WIT Activity	**Baseline**	**Projected to LoL**	**Projected Total**
Demos	1.0	0.9	2.0
Fund	12.4	32.6	45.0
Incentives	2.7	8.4	11.1
Total	**17.6**	**47.5**	**65.2**

Figure 6 illustrates total cumulative water saved both during WIT (Baseline) and for the remaining length of life of the WSTs for each WIT activity:

- WSTs implemented as part of the WIT demonstration activity were split between improved-GR and PC systems – 5- and 8-year lifespans, respectively;
- WSTs adopted under the investment fund were primarily PC systems — having the longest lifespan of the three technologies; and
- WSTs adopted as a result of supplier incentives were mostly improved-GR systems.

Figure 6. Projected Cumulative Water Savings to WST Length of Life



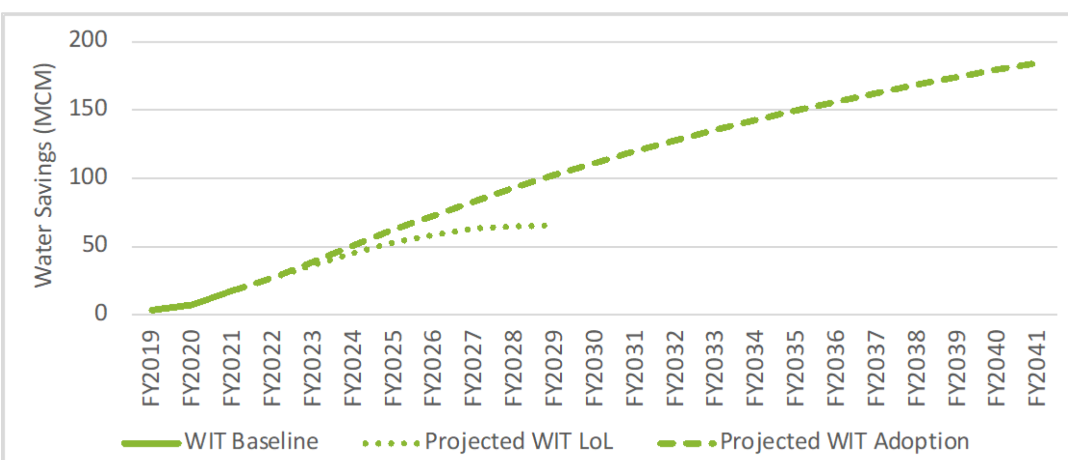
5.4.1.3. Agriculture – WIT Adoption

If suppliers continue to promote WSTs, water savings as a result of WIT could continue to increase over time. Results in this section build on those from the previous section and include water savings 1) through the LoL scenario; 2) continued use by farmers who have already adopted WSTs; and 3) and new adopters.

The average rate of new adoption during the course of WIT was estimated to be 259 dunums/month with average water savings of 64 m^3/dunum/month, which were used as the assumed rate of continued adoption and average water savings from continued adoption. New adoption was assumed to continue from the current level (dunums adopted under investment fund and supplier incentive activities) at a constant rate for a period of two years (Figure 7). This conservative timeframe was selected as a period across which continued adoptions could be reasonably be attributed to the lasting influence of WIT.

In total, over that timeframe an additional 6,220 dunums are assumed to adopt WSTs as a result of WIT activities (representing an over 50% increase over dunums adopted during WIT). Compared to the Baseline and LoL scenarios, water savings under the Adoption scenario is 184 MCM.

Figure 7. Comparison of Projected Water Savings



5.4.2. Household Water Savings

Baseline water savings from households are reported in this section, along with projected water savings through the length of life of WSAs adopted by households.

5.4.2.1. Household – WIT Baseline

The WIT Water Account Monthly Report for September 2021 stated that the cumulative total of household water savings was almost 1.2 MCM (Amdar and Elmahdi 2021). A recent report that provided the final results of the KAP household end-line survey deployed by id:rc indicated that this value could be much higher, potentially by an order of magnitude (Interdisciplinary Research Consultants 2021). The final WIT household water savings value through the end of December 2021 was determined to be approximately 4.0 MCM, including an adjusted value for water savings from WSTs extrapolated from end-line and mid-line surveys of approximately 3.3 MCM (Mercy Corps 2022). Water savings from WSPs were excluded from the final tabulation. Because the findings of the id:rc report were still in discussion at the time of this analysis, estimated water savings presented here were based only on data from the IWMI WIT Water Accounting spreadsheet and a sensitivity analysis of results was conducted to incorporate the final values.

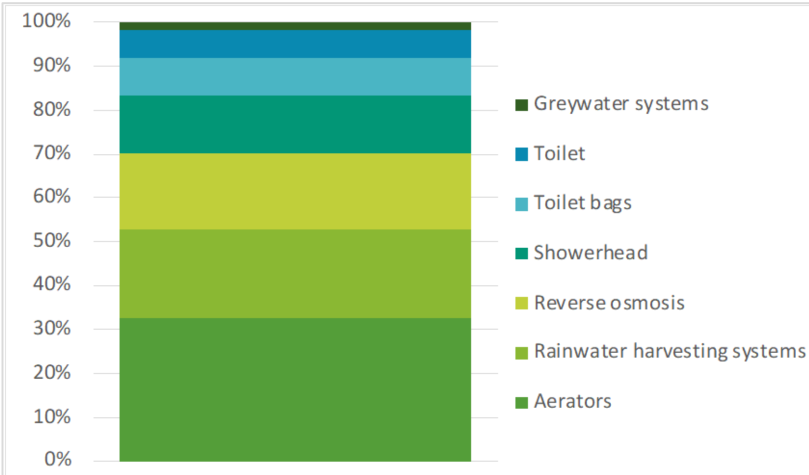
Of the 1.2 MCM of water savings recorded, the greatest savings were realized from WSAs adopted as a result of the social media campaign (74%), followed by 19% from communal storage projects, 4% from the household investment fund, and 3% from the revolving loan fund (Table 8).

Table 8. Household Water Savings by Activity

WIT Activity	Total (MCM)	Water Savings (% Total)
Fund	0.05	4%
Loans	0.03	3%
Media	0.9	74%
Schools	0.00	0%
Storage	0.2	19%
Total	**1.2**	**100%**

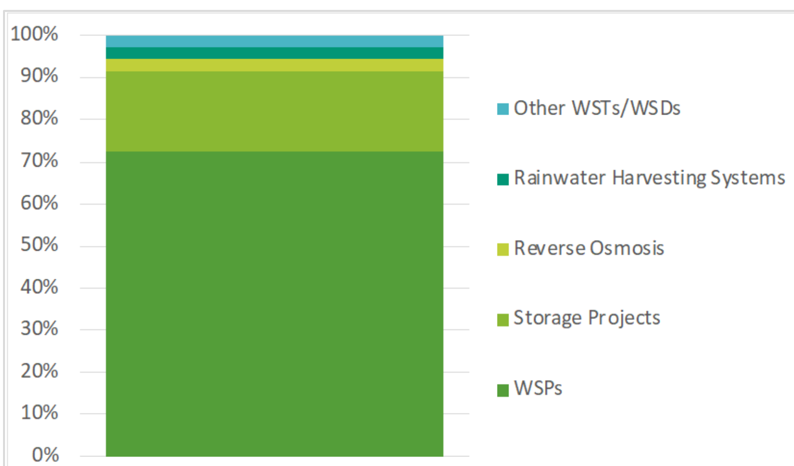
Over 2,900 WST/WSDs were adopted by households, with tap aerators being the most popular (33%), followed by RWH systems (20%) and RO systems (17%) (Figure 8).[5]

Figure 8. Household Adoption by Type



As seen in Figure 9, overall, WSPs resulted in the largest water savings (72%), followed by storage projects (9%). Note that water savings from schools and demos are not included in the figure as these each represented less than one percent of total household water savings.

Figure 9. Household Water Savings by Type



[5] In addition to the WSTs/WSDs presented in the figure, there were two adoptions of dry sanitation systems.

5.4.2.2. Household – WIT Length of Life

Because the majority of WSAs adopted by households have long lifespans, except for tap aerators, annual water savings were found to be relatively consistent from the end of WIT in FY2021 through FY2071 (Table 9). Cumulative household water savings were estimated to be 11 MCM by FY2071, nearly ten times more water savings than during WIT.

Table 9. Projected Water Savings

	Water Savings (MCM)		
WIT Activity	Baseline	Projected to LoL	Projected Total
Fund	0.05	0.6	0.6
Loans	0.03	0.5	0.5
Media	0.9	7.3	8.2
Schools	0.00	0.2	0.2
Storage	0.2	1.3	1.5
Total	**1.2**	**9.8**	**11.0**

5.5. Sensitivity Analysis

The two scenarios included a number of assumptions regarding the value of key variables, making it important to test how the results change when the value of a variable or variables was adjusted (i.e., how sensitive the analysis was to the assumptions used). This section outlines methods used for sensitivity testing and provides a summary of key findings.

5.5.1. Methods

The list below details the key variables for which assumptions were made and how the analyses' sensitivity to these assumptions were tested.

- **Discount rate**. To test the sensitivity of the results to the discount rate, two additional discount rates were tested (i.e., 3% and 7%). Discount rates were applied to annual water savings to indicate that water saved in the future is of lesser value and lower certainty. Note that a higher discount rate indicates greater uncertainty associated with the projected water savings.
- **Decreased agricultural WST lifespan**. Lifespans for agricultural WST used in the baseline scenarios were estimates of how long each system could last without extensive maintenance or replacement (PC systems: eight years, Improved-GR: five years, and T-Tape: three years). Additional feedback from the WIT team based on field observations suggested that the lifespans may actually be shorter due to degradation in performance (i.e., leaks, clogging) and the voluntary removal of WSTs by farmers due to inconvenience, expense, or some other factor. To test the impact of lifespan on the results, the following values were used: PC systems: three years; Improved-GR: two years; and T-Tape: one year. Anecdotal evidence of decreased lifespans of PC systems were provided by WIT staff and the proportion of the PC observed lifespan to the baseline lifespan was applied to the other two WSTs to arrive at the decreased values of two years and one year for improved-GR and t-tape, respectively.
- **Household water savings including end-line survey results.** The baseline analysis makes use of water savings estimates from the IWMI water accounting spreadsheet and reports. The final WIT report included substantially higher water savings for community initiatives resulting

from WSTs based on the end-line and mid-line surveys conducted by id:rc. This sensitivity analysis reruns the baseline scenarios using 3.3 MCM of water savings generated during the WIT project and 3.6 MCM/year in subsequent years instead of IWMI's 0.9 MCM/year. The impetus for this sensitivity analysis is explained in the discussion of household water savings data in Section 5.2.2.

5.5.2. Sensitivity Results

Results from the sensitivity analysis are presented by variable: discount rate; agricultural WST lifespan; and household water savings including end-line survey results.

The choice of discount rate had limited effects on projected agricultural water savings under the WIT LoL as result of the relatively short lengths of life of WSTs already adopted — with projected water savings increasing or decreasing by approximately 5%. Given that household WSAs have longer lengths of life, the choice of discount rate had a greater impact — with projected household water savings increasing or decreasing by approximately 25% (Table 10).

Table 10. Sensitivity Analysis of Discount Rate

WIT Activity	Water Savings (MCM)		
	3%	Baseline (5%)	7%
Ag	68.3	65.2	62.3
HH	14.6	11.0	8.6

Projected agricultural water savings were found to be highly sensitive to the assumed lifespan of the WSTs. When the shorter WST lifespans were used for the LoL scenario, projected agricultural water savings were only 27.7 MCM, as compared to 65.2 MCM under the original analysis. Because the WIT Adoption scenario assumes that farmers maintain or replace WSTs after the end of their lifespan, the water savings projections under this scenario would be unaffected.

Household water savings were found to be highly sensitive to the choice of values for water savings under the WIT Baseline scenario (i.e., water savings that occurred during WIT), primarily because the values extracted from the id:rc report were many times larger than those reported by IWMI. The use of id:rc values increased household water savings during WIT by 2.4 MCM. Total estimated household water savings under the WIT LoL scenario increase from an estimated 11 MCM to over 70 MCM (Table 11).

Table 11. Projected Water Savings from WIT Adoption (id:rc Baseline Data)

WIT Activity	Water Savings (MCM)		
	Baseline	Projected to LoL	Projected Total
Total	3.6	67.6	71.2

Note: Baseline values do not match values reported in Mercy Corps (2022) as water savings from Oct.-Dec. 2021 were not included in this analysis.

6. COST-EFFECTIVENESS ANALYSIS

Cost-effectiveness analysis is a way to examine both the costs and the outcomes of a project. It compares the project to the status quo (or another project) by estimating the cost per unit gain —in the case of the WIT project, the unit is one cubic meter of water.

It is important to note that cost-effectiveness analysis typically focuses on comparing the costs of different options designed to achieve a similar outcome, with the benefits expressed in physical, not monetary terms. This differs from a cost-benefit analysis (CBA), which typically compares total project costs with total project benefits in monetary terms. CBAs are difficult to conduct because it is often difficult to quantify all economic, social, environmental and cultural outcomes of a project in monetary terms. The cost-effectiveness analysis conducted here compares the public investment for and water saving achieved through each direct activity intervention — additional costs (e.g., costs to households purchasing WSDs) and benefits (e.g., increased profit for farmers adopting WSTs) were not considered here, but are in a later section of this report.

It is important to note that an activity with a higher cost per cubic meter of water saved does not necessarily imply that the activity was ineffective as compared to other water saving alternatives. For example, certain activities, even though less cost-effective than other alternatives in terms of dollars per cubic meter, may have been implemented with the intent of supporting additional, non-monetary or water saving outcomes such as increased community awareness or a shift in public perception. For this reason, while cost-effectiveness can be a useful indicator for measuring "success", it is important to consider the results in terms of the broader goals and outcomes of the project.

6.1. Cost-Effectiveness Methods

The cost-effectiveness of WIT activities was assessed by comparing water savings from the WIT LoL and WIT Adoption scenarios to: 1) activity costs only; and 2) all project costs.

While direct activity costs already correspond to each activity, shared activity costs and other indirect costs supported a range of direct activities. These costs were allocated as follows:

- For shared activity costs: The proportion that each activity's direct costs represented for either the agriculture or household grouping costs as a whole was calculated. Each activity was then assigned the same proportion of total shared activity costs for either agriculture or household activities, respectively. For example, direct costs for the agriculture investment fund were $1.1 million, which represented 60% of the $1.8 million total spent on direct agriculture activities. Therefore, 60% of the $1.8 million in total shared agriculture activity costs was assigned to the agriculture investment fund.
- For indirect costs: The proportion that each activity's direct costs represented of total activity costs was calculated. Each activity was then assigned the same proportion of total indirect costs. For example, direct costs for the agriculture investment fund were $1.1 million, which represented 10% of the $11.1 million invested in all activities. Therefore, 10% of the $13.6 million in indirect costs was assigned to the agriculture investment fund.

Costs were then divided by water savings to estimate the cost per cubic meter of water saved by each activity.

6.2. Cost-Effectiveness Results – WIT Length of Life

Table 12 presents the results of the cost-effectiveness analysis by activity and cost type. Water savings from the WIT LoL scenario were used. Generally, agriculture activities were more cost-effective than household activities, a result consistent with the expectations expressed by WIT staff. The agriculture investment fund was the most cost-effective WIT activity, with activity costs of $0.05/m^3 and total costs of $0.08/m^3. The household loan fund was the least cost-effective activity, with an estimated total cost of over $13/m^3. Calculated as a weighted average, the cost-effectiveness of all activities was $0.36/m^3, with activity costs accounting for 50% (i.e., $0.18/m^3).

Table 12. Cost-Effectiveness by Activity and Cost Type

Activity	Activity Costs ($/m^3)	Indirect Costs ($/m^3)	Total Costs ($/m^3)
Ag	$0.05	$0.03	$0.09
Demos	$0.23	$0.14	$0.37
Fund	$0.05	$0.03	$0.08
Incentives	$0.09	$0.05	$0.14
HH	$0.92	$1.04	$1.96
Fund	$1.29	$1.47	$2.76
Loans	$6.26	$7.11	$13.37
Media	$0.37	$0.41	$0.78
Schools	$5.65	$6.42	$12.08
Storage	$1.44	$1.63	$3.07
Total	**$0.18**	**$0.18**	**$0.36**

6.3. Cost-Effectiveness Results – Other Scenarios

The cost-effectiveness of WIT also was assessed under two additional scenarios: 1) the WIT Adoption scenario for agriculture; and 2) the use of water savings estimates from id:rc instead of IWMI for the WIT Baseline household scenario. Cost-effectiveness improved substantially under both scenarios (Table 13), with total cost per cubic meter ranging from $0.04-0.28. It should be noted that, since costs don't change, this improvement in cost-effectiveness was the direct result of increasing projected water savings from Ag-Fund, Ag-Incentives and HH-Media activities only.

Table 13. Sensitivity of Cost-Effectiveness

Scenario	Activity Costs ($/m^3)	Indirect Costs ($/m^3)	Total Costs ($/m^3)
Ag - WIT Adoption	$0.02	$0.02	$0.04
HH - WIT Baseline (w/ id:rc water savings estimates)	$0.14	$0.14	$0.28

6.4. Literature Comparison

Assessing the cost-effectiveness of the various WIT activities is useful for informing possible future efforts in Jordan, but it also raises the question of how these costs compare to 1) the cost of existing water sources in Jordan; 2) other water saving/water supply projects in Jordan; and 3) other efforts elsewhere.

Figure 10 shows WIT activities ordered from most cost-effective to least, including the weighted cost-effectiveness of all agricultural (Ag), all household (HH), and all WIT activities and the cost-effectiveness of the two additional scenarios considered (i.e., Ag-Adoption and HH-Baseline (id:rc)).

Figure 10. Cost-Effectiveness of WIT by Activity

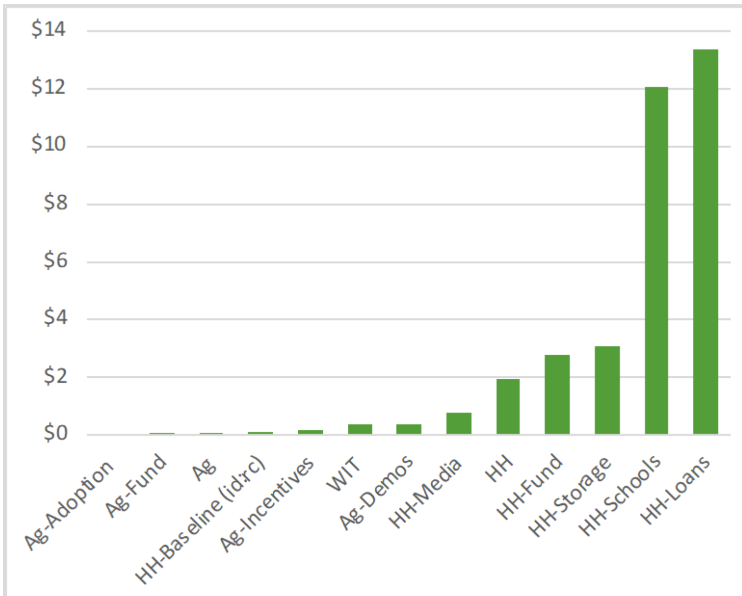
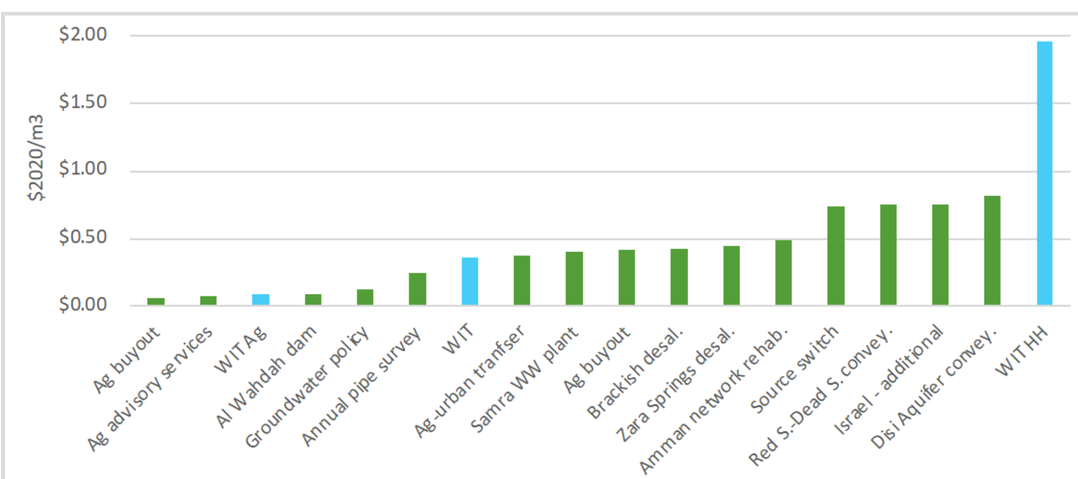


Figure 11 presents a comparison of cost per cubic meter from both the literature and WIT activities (highlighted in blue). Given that agriculture accounts for over 50% of total water use in Jordan (Ministry of Water and Irrigation 2015), WIT activities (and agricultural activities in particular) appear to be cost-effective strategies compared to other alternatives.

Figure 11. Comparison of Projects



7. Incentive Evaluation & Return on Investment Analysis

Another important component in evaluating the benefits of the WIT project was to consider the motivations for and costs/benefits to participants (as opposed to the public) associated with adoption of WSAs. In evaluating the motivations of participants and the benefits of adoption, future projects could be more targeted in their outreach and implementation. For example, some individuals may be motivated to adopt WSAs for "stewardship" reasons, therefore, outreach to them might focus on the long-term environmental benefits of WSAs. Alternately, if potential cost-savings or financial benefits are the only reason an individual might consider WSA adoption, outreach focused on potential cost-savings and ROI might be a better approach. Providing individuals with a better understanding of the personal benefits of WSA adoption may potentially yield greater and more engaged long-term adoption.

Data gathered as part of the WIT end-line KAP surveys first was used to evaluate the incentives used to motivate participation and adoption. The survey data was then combined with additional data from external sources to conduct a return on investment (ROI) analysis for participants.

Return on investment is a common financial metric used to compare the gain/loss from an investment relative to the initial investment. In the context of WIT, ROI was used to assess whether the upfront costs of investing in a WST/WSD was greater or less than the likely cost savings resulting from adoption.

7.1. Agriculture

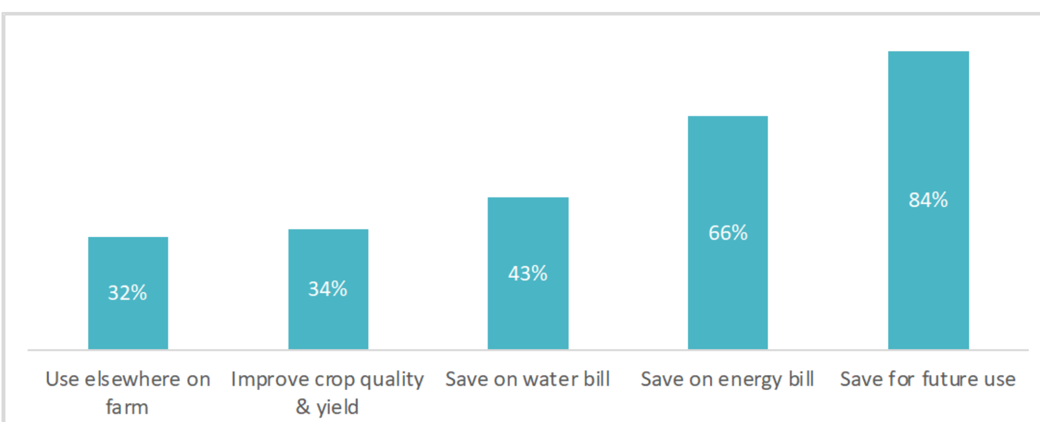
The agriculture KAP end-line survey included responses from farms that adopted WSTs as part of WIT and farms that did not. As the focus of this analysis was on incentives and benefits to farmers participating in WIT, only responses from the 44 farms identified as a WIT farm were analyzed.

7.1.1. Agriculture – Incentive Evaluation

As part of the agriculture end-line survey, respondents were asked what their motivation was for adopting WSTs. Respondents were provided with seven responses options (including an "other" option) and could select all that applied.

Respondents, on average, selected three of the seven options. As seen in Figure 12, saving water for future use was the most common motivation; however, almost one-third of respondents were motivated, at least partially, by the potential to use the water elsewhere on their farms. An additional motivation not included in the Figure 12 was "fish farm", which 7% of respondents selected, however, no additional information was included on what this represented.

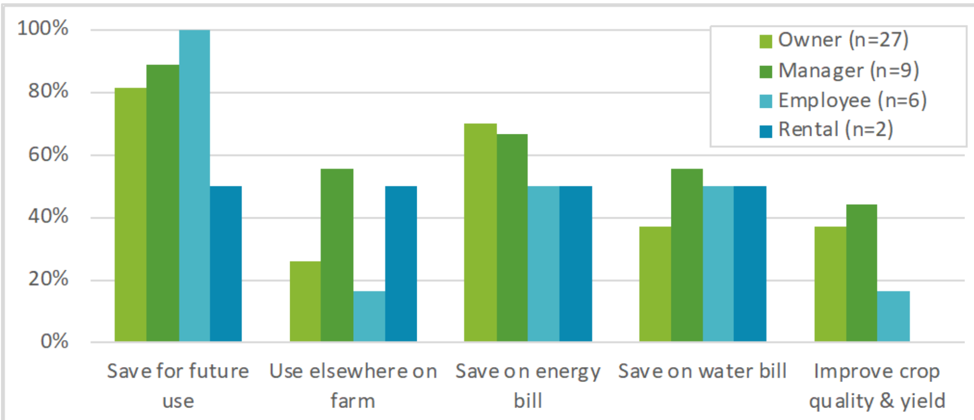
Figure 12. Motivation for Adopting WSTs



Farmer motivation also was stratified by a variety of respondent characteristics in order to assess whether other key variables affected the distribution of responses. All respondents were male and 75% of responses were from individuals whose farm was ten years or older, so it was not possible to assess whether differences in gender and farm age resulted in different motivations.

Motivations next were analyzed by the respondent's position on the farm (e.g., owner, manager, employee or renter). It is interesting to note that while saving water for future was the most frequently cited motivation regardless of position, 100% of employees selected this response (Figure 13).

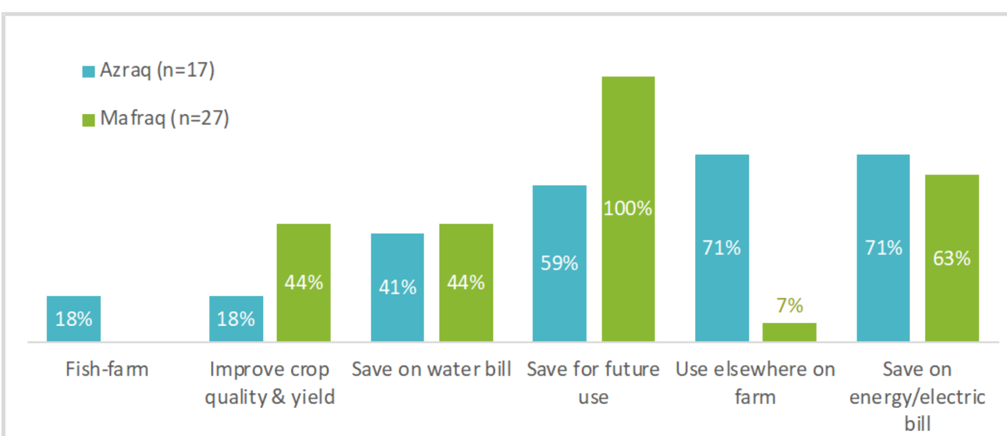
Figure 13. Motivation for Adopting WSTs by Position



Finally, motivations were examined by governorate (Figure 14). Perhaps most notable was that 100% of respondents from Mafraq said saving water for future use was a motivation, while only 59% of Azraq respondents felt similarly. In contrast, 71% of Azraq respondents said a primary motivation was to use saved water elsewhere on their farm, whereas only 7% of Mafraq respondents were motivated by this.

This clear difference in motivation related to how water saved would be used (or not) highlights that not all agriculture water "saved" as a result of WST adoption may actually stay in the ground for future use, and also that there may also be a geographic component to this choice. A previous study by IWMI found that 15 of 21 farms reporting water savings because of WST adoption were using the saved water to irrigate other areas of the farms — five of these farms were in Mafraq and 10 were in Azraq, which represented 50% and 63% of farms surveyed in each governorate, respectively (Mapedza, Amdar, and Al-Zu'bi 2020).

Figure 14. Motivation for Adopting WSTs by Geographic Area



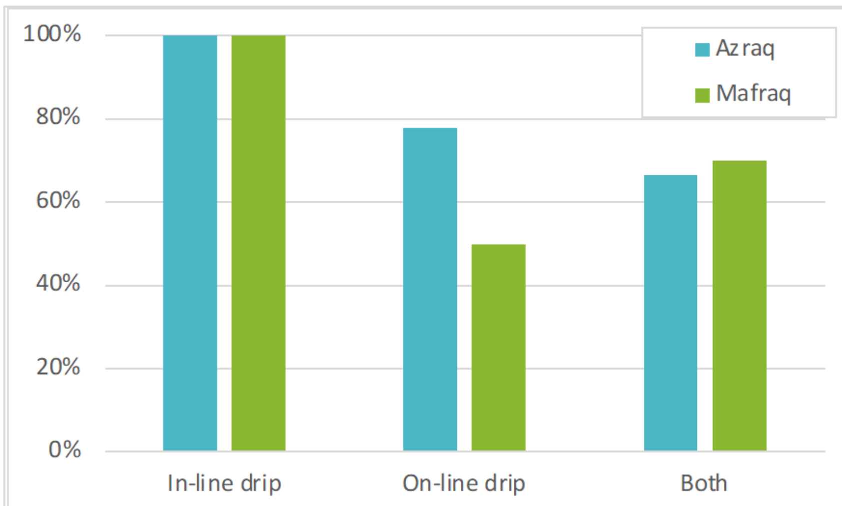
In terms of external incentives to adopt WSTs, only one respondent knew for certain that he had paid a lower price as a result of participating in WIT. Twenty-one respondents did not know if they received a lower price and 18 said they did not. Similarly, only one respondent received assistance installing his WST, with the remaining respondents stating that they installed the system themselves. These results make it difficult to assess whether a decrease in price or assistance with installation would result in more adoptions than otherwise would occur without these types of incentives.

7.1.2. Agriculture – Benefits

Survey respondents also were asked whether WST adoption had resulted in positive on-farm changes such as improvement in crops and/or decreased production costs, and if so, by how much.

With regards to crop quality, on average, 73% of survey respondents who participated in WIT saw improvement in crop quality. These results, however, varied by technology, and to some degree geographic area (Figure 15).

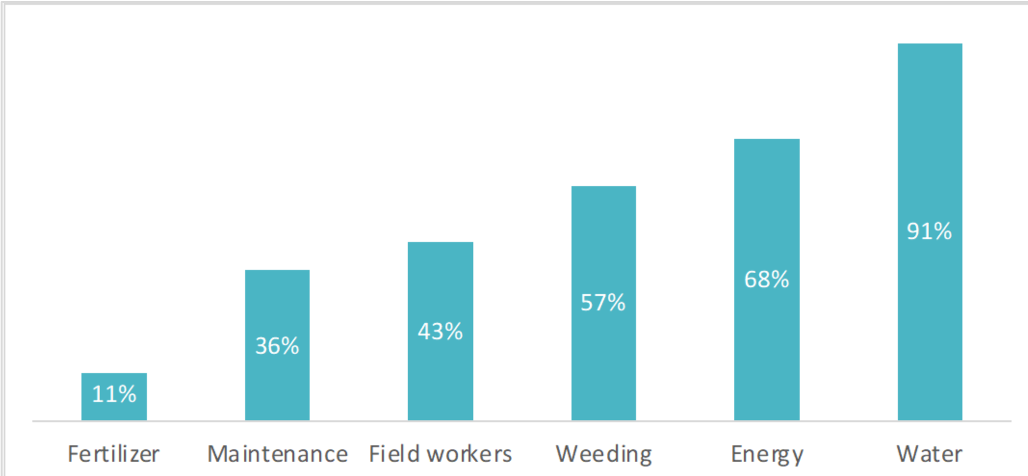
Figure 15. Crop Quality Improved – WIT Participants



The majority of WIT farms reported that their production costs had decreased — of the 44 survey respondents, only four reported that they did not see any cost savings. Of these four, however, one stated the WST had been removed from his farm and the other three cited the ability to use water savings elsewhere on their farm as a primary motivation for adoption. If these farms were still using similar amounts of water, just applying it to different areas without WSTs, then it is not surprising that no cost savings at the farm-level were realized.

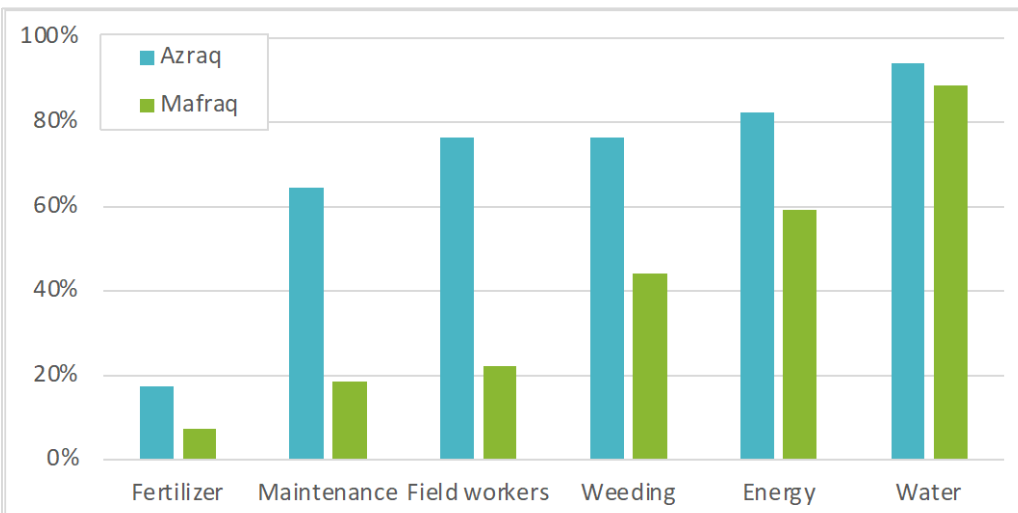
On average, respondents reported savings in three of the six cost categories. As seen in Figure 16, water was the cost category where the most respondents saw savings, with over 90% of respondents reporting that their water bill had decreased. Energy (e.g., diesel, electricity) was the cost category with the second highest number of respondents reporting savings (70%).

Figure 16. WIT Participants Reporting Decreased Costs by Type



In addition, a greater percentage of respondents in Azraq reported savings in every cost category as compared to respondents in Mafraq (Figure 17). The percentage of farms reporting cost savings between the two governorates were most similar for water and showed the greatest divergence for field workers.

Figure 17. WIT Participants Reporting Decreased Costs



As mentioned previously, if a respondent reported decreased costs for a specific category, he also was asked to estimate the percentage by which costs had decreased. Table 14 presents results two ways: 1) the average decrease in costs for only respondents reporting a percentage; and 2) the average decrease in cost for all respondents. The average for all respondents was based on two assumptions — if a respondent said they did not have decreased costs for a given category, his decrease was assumed to be 0% and if a respondent said he had decreased costs, but did not report a percentage, his decrease was assumed to be the lowest percentage decrease reported by another respondent for that category.

It is interesting to note that not only did more respondents from Azraq report decreased costs, but the average decrease in cost was also higher, as compared to Mafraq, for every category, with the greatest difference being seen for energy.

Table 14. Estimated Average Decrease in Cost by Governorate

Category	Reported % Saved		All	
	Azraq	Mafraq	Azraq	Mafraq
Energy	33%	16%	19%	10%
Labor	41%	32%	22%	7%
Water	37%	29%	28%	25%
Other	33%	18%	12%	5%

For respondents who reported decreased costs, the type of WST adopted also appeared to be somewhat correlated to the percentage decrease in cost reported. More specifically, respondents who installed in-line drip systems reported higher cost savings across all categories.

Table 15. Estimated Average Decrease in Cost by WST

Category	In-line drip	On-line drip	Both
Energy	29%	22%	18%
Labor	40%	35%	38%
Water	37%	30%	30%
Other	39%	24%	20%

A recent article by Al Naber and Molle (2017) included average farm production costs by cost category for Azraq and Mafraq (Table 16). Based on their research, annual production costs for an average farm were approximately $300/dunum and $500/dunum in Azraq and Mafraq, respectively, with energy accounting for the highest proportion of costs (i.e., 43%) in both governorates.

Table 16. Average Farm Production Costs (Al Naber and Molle 2017)

Category	Azraq		Mafraq	
	$/dunum/yr	%	$/dunum/yr	%
Energy	122	43%	214	43%
Labor	88	31%	104	21%
Water	9	3%	30	6%
Inputs	65	23%	149	30%
Total	284	100%	497	100%

As these cost categories generally align with those used in the KAP end-line survey, the estimated average percentage decrease in costs by cost-category were applied to these average farm production costs. For example, Azraq farmers reporting energy costs savings, on average, saw a 33% decrease in energy costs. For the average Azraq farm, energy costs were estimated to be $122/dunum/year — 33% of this amount results in average savings of $40/dunum per year (Table 17). Note that results presented in Table 17 represent estimated average annual savings per dunum for participants who reported savings; participants who did not report savings presumably had zero savings.

Table 17. Estimated Average Annual Savings per Dunum

Category	Azraq $/dunum/yr	Mafraq $/dunum/yr
Energy	40	35
Labor	36	33
Water	3	9
Inputs	21	27
Savings	100	104
% of Original Cost	35%	21%

The median treatment plot area in WSTs for respondents who reported cost savings in at least one category were 72.5 dunums and 90 dunums for Azraq and Mafraq, respectively. For areas these size, the average annual cost savings from WST adoption would be approximately $7,200 (Azraq) and $10,600, (Mafraq). With average cost savings of 35% and 24% reported in Azraq and Mafraq, respectively, WST adoption had a substantial impact on farm costs.

7.1.3. Agriculture – Return on Investment

For the purposes of the agricultural analysis, ROI was calculated as:

$$ROI = \frac{Present\ Value\ of\ Cost\ Savings - WST\ Cost}{WST\ Cost} x\ 100$$

While multiple technologies were adopted on participating farms, all end-line survey respondents adopted PC online drip systems, PC inline drip systems or both. Data used elsewhere in the WIT project to calculate supplier compensation for motivating on-farm adoption estimated average total costs to install PC systems (either automatic or manual) at $119/dunum. Using this information and assuming an average lifespan of eight years, for participants who reported estimated cost savings, WST adoption had an ROI of 442% and 464% for WIT participants in Azraq and Mafraq, respectively. Assuming a shorter length of life for the WST (i.e., three years instead of eight), the expected ROI was still positive in both Azraq (129%) and Mafraq (138%). Note that estimated annual costs savings were discounted over the lifespan of the technology.

7.2. Household

The household KAP end-line survey included responses from residents of the Mafraq, Irbid, Jerash, Ajloun, and Azraq governorates. Survey respondents were asked whether they adopted a WSA in the last two years (a timeframe that encompassed the education, outreach, and funding efforts of the WIT project), but the question was not specific to only those who adopted WSAs as a direct result of WIT.

Because the survey was extensive and covered many WSAs, it became necessary to focus the analysis on those WSAs that were similar to those implemented under WIT and likely to result in a monetary benefit to the adopters. The methodology for identifying the WSAs that were likely to result in benefits to the adopters is described in the section below. Once these WSAs were identified, the incentives/motivations for the adopters of these WSAs were analyzed, then the reported benefits were analyzed, and finally the ROI for each identified WSA was estimated.

Greater detail on each of the subsections below is provided in Appendix A.

7.2.1. Identification of WSAs with Potentially Positive ROIs

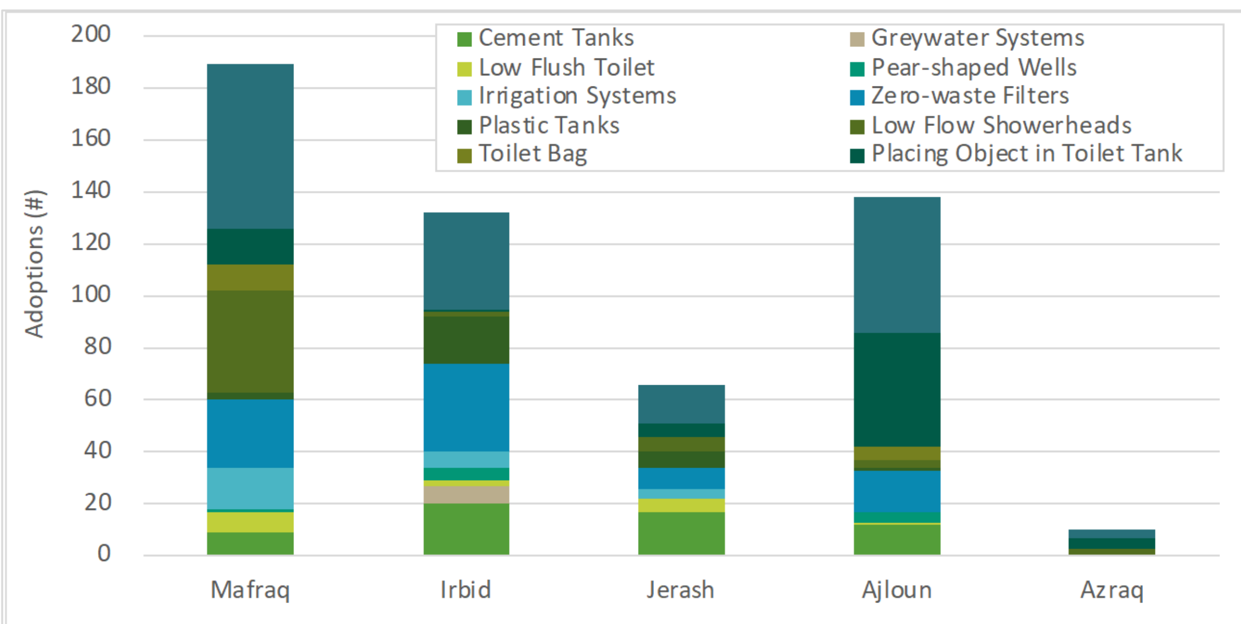
The largest potential ROI from household water savings is likely derived from WSAs that can reduce a household's purchase of tanker water, as water supply from private water tankers represents one of the most expensive sources of household water supply (Klassert et al. 2015). In the household end-line survey respondents who adopted a WSA were asked to list any benefits observed from adopting WSAs, with one of the responses being a reduction in purchases of tanker water. The results of the survey were broken out by governorate and WSA to determine which of the WSAs resulted in the greatest number of positive responses for reduction of tanker water purchases. A WSA was assumed to regularly result in reduction of tanker water purchases if 25% or more of the respondents who adopted the WSA indicated that they observed a reduction in their purchases of tanker water.

Responses were notably different across governorates as follows:

- Mafraq - plastic tanks;
- Irbid - cement tanks and pear-shaped wells, GWS, and low flush toilets;
- Jerash - cement and plastic tanks, low flush toilets, water irrigation systems, zero-waste filters, placing an object in the toilet tank, and regular water network maintenance;
- Ajloun - cement tanks and pear-shaped wells, low flow showerheads, and toilet bags; and
- Azraq - no WSAs identified.

In part, this variation was due to WSA adoption across governorates (Figure 18), but some variation was due to the potential for water savings resulting from the WSAs and the varying level of reliance on tanker water purchases across governorates.

Figure 18. WSA Adoptions by Governorate Resulting in Decreased Tanker Water Purchases



Further quantitative and qualitative analysis of the end-line survey results focused on those WSAs identified as producing observed reductions in tanker water purchases.

7.2.2. Household – Incentive Evaluation

As part of the household end-line survey respondents were asked what their motivation was for adopting WSAs. Respondents were provided with four response options — reduce tanker water purchases, reduce water bill, save water for the future of Jordan, and religion dictates that it is the right thing to do — and could select all options that applied. The majority of respondents, regardless of governorate or WSAs adopted, cited their religion as a primary motivating factor. For the WSAs that resulted in reductions in tanker water purchases by governorate, the respondents' motivations for adoption were extracted.

Overall, reducing tanker water purchases was not a primary motivation for most survey respondents and those that were motivated by this factor often adopted WSAs that were unlikely to produce this benefit (as indicated by self-reporting in the survey). This result was particularly true in Mafraq and Irbid. In Ajloun, adopters of WSAs reported being motivated by all the options presented and their motivations did not vary greatly by WSA, even those that were more likely to result in a reduction of tanker water purchases. In Jerash, though religion remained the primary motivation, the majority of WSA responders also identified reducing tanker water purchases as a motivating factor for the adoption of cement tanks, low flush toilets, zero-waste water filters, and placing an object of the toilet tank — the WSAs that actually were found to support reductions in tanker water purchases in this governate. Azraq differs from the other governorates in that none of the adopters of WSAs cited reduced tanker water purchases as a motivation for adoption and none of the respondents who adopted WSAs reported reducing their purchases of tanker water as a result of adoption.

In addition to being asked about specific motivations for adopting a WSA, srespondents were asked about their perceived level of water security, whether the amount of water they receive from the municipality was currently sufficient for their use. On the whole, responses were primarily stratified by governorate rather than by adoption of WSA, with the majority of respondents (approximately 70%) in Mafraq and Azraq responding that municipal water supply was sufficient for their needs. In Irbid, Jerash, and Ajloun responses were more varied with approximately half of the respondents in Irbid and Ajloun (48% and 40%, respectively) stating sufficient water supply and 40% in both governorates experiencing insufficient water supply. In Jerash the majority of respondents (53%) reported insufficient water supply and the rest reported sufficient or sometimes sufficient water supply. In these three governorates responses on water sufficiency appeared to vary with WSA adoption, but no clear trend was visible.

Survey respondents were also asked how they purchased and installed WSTs/WSDs — either with cash or through a loan. Of the survey respondents who adopted one or more of the 525 WSTs/WSDs that were found to result in reductions in tanker water purchases in at least one governorate, responses to this question were so limited as to correspond only to 56 adoptions of WSTs/WSDs so no real conclusions could be drawn from the data.

Looking at this from a different perspective, did respondents who stated that reducing the need to purchase additional tanker water as a "major factor" in their choice to adopt WSAs in the last two years meet their objective with the WSAs they adopted? First, only 9% of respondents selected this as a major motivating factor. On average, those respondents adopted two of the five WSA categories included in the survey, with the majority changing practices (69%) and/or purchasing a WSD (e.g.., tap aerator, low flow showerhead). Fewer than 25% acquired a rainwater harvesting system, reverse osmosis system or greywater system, which generally were the WSTs adopted by respondents who did see a reduction in tanker water purchases. Given this, it is not surprising that only 35% of respondents hoping to reduce tanker water purchases responded that they had realized that goal.

7.2.3. Household – Benefits

As mentioned in Section 7.2.1, survey respondents were asked whether the adoption of WSAs resulted in a reduction in tanker water purchased; whether they experienced a decrease in their water bill; whether their water tank lasted longer; and/or whether they did not benefit or benefited in some other way from the WSA adoption. Respondents could choose multiple benefits and not all respondents answered this question. Of the potential benefits listed in the survey, a decrease in tanker water purchases as a result of WSA adoption was the one most likely to result in substantial cost savings and, therefore, the ROI analysis for households focused on this. An additional discussion of benefits is provided in Appendix A.

Overall, WSAs associated with observed reductions in tanker water purchases resulted in mixed benefits for their adopters, either in the form of additional co-benefits — reduced water bills or longer lasting water tanks — or in not providing any benefit at all. For example, in Mafraq, the only WSA that resulted in a reduction in tanker water purchases for more than 25% of adopters (the cut-off employed in the methods described in Section 7.2.1) was plastic tanks, and, of the three adopters of plastic tanks, one reported a reduction in their purchase of tanker water; one reported their water tanks lasting longer, and one experienced no benefit. Similarly, in Irbid, where adopters of cement tanks, greywater systems, low flush toilets, and pear-shaped wells observed reductions in their tanker water purchases, benefits were mixed with many adopters in this governate experiencing no benefit at all.

In Jerash, benefits of adoption were substantially more pronounced, with benefits in the form of reduced tanker purchases reported for cement tanks, low flush toilets, water irrigation systems, zero-waste or reverse osmosis filters, plastic tanks, placing an object in the toilet tank, and regular water network maintenance. These WSAs typically produced additional co-benefits and very few adopters experienced no benefit. Similar results were seen for adopters of cement tanks, pear-shaped wells, low flow showerheads, and toilet bags in Ajloun. In Azraq, limited WSAs were adopted and no respondents reported reduced tanker water purchases.

7.2.4. Household – Return on Investment

Average annual water savings for each WSA were used as the basis for estimating annual cost savings by comparing the annual water savings for the WSAs to the average annual water demand by governorate for tanker water. It was assumed that water savings would first be utilized by a household to reduce purchases of tanker water, rather than municipal supply, as tanker water purchases represent one of the most expensive sources of water supply for a household (Klassert et al. 2015).

Average annual tanker water demand was estimated by governate using data from the household end-line survey. When a weighted average was calculated across respondents, tanker purchases per month were relatively consistent across governorates. There were either one or two purchases per month in the winter and one (Ajloun), two (Jerash), or three purchases (Mafraq, Irbid, and Azraq) per month in the summer. Total annual average water demand (assuming five months of winter demand and seven months of summer demand) ranged from a minimum of 73 m^3/year in Ajloun to a maximum of 186 m^3/year in Azraq. For additional detail on the methods for selecting WSAs to include in the ROI analysis and the methods for estimating water savings, please see Appendix A.

The minimum of either the WSA annual water savings or the demand for tanker water was then multiplied by the average cost per cubic meter for tanker water to determine the average annual cost savings resulting from each WSA. Average cost per cubic meter of tanker water by governate for those adopters of the WSAs identified as resulting in reduced tanker purchases was also relatively consistent (\$4.67-5.75/m^3 in Mafraq, Jerash, Ajloun, and Azraq) with Irbid being somewhat of an outlier with a cost of \$10.68/m^3. For WSTs/WSDs, which have an upfront cost, as opposed to WSPs, the present value of this annual cost savings was extrapolated over a 50-year timespan and then compared against the approved WIT loan amount (i.e., the cost of the WST/WSD) for that WST/WSD to provide the ROI (Table 18).

Table 18. Household Loan Amounts (Costs) by WST/WSD

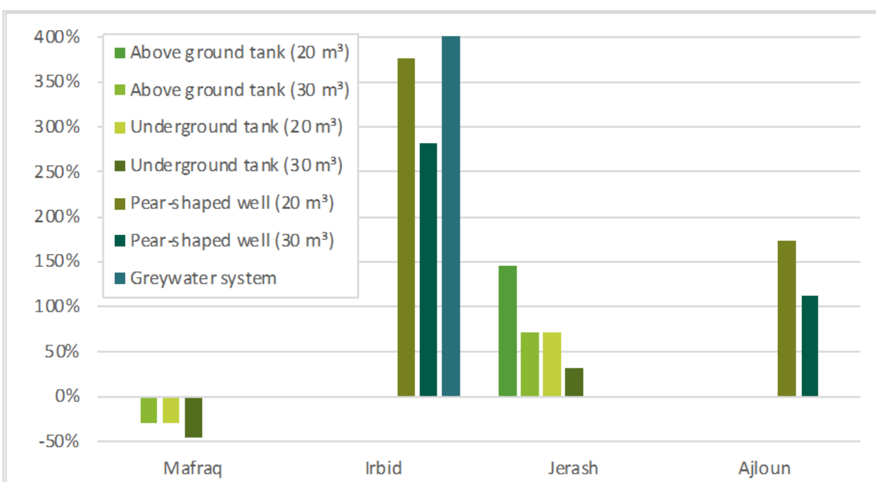
WST/WSD	Loan Amount ($)
Plastic tank above ground 20 m^3	2,450
Plastic tank above ground 30 m^3	3,500
Plastic tank underground 20 m^3	3,500
Plastic tank underground 30 m^3	4,550
Pear-shaped well 20 m^3	2,730
Pear-shaped well 30 m^3	3,500
Greywater system	1,708
Low flush toilet	252
Low flow showerhead	38
Toilet bag	4

For the purposes of the household analysis, ROI was calculated as:

$$ROI = \frac{Present\ Value\ of\ Cost\ Savings - WST\ Cost}{WST\ Cost} x\ 100$$

For the majority of WSTs/WSDs identified as resulting in fewer purchases of tanker water, a positive ROI was calculated, with the exception of larger above-ground plastic tanks (30 m^3) and below-ground plastic tanks (both 20 m^3 and 30 m^3) in Mafraq. The low ROI results for Mafraq are logical as it has the second lowest average annual rainfall of the five governorates included in the analysis. Positive ROIs ranged from 1% for 20 m^3 above ground plastic tanks in Mafraq to 3,121% for low flush toilets in Jerash (Figure 19).

Figure 19. ROIs for WSTs/WSDs Associated with Fewer Tanker Water Purchases



Note: ROIs for low flush toilets in Irbid and Jerash (2,932% and 3,121%, respectively) and low flow showerheads (1,254%) and toilet bags (23,749%) in Ajloun were removed to allow for easier interpretation of the y-axis.

For those individuals adopting the practice of placing an object in their toilet tank to reduce flush volumes, a present value cost savings of $232 over the projected 50-year timeframe was estimated (no ROI was calculated as it was assumed that there is no cost of this practice).

Although low flush toilets in Mafraq were not identified as a WSD that resulted in an observed reduction in tanker water purchases, the high annual water savings indicates that this WSD could result in substantial reductions. Calculations suggested an ROI of 4,219% could be possible for low flush toilets in Mafraq — one of the highest ROI produced by any of the identified WSTs/WSDs.

Of the household WSTs/WSDs analyzed, WSTs/WSDs with the highest ROIs were those that had the lowest up-front investment (e.g., low flow showerheads). A household's reliance on tanker water purchases, however, was found to be primarily a function of water savings produced by WSTs/WSDs, so even though lower cost WSTs/WSDs produce high ROIs, more water savings were found to be realized by WSTs/WSDs with higher upfront costs and moderate to low ROIs.

8. Findings, Conclusions & Recommendations

The focus of this research was to leverage relevant data, information, and studies already carried out by Mercy Corps as part of the WIT project to conduct a study of the costs, benefits, and incentives associated with implementing the range of water saving activities completed as part of WIT. To achieve this, three distinct tasks were completed: a review of literature, a cost-effectiveness analysis, and an analysis of participant incentives and benefits. This section covers findings, conclusions and recommendations that could potentially improve outcomes of similar projects in the future.

8.1. Findings

- Activity costs represented 50% of total project costs, with WIT overhead and activities in supporting offices in Jordan and Washington, D.C. accounting for the other 50%.
- For the purposes of this analysis, estimated water savings during WIT were approximately 18.8 MCM (with final agricultural estimates this increased to 22.8 MCM). Actual and projected water savings under the LoL scenario, however, were estimated to be 76.2 MCM — a substantial difference.
- Water savings from adoption of WSAs do not stop because the project is over. For agriculture, drip irrigation systems, if maintained properly, should continue to function for several more years with minimal additional costs, and based on the estimated ROI, farmers would hopefully recognize the financial benefits of continuing to use WSTs even when their system needs replacing. For households, with the exception of tap aerators, WSTs/WSDs adopted have long lifespans (50+ years) if properly maintained. Differences in the results of the Baseline and LoL scenarios highlight the importance of accounting for future water savings. For agriculture, Baseline and LoL water savings were estimated to be 17.6 MCM and 65.2 MCM, respectively. Similarly, household Baseline and LoL water savings were estimated to be 1.2 MCM and 11.0 MCM, respectively, suggesting that the majority of water savings coming from WIT will occur after the project has been completed.
- The agriculture investment fund was the most cost-effective WIT activity, with activity costs of $0.05/m^3 and total costs of $0.08/m^3. The household loan fund was the least cost-effective activity, with an estimated cost of over $6.00/m^3 considering activity costs only and a total cost of over $13.00/m^3.
- WIT activities (and agricultural activities in particular) appear to be cost-effective strategies compared to other alternatives found in the literature.

- While the majority of farmers participating in WIT were motivated by a desire to save water for the future, when results were broken out by governate, a different pattern emerged — 100% of survey respondents from Mafraq said saving water for future use was a motivation, while only 59% of Azraq respondents felt similarly. In contrast, 71% of Azraq respondents said a primary motivation was to use saved water elsewhere on their farm, whereas only 7% of Mafraq respondents were motivated by this.
- The ROI for farms adopting WSTs was estimated to be approximately 450%. Even assuming a conservative length of life for the WST (i.e., three years instead of eight), the expected ROI was still positive in both Azraq (129%) and Mafraq (138%).
- Only 25% of WIT agricultural participants responding to the endline survey were aware of WSTs prior to 2017.
- Although adopters of household WSAs cited multiple factors that motivated their adoptions, religion appeared to play an outsized role across governorates.
- RWH systems, particularly lower cost ones (above ground plastic tanks and 20 m^3 pear-shaped wells) produced positive ROIs in governorates with higher average annual rainfall, but were unlikely to produce positive ROIs for adopters in drier governorates such as Mafraq and Azraq.
- Of the HH WSTs/WSDs analyzed, those with the highest ROIs were typically those that had the lowest up-front investment (e.g., low flow showerheads). A household's reliance on tanker water purchases, however, was found to be primarily a function of water savings produced by WSTs/WSDs, so even though lower cost WSTs/WSDs produced high ROIs, more water savings were found to be realized by WSTs/WSDs with higher upfront costs and moderate to low ROIs.
- The cost of tanker water was a determining factor of whether a WST/WSD might produce a positive ROI in one governate and a lower or negative ROI in another. Irbid had the highest costs per cubic meter of tanker water compared to the other governorates by a factor of two. The cost of water from tankers also was one of the highest observed values for water — in part, because of the basic human need for water makes demand for it inelastic.

8.2. Conclusions

- When considering the cost-effectiveness of a project (or comparing it to the cost-effectiveness of other projects), it is important to consider and be aware of whether or not the reported cost-effectiveness measure is inclusive of all relevant costs. As an example, using the results of this analysis in which activity costs represented 50% of total costs, if one cubic meter of water were saved at a cost of one dollar, reporting cost-effectiveness based on activity costs and total costs would result in two very different measures — \$0.50/m^3 and \$1.00/m^3, respectively.
- Clear differences in motivations to adopt WSTs highlighted that not all agricultural water "saved" may actually stay in the ground for future use, and furthermore, these differences may be driven, in part, by the geographic location of the adopter.
- Findings suggest that even if a farmer pays the full cost of WST installation, over the lifespan of the WST, the resulting cost-savings are very likely to outweigh the initial cost. On-farm WST adoption not only appears to generally support cost-savings, but also positive ROIs, suggesting that farmers should adopt WSTs even if their only motivation is financial.
- The potential financial benefits for households of adopting RWH systems appears to be correlated, at least to some degree, with the average annual rainfall of the location where the system is installed.
- Results suggest that 1) funding water conservation efforts in Jordan may be less expensive than other water saving alternatives; and 2) regardless of outside funding or incentives, WSA adoption often has a positive ROI for the water user, and, therefore, should be strongly encouraged as part

of government policy and/or donor funding. A government policy to subsidize WSA adoption would also likely be cost-effective, as the cost of other, more expensive alternatives could potentially be avoided. A notable example of where this has occurred elsewhere is in the western United States. The Southern Nevada Water Authority, which supplies water to Las Vegas and other areas of Nevada, has a program that provides rebates to water users who convert turf to xeriscape (i.e., desert landscaping).[6]

8.3. Recommendations

- In order to accurately measure cost-effectiveness by activity (and also account for indirect costs), cost categories and methods for assigning expenditures to these categories should be established at the start of a project and used consistently throughout.
- Calculations of water savings from a project should incorporate some estimate of future water saving (a suggested timeframe would be the length of life of the WST adopted).
- Given that farms are businesses and often make decisions based on potential financial gain/loss, efforts to increase WST adoption by agriculture should include information on the potential cost-savings and positive ROI of adoption.
- For households, the effectiveness of future water conservation education and outreach efforts may be enhanced if the messaging is placed in a religious context and/or if religious institutions are taken on as partners to the effort.
- Future efforts to increase household WSA adoption should consider strategic marketing of RWH systems, with a focus on areas with higher average annual rainfall — and include information on the potential long-term financial benefits of adoption.
- While only considered for one motivation — reduction in tanker water purchases — differences in respondents who stated this as a primary motivation, their selection of WSAs to address this and the proportion who realized actual benefits suggests an opportunity for future efforts to highlight potential water savings as a proportion of total household water use for various WSAs as part of outreach efforts.
- If regular maintenance is not a part of the farmer/household knowledge when a WST/WSD is adopted, then total potential water savings may not be realized. Providing technical assistance/training on care and maintenance may be an important aspect of supporting long-term use.
- Future household efforts might consider a more limited set of WSTs/WSDs, and, in particular those with the largest potential for water savings (e.g., RWH systems) and also potentially provide mechanisms to support adoption as up-front costs are typically higher (e.g., discounted pricing).
- Based on limitations encountered as part of this effort, if cost-effectiveness and return on investment are considered relevant indicators for future projects, it is recommended that increased coordination both at the start of and throughout the project occurs to standardize data collection and tracking methods and ensure consistency of terminology, IDs, etc. used across multiple data sets and organizations.
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[6] https://www.snwa.com/rebates/wsl/index.html.

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9. APPENDIX A. INCENTIVES & BENEFITS OF HOUSEHOLD WSA ADOPTION

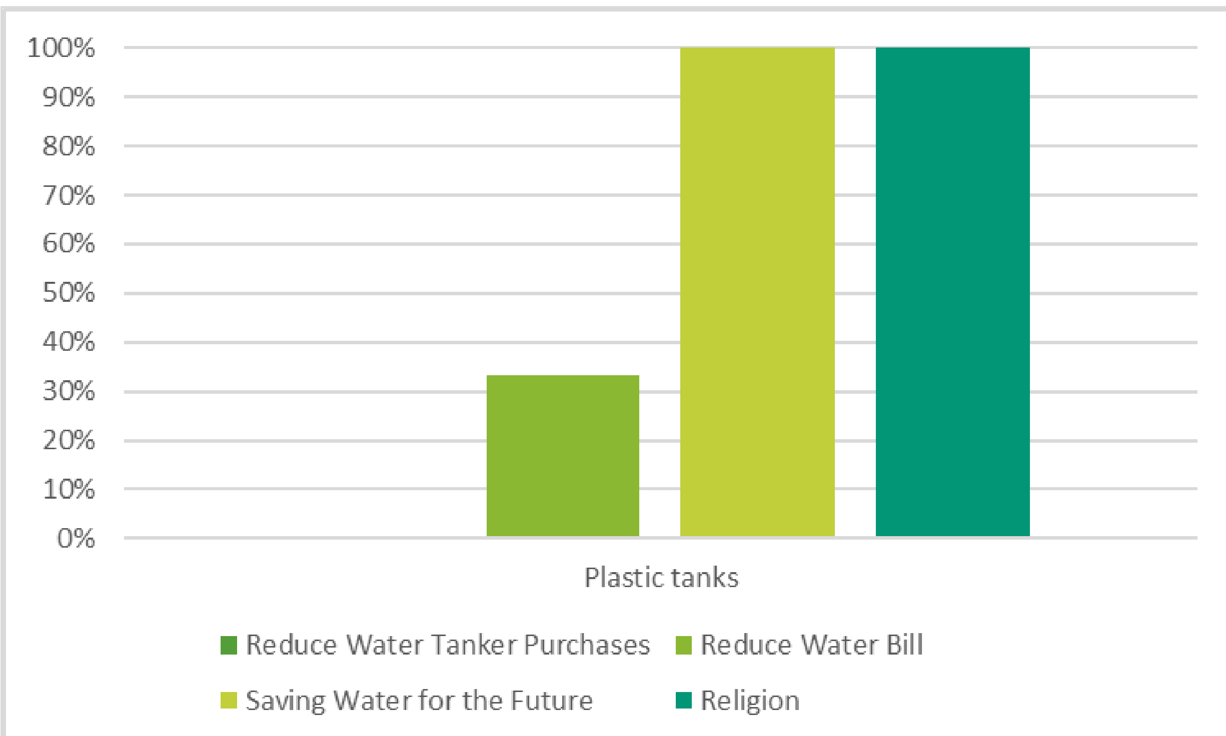
This appendix provides greater detail on the incentives for, benefits of, and ROIs for household adoption of WSAs introduced in Section 7.2.

Incentives

As part of the household end-line survey respondents were asked whether their motivation for adopting WSAs was to reduce their purchases of tanker water, reduce their water bill, save water for the future of Jordan, or because their religion dictates that it is the right thing to do. The majority of respondents, regardless of governorate or WSAs adopted, cited their religion as a primary motivating factor. For the WSAs that resulted in reductions in tanker water purchases, the respondents' motivations for adoption were extracted and analyzed by governorate.

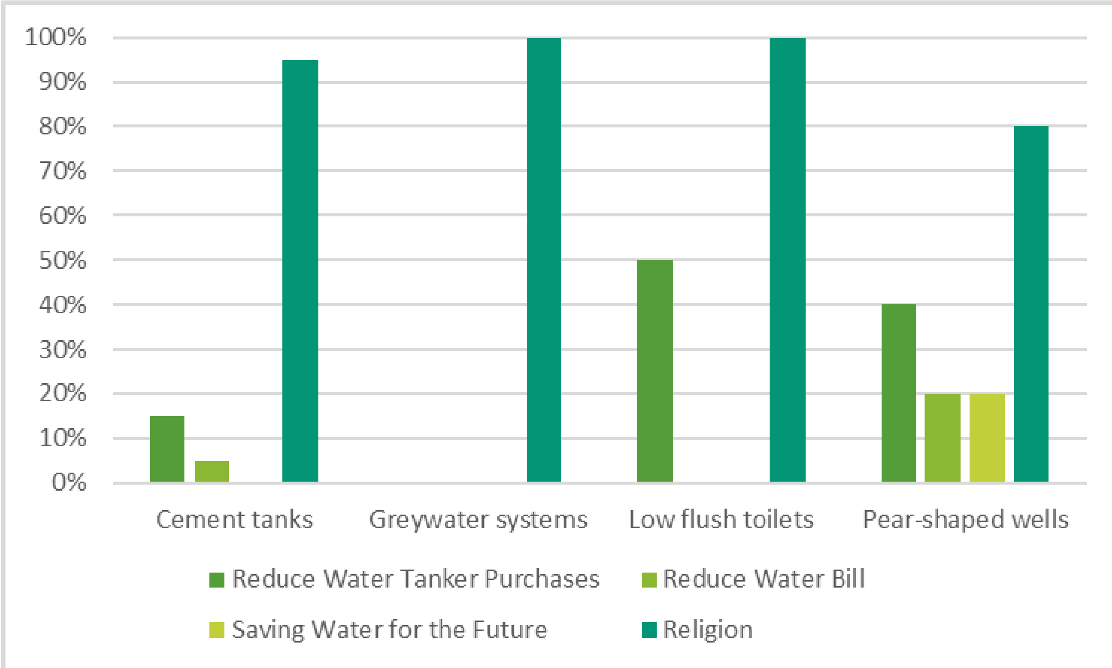
In Mafraq, the primary motivations for the adoption of plastic tanks (the only WSA found to result in reduction in tanker water purchases) were a) to save water for the future; or b) as dictated by the respondents' religion. Reduced purchases of tanker water were not cited as a motivation by any of the three adopters of plastic tanks (Figure A1). Respondents who adopted other WSAs, such as low flow toilets and shower heads, toilet bags, water irrigation systems, zero-waste water filters, placing an object in the toilet tank, and regularly maintaining the water network did cite reduced tanker water purchases as a motivation for adopting those WSAs, but at relatively low rates (i.e., less than 28% of respondents who adopted the individual practices).

Figure A1. Motivations Resulting in Decreased Tanker Purchases - Mafraq



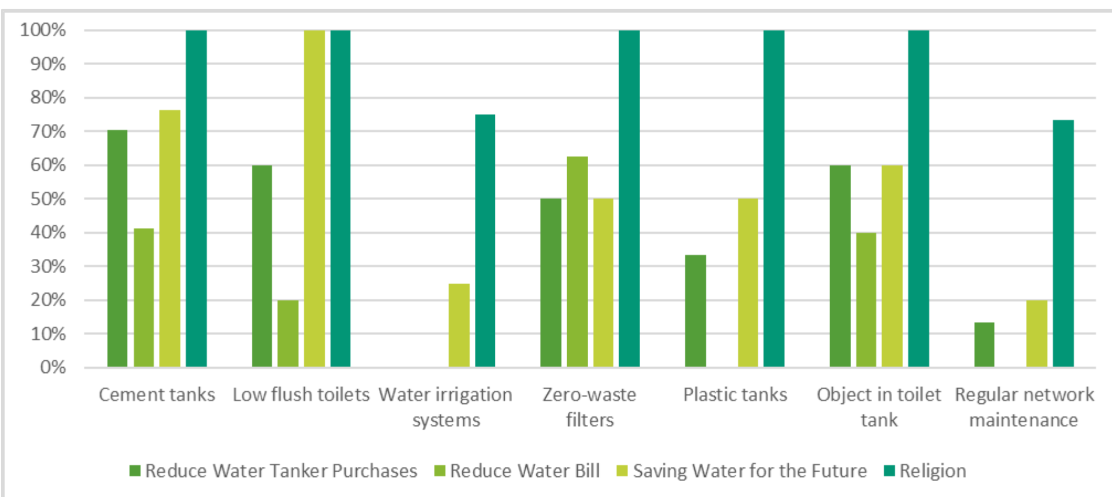
In Irbid, the primary motivation for WSA adoption that resulted in observed reductions in tanker water purchases was the respondents' religion with the other categories of motivation ranking far below that of religion (Figure A2).

Figure A2. Motivations Resulting in Decreased Tanker Purchases - Irbid



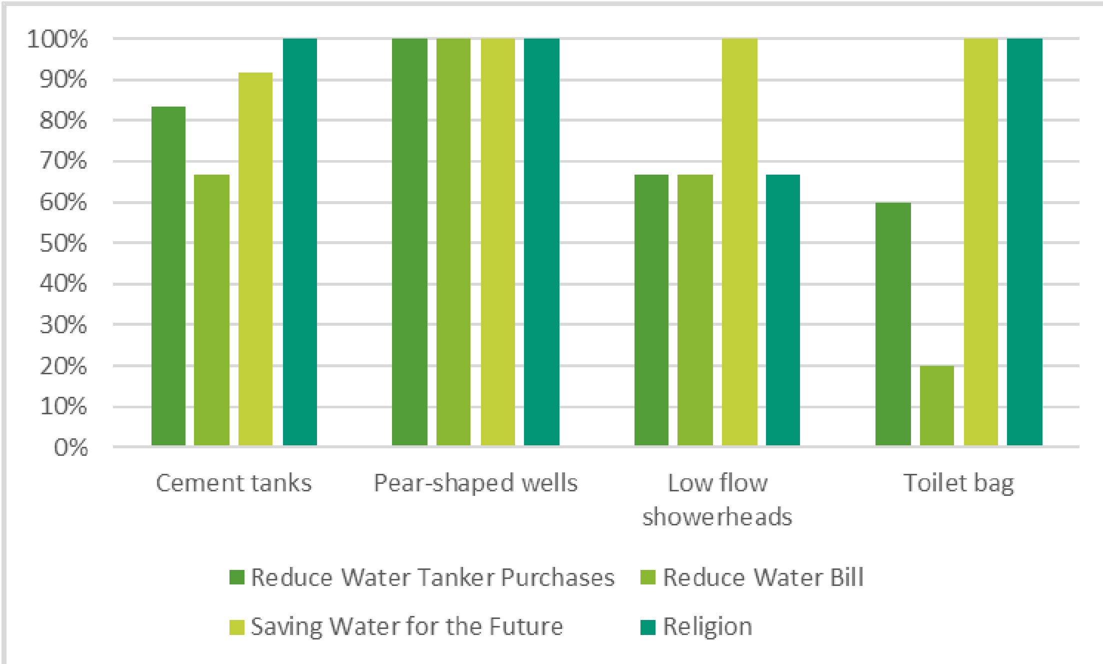
In Jerash motivations for adoption of WSAs were more varied. Though religion remained the primary motivation, the majority of WSA responders also identified reducing tanker water purchases as a motivating factor for the adoption of cement tanks, low flush toilets, zero-waste water filters, and placing an object of the toilet tank (Figure A3).

Figure A3. Motivations Resulting in Decreased Tanker Purchases - Jerash



The majority of respondents from Aljoun cited all categories — reduced tanker water purchases, reduced water bills, saving water for the future, and religion — as motivating factors for the adoption of WSAs (Figure A4). As such there appears to be greater alignment between the motivation for adoption and the outcome of reduced tanker water purchases, however, reduced tanker water purchases were also motivations for the adoption of low flush toilets (100% of WSA adopters), zero-waste water filters (56% of WSA adopters), and plastic tanks (100% of WSA adopters).

Figure A4. Motivations Resulting in Decreased Tanker Purchases - Ajloun



In Azraq no adopters of WSAs cited reduced tanker water purchases as a motivation for adoption and none of the respondents who adopted WSAs reported reducing their purchases of tanker water as a result of adoption.

Benefits

Additional benefits beyond reducing purchases of taker water were realized by adopters of WSAs that may be important to understand for future water conservation and outreach efforts. In Mafraq, the majority of the adopters of WSAs observed that their water tanks lasted longer. On the other hand, a large percentage of the adopters of zero-waste filters and cement tanks indicated that they experienced no benefit from their adoptions (Table A1).

Table A1. Benefits of WSA Adoption in Mafraq

			Benefits (% WSA Adopters)				
Governate	WSA	Adoptions	Water Bill Decreased	Water Tanks Lasts	Reduced Tanker Purchases	No Benefit	Other
Mafraq	Cement tanks	9	0%	33%	0%	67%	0%
	Low flush toilets	8	38%	63%	0%	0%	0%
	Pear-shaped well	1	100%	100%	0%	0%	0%
	Water irrigation systems	16	6%	69%	0%	31%	0%
	Zero-waste filters	26	4%	23%	0%	73%	0%
	Plastic tanks	3	0%	33%	33%	33%	0%
	Low flow showerheads	39	49%	38%	18%	28%	0%
	Toilet bag	10	10%	80%	10%	20%	0%
	Object in toilet tank	14	21%	50%	21%	14%	0%
	Regular network maintenance	63	5%	25%	8%	8%	2%

Note: Cells are highlighted green to ease interpretation of the table and indicate percentages of WSA adopters greater than 25%.

In Irbid, with the exception of placing an object in the toilet tank, benefits from the adoption, including those that resulted in reductions in tanker water purchases, were mixed with many respondents citing no benefit as a result of their adoption (Table A2).

Table A2. Benefits of WSA Adoption in Irbid

Governate	WSA	Adoptions	Benefits (% WSA Adopters)				
			Water Bill Decreased	Water Tanks Lasts	Reduced Tanker Purchases	No Benefit	Other
Irbid	Cement tanks	20	5%	20%	30%	50%	0%
	Greywater systems	7	14%	29%	29%	43%	0%
	Low flush toilets	2	0%	0%	50%	50%	0%
	Pear-shaped wells	5	20%	40%	40%	40%	0%
	Water irrigation systems	6	0%	0%	0%	100%	0%
	Zero-waste filters	34	9%	41%	3%	47%	0%
	Plastic tanks	18	22%	22%	0%	56%	0%
	Low flow showerheads	2	0%	50%	0%	50%	0%
	Object in toilet tank	1	0%	100%	0%	0%	0%
	Regular network maintenance	37	11%	11%	0%	5%	0%

Note: Cells are highlighted green to ease interpretation of the table and indicate percentages of WSA adopters greater than 25%.

Conversely, WSAs adopted in Jerash very rarely resulted in the adopter experiencing no benefit, with the exception of low flow showerheads. Additionally, WSAs rarely resulted in the adopters' water bill decreasing, with most of the benefits of WSA adoption manifesting as reduced tanker water purchases or adopters' water tanks lasting longer (Table A3).

Table A3. Benefits of WSA Adoption in Jerash

Governate	WSA	Adoptions	Benefits (% WSA Adopters)				
			Water Bill Decreased	Water Tanks Lasts	Reduced Tanker Purchases	No Benefit	Other
Jerash	Cement tanks	17	29%	100%	88%	0%	0%
	Low flush toilets	5	20%	100%	80%	0%	0%
	Water irrigation systems	4	25%	75%	25%	25%	0%
	Zero-waste filters	8	50%	75%	63%	13%	13%
	Plastic tanks	6	17%	100%	67%	0%	0%
	Low flow showerheads	6	17%	33%	0%	50%	0%
	Object in toilet tank	5	20%	60%	60%	0%	0%
	Regular network maintenance	15	20%	40%	27%	20%	0%

Note: Cells are highlighted green to ease interpretation of the table and indicate percentages of WSA adopters greater than 25%.

In Ajloun, adopters of WSAs experienced mixed benefits. Interestingly, plastic tanks, despite the benefits experienced from adoption of other rainwater harvesting WSAs in the governate, were found to provide no benefit to its single adopter. Low flush toilets, toilet bags, and zero-waste filters also provided no benefit to a large percentage of their adopters in Ajloun. Low response rates for placing an object in the toilet tank or performing regular water network maintenance makes interpretation of this data difficult (Table A4).

Table A4. Benefits of WSA Adoption in Ajloun

Governate	WSA	Adoptions	Benefits (% WSA Adopters)				
			Water Bill Decreased	Water Tanks Lasts	Reduced Tanker Purchases	No Benefit	Other
Ajloun	Cement tanks	12	75%	33%	75%	17%	0%
	Low flush toilets	1	0%	0%	0%	100%	0%
	Pear-shaped wells	4	50%	50%	75%	25%	0%
	Zero-waste filters	16	31%	25%	0%	44%	0%
	Plastic tanks	1	0%	0%	0%	100%	100%
	Low flow showerheads	3	33%	67%	33%	0%	0%
	Toilet bag	5	40%	20%	40%	60%	0%
	Object in toilet tank	44	2%	11%	7%	9%	0%
	Regular network maintenance	52	4%	21%	6%	2%	2%

Note: Cells are highlighted green to ease interpretation of the table and indicate percentages of WSA adopters greater than 25%.

In Azraq, limited WSAs were adopted and none that resulted in reduced tanker water purchases (Table A5). This could be the result of survey participants in Azraq, on the whole, expressing relative water security provided by their municipal supply – suggesting that they do not need to reduce their reliance on tanker water. However, the responses by Azraq residents regarding the purchase of tanker water suggests that Azraq residents who do rely on these purchases are among the most highly reliant on tanker water of the governates (an estimated 186 m^3/year of tanker water purchases compared to 171 m^3/year as the next highest in Irbid and 73 m^3/year as the minimum reliance in Ajloun).

Table A5. Benefits of WSA Adoption in Azraq

Governate	WSA	Adoptions	Benefits (% WSA Adopters)				
			Water Bill Decreased	Water Tanks Lasts	Reduced Tanker Purchases	No Benefit	Other
Azraq	Low flow showerheads	3	33%	33%	0%	33%	0%
	Object in toilet tank	4	25%	25%	0%	0%	0%
	Regular network maintenance	3	0%	0%	0%	0%	0%

Note: Cells are highlighted green to ease interpretation of the table and indicate percentages of WSA adopters greater than 25%.

ROI

The WSAs included in the ROI analysis were:

1. WSAs for which at least 25% of adopters by governorate reported fewer purchases of tanker water.
2. Water savings resulting from zero-waste filters and water irrigation systems were not included as the id:rc end-line report provides no quantification of water savings from these WSAs and does not provide an obvious explanation as to why they have been excluded.
3. Cement tanks were not considered in the ROI analysis because, although survey respondents indicated reduced tanker water purchases as a result of cement tank adoption, the prohibitive cost of the tanks at the capacities to be offered under the WIT project (approximately $15,500) resulted in a complete lack of demand for the WSA from participants in the WIT project.

Therefore, it was assumed that any reported adoption of this technology by a survey respondent did not occur as a result of WIT.

Data sources for average annual water savings resulting from WSA adoption were:

1. The end-line survey report from id:rc (2021) for the following WSAs that aligned with WSAs that could have been adopted under the WIT project:
    a. Low flush toilets;
    b. Low flow showerheads;
    c. Toilet bags; and
    d. Greywater systems.
2. IWMI methodologies for calculating water savings (IWMI 2019) for those WSAs whose reported capacities in the end-line survey ranged both above and below the capacities supported by the WIT project. For example, survey respondents indicated adoption of pear-shaped wells that ranged in capacity from 10 m^3 to 60 m^3, whereas the tank capacities supported by WIT were for a more limited range. Because the focus of this analysis is on the potential ROI of WSAs adopted by WIT participants, only the tank capacities supported by WIT and included in the IWMI methodologies were assessed,
    a. Plastic tanks (both above and below ground for 20 and 30 m^3 capacities); and
    b. Pear-shaped wells (20 and 30 m^3 capacities; despite 10 m^3 capacities being supported by WIT, the available IWMI methodologies for calculating water savings were only available for 20, 30, and 40 m^3 capacities).

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