OCTOBER 2016 – MARCH 2017

WATER AND LIVELIHOODS INITIATIVE (WLI) SEMI-ANNUAL TECHNICAL PROGRESS REPORT

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ACRONYMS

ADOPT	Adoption and Diffusion Outcome Prediction Tool
AFESD	Arab Fund for Economic and Social Development
ANU	An-Najah National University
APSIM	Agricultural Production Systems Simulator
AREA	Agriculture Research and Extension
ARC	Agricultural Research Center
ARIJ	Applied Research Institute of Jerusalem
AUB	American University of Beirut
BAU	Business as Usual
CA	Conservation Agriculture
CC	Climate Change
FAO	Food and Agricultural Organization
FY	Fiscal Year
GBRR	Great Basin Rangeland Research (GBRR)
HU	Hebron University
ICARDA	International Center for Agricultural Research in the Dry Areas
INAT	Institute National Agronomique de Tunisie
INRAT	Institut National de la Recherche Agronomique de Tunisie
INVEST	Integrated Valuation of Ecosystem Services and Trade-offs
IPCC	Intergovernmental Panel on Climate Change
IRA	Institut des Regions Arides
IWLMP	Integrated Water and Land Management
LRC	Land Research Center
LARI	Lebanese Agricultural Research Institute
MAP	Medicinal Aromatic Plant
MENA	Middle East and North Africa
MF	Mono Fertilizer
NARC	National Agricultural Research Center
NCARE	National Center for Agricultural Research and Extension
NDVI	Normalized Difference Vegetation Index
NWRA	National Water Resources Authority
NWRC	National Water Resource Center
RDI	Regulated Deficit Irrigation
RHEM	Rangeland Hydrology and Erosion Model
SEED	Sustainable Environment and Economic Development
SWERI	Soil, Water and Environment Research Institute
TDR	Time Domain Reflectrometry
USAID	United States Agency for International Development
USDA ARS	United States' Department for Agriculture Agricultural Research Service
USFS	United States Forest Services
WH	Water Harvesting
WLI	Water and Livelihoods Initiative
WMRI	Water Management Research Institute

WP	Water Productivity
WUA	Water User Association
WUE	Water Use Efficiency

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EXECUTIVE SUMMARY

This semi-annual report represents work completed by the Water and Livelihoods Initiative (WLI) during the first two quarters of the fiscal year (FY) 2017 (October 2016 - March 2017). The WLI aims to improve rural livelihoods in areas where water scarcity, land degradation, water quality deterioration, food insecurity and health problems are prevalent; focusing initially on selected benchmark sites in Egypt, Iraq, Jordan, Lebanon, Palestine, Tunisia and Yemen.

Research during the reporting period span over a range of topics covering on-farm and watershed level interventions. Farm level activities included pilot-testing water and land management strategies to increase water and crop productivity of important cash crops, and understanding interactions between surface and groundwater under different scenarios. At the watershed level, WLI team engaged in intercepting, decelerating, and retaining runoff in upstream areas to enhance water infiltration and in situ storage; and modeling water and soil management systems. Socio-economic studies considered strategies for out-scaling innovative agricultural practices that were either developed or refined through WLI's support, assessing livelihood vulnerabilities in selected communities, and promoting alternative off-farm income generating activities. Regional collaborative work also continued with partners from Palestine and Jordan working using RHEM modeling to assess and compare the out-scalability of proven soil and water conservation measures. The socio-economic thematic group continues to work on publications based on obtained results from FY 2016.

The period also saw continued collaboration with the United States Department of Agriculture-Agricultural Research Services (USDA-ARS), the United States Forest Services (USFS), University of Florida (UF), the American University of Beirut (AUB); and projects funded by other donors such as the Arab Fund of Social and Economic Development (AFSED) and CARE International. Several events were also carried out during this time including the 9th Steering Committee Meeting, capacity building efforts both at community and regional levels, and efforts geared towards resource mobilization. Detailed report on all activities conducted during the period are provided below.

I. Introduction

This report represents the achievements and progress made by WLI partners over the past six months (October 2016 – March 2017). The WLI aims to improve rural livelihoods and communities in areas where water scarcity, land degradation, water quality deterioration, food security and health problems are prevalent, focusing initially on selected benchmark sites in Egypt, Iraq, Jordan, Lebanon, Palestine, Tunisia and Yemen (Fig 1). The Initiative is funded by the United States Agency for International Development (USAID) and managed by the International Center for Agricultural Research in the Dry Areas (ICARDA).

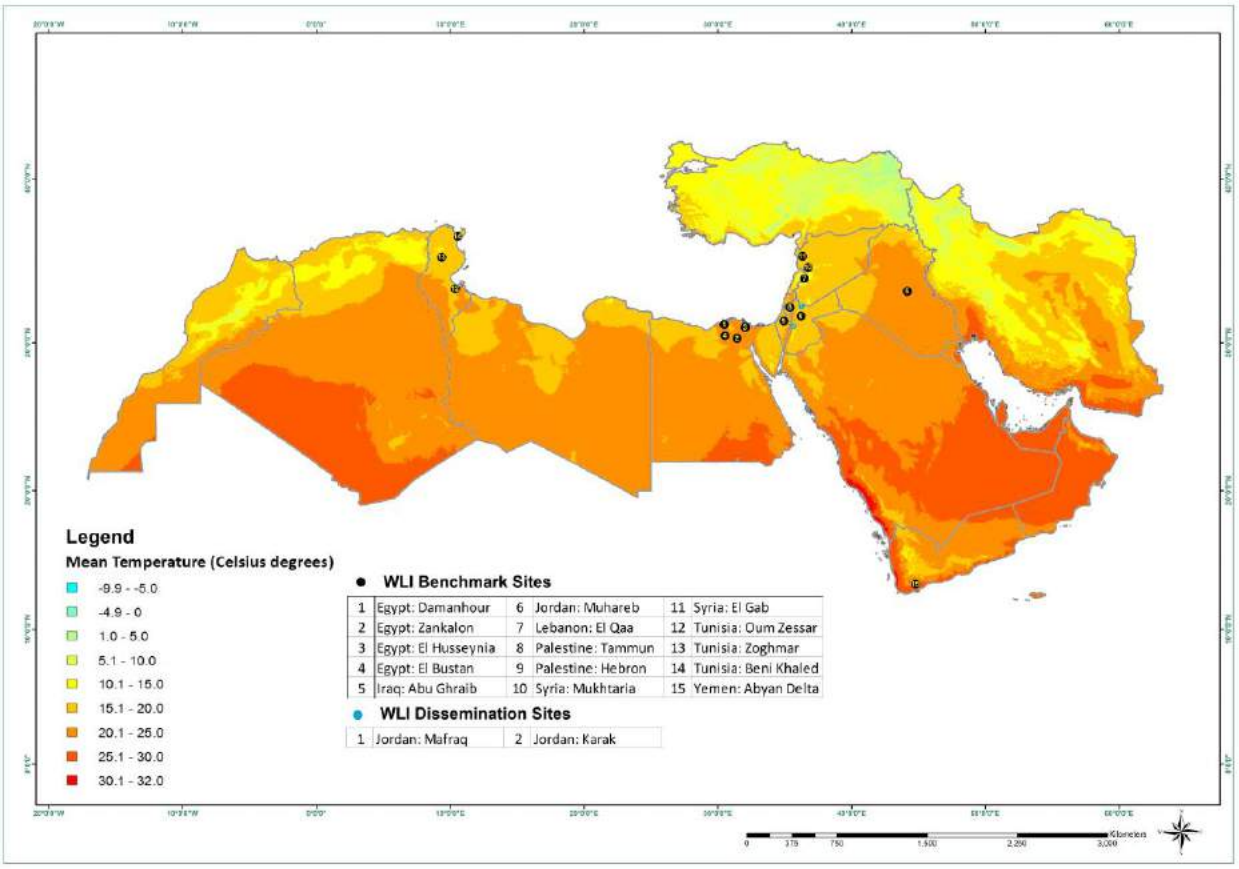


Fig. 1: WLI Benchmark sites in seven partnering countries

1.1. Overview of completed activities during the reporting period

In addition to country specific activities, reported under Section II below, a number of activities were conducted during the reporting period.

Delays in the approval of the Congressional Notification (CN) had direct implications on the approval and implementation of activities for the year. The regional annual coordination meeting

which often took place in the first quarter of the year was cancelled. Report on work completed during the FY was instead presented at the Steering Committee Meeting.

9th Steering Committee Meeting was held in Amman on February 6, 2017. The meeting was chaired by Dr. Kamel Shideed and attended by dignitaries and focal persons from all seven partnering countries (Fig. 2). Also in attendance was Dr. Scott Christiansen, who served as a resource person and provided guidance on potential future steps for the WLI based on a survey he conducted among WLI partners. Results of his survey and recommendations were shared and openly discussed during the meeting. Dr. Sandra Russo, from the University of Florida attended the meeting remotely. The Committee reviewed WLI achievements during the year, and examined and approved proposed work plans for FY 2017. Reports on regional initiatives, budget expenditures, and proposed budget breakdown were presented by the WLI Manager – Bezaiet Dessalegn.

Figure 2: WLI 9th Steering Committee Meeting, February 6, 2017. Amman, Jordan.

Plans for engagement with University of Florida (UF) were discussed and agreed upon during Dr. Russo's visit to Jordan in December 2016. Ms. Elizabeth Poulsen, was brought on board to compile previous WLI work conducted in Palestine, Jordan, Iraq and Lebanon using the Adoption and Diffusion Outcome Prediction Tool (ADOPT).

Preliminary agreements and arrangements were also made to engage UF to conduct a training on "Valuation of Ecosystem Services". Subsequently, the training was held during the period of March 6-9, 2017 (Fig 3). The training was led by Dr. Gregory Kiker from the University of Florida (UF), and Dr. Monji Sghaier from Institut des Regions Arides (IRA), Tunisia; with support from Dr. Sandra

Russo from UF and Dr. Stefan Strohmeier from ICARDA. The trainers who specialize in the bio-physical and socio-economic aspects of the topic respectively, used a multi-disciplinary approach to identify effective and efficient tools to integrate ecosystem management, economics, and socio-political factors. The four-day training included introductory sessions on various Scenario Analysis Tools, the InVEST (Integrated Valuation of Ecosystem Services and Trade-off) Model, as well as specific methods used to estimate economic values for ecosystem services. The training was useful in equipping participants with essential tools to generate the evidence that decision-makers need to understand the cost of action vs inaction, and associated trade-offs involved to make informed decisions on the use and management of ecosystems.

Fig. 3: Training on Valuation of Ecosystem Services

Fostering partnerships

Efforts to build partnerships and explore potential funding opportunities were stepped up during the period with several field trips organized in Jordan to demonstrate the work done by the Initiative. For instance, on February 1st a field trip was organized for representatives from **USDA-FAS** who were interested in working with the government of Jordan to develop pastoral communities in Jordan Badia. Extensive discussions were held with the team led by Ms. Jocelyn Brown, to explore potential opportunities for collaboration. The visit was also attended by Mr. Evan Mayer, the Water Conservation Officer, from USAID office in Jordan.

A similar visit was also organized on February 21st for Mrs. Esse Nilsson, Senior Program Manager for the Middle East and North Africa (MENA) Division, **Sida**. Follow up discussions with Mrs. Esse has led to a request for a Concept Note which is currently under development covering Jordan, Lebanon, and Palestine and building on WLI work in these countries.

Community engagement

Several meetings were also held with the communities in WLI benchmark site in Jordan including an event for the elders of the community to explain linkages between WLI's work and complimentary activities conducted by USFS (Fig. 4). The event was attended by 12 men who engaged in active discussions on what has been accomplished by the project thus far, and what they would like to see continued in the future.

Fig. 4: Community discussion at Majdiyae

An event was also organized on March 28 for school children who attended the Majedeah Primary Mixed School located in WLI benchmark site in Jordan. The event was attended by more than 35 participants including students aged between 6-14, and school staff. The event was co-hosted by WLI and the Sustainable Environment and Economic Development (SEED) project supported by US Forest Services and focused on the sustainable management of the Badia ecosystem (fig. 5). The students participated in role plays representing the Badia at different times including the past, present and the future to establish the fact that their environment changes over time due to natural and human actions. This session was then followed by field visits to the project sites for practical demonstration of project interventions.

Fig. 5: Awareness raising - Majdiyae Primary Mixed School

Conference Participation

WLI was represented at the following regional conferences:

- **4th Arab Water Week Conference** held in Jordan during March 19-23, 2017. Relevant work done on Climate Change impacts on water resources was presented and received very good feedback.
- Esri Middle East and North Africa User Conference (MENAUC) held at the Dead Sea during November 8 – 10, 2016. Remote Sensing wok conducted with the support of WLI was presented.

II. Country Reports

Egypt

WLI's benchmark sites in Egypt are located in the Nile Delta, which represents the major agricultural area in the country. The benchmark sites represent the Old (El-Boheya), New (El-Bustan), and Salt-Affected Lands (South El-Husainia) thus covering the full range of issues facing irrigated agriculture in the country including on-farm water management, salinity build-up, poor soil fertility, crust formation, low water-holding capacity, and deplet ion of groundwater (Fig. 6). The research team is composed of representatives from Egypt's Water Management Research Institute (WMRI), National Water Research Center (NWRC) and in particular the Soil, Water and Environment Research Institute (SWERI) which also serves as the lead institute for WLI activities in Egypt in this fiscal year; and the Agricultural Research Center (ARC).

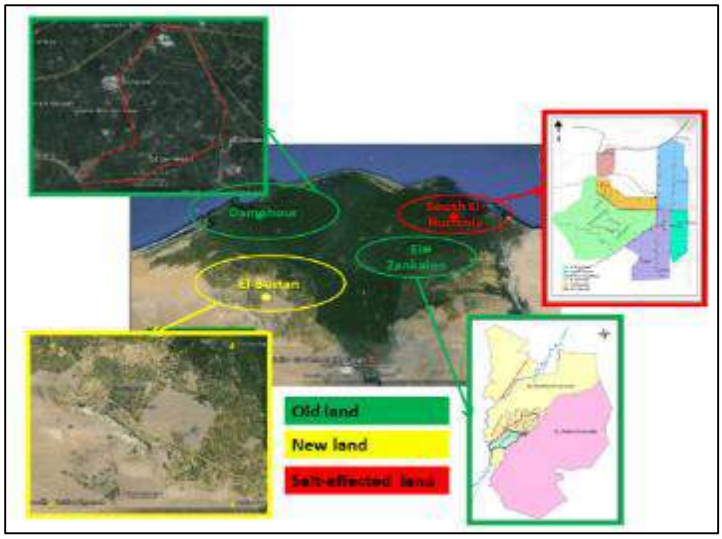


Fig. 6: WLI Benchmark sites in Egypt

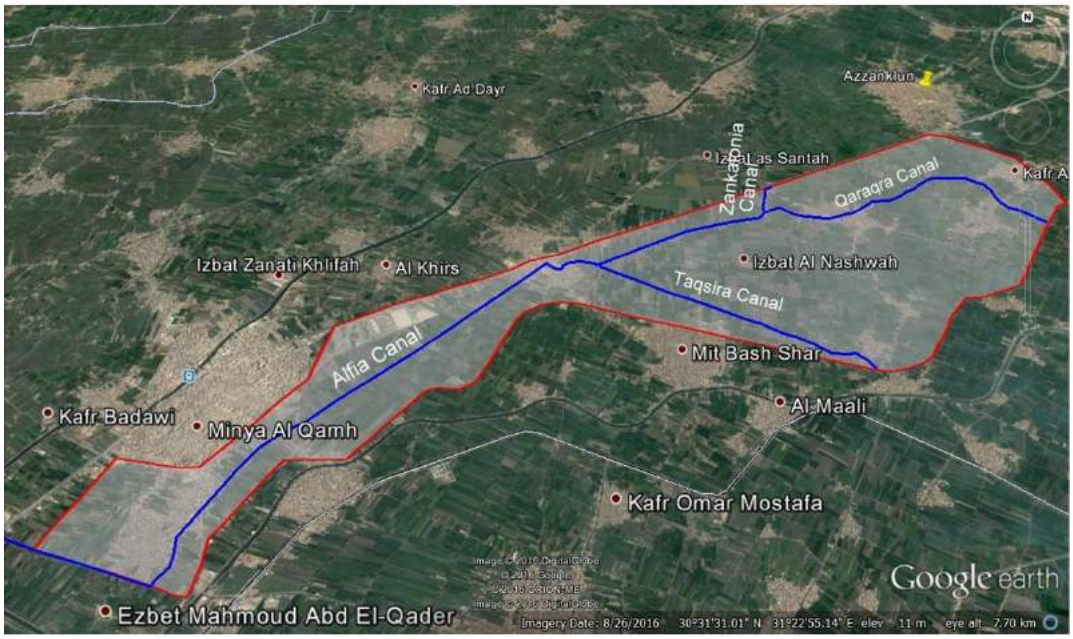
Activities planned for FY 2017 build on achievements from last year and continue to explore interactions between surface and groundwater in Central Delta to identify sustainable conjunctive use options under three scenarios, namely – reduction in the supply of surface water, changes in cropping patterns, and under increased groundwater use. Socio-economic efforts focus on assessing the impact of groundwater use on farmers' livelihoods. Progress made by the team during the reporting period are summarized below.

1. **Groundwater modeling for sustainable resource management in the Nile Delta**

Over-extraction of groundwater is becoming common practice in the Central part of the Delta to compensate for reductions in surface water available for irrigation. The increased use of groundwater for irrigation is also putting extra pressure on the country's energy resources, as pumping from a tube well requires more energy than pumping from waterways, and on average costs 2 to 3 times more than pumping from the canal. Water balancing model is combined with field experiments to provide a better understanding of the components of the hydrological cycle from which appropriate management options can be developed. The activity is implemented in the command area of El Alfia canal, which is a branch canal from Bahr Abouel-Akhdar Canal, and located in Menia EL- Qamh district, El-Sharkia governorate, East Delta Region (Fig. 7) and feed from Abouel-Akhdar Canal

through Mostafa Afandy Canal. The canal is 8.95 km long and extends another 6.60 km under the name Qaraqra, and has two branches -Taqsira and Zankalonia. Private shallow groundwater wells cover a part of the area especially at the downstream part. The irrigation rotation is 5 days on and 10 days off.

Figure 7: Layout of the Command Area of El Alfia Canal



During the reporting period the team continued collecting meteorological data, as well as data on physical and chemical properties of soil in the experiment site. Crop water requirement for main summer crops were calculated using Food and Agricultural Organization's (FAO) crop Wat8 model. Moreover, water levels at head regulators were manually recorded by WMRI field staff on a weekly basis and along the Abou El-Khader main, and Mostafa Afindy branch canals. Gate openings of the canals were also recorded twice a week by gate keepers, and randomly cross-checked. Moreover, routine measurements of the discharge in the sample canals were done using ultra sonic magnetic current meters.

2. **Socio-economic Component:**

Under this component the team focused on assessing the impacts of groundwater use for agriculture. In this regard, the team prepared and pre-tested a questionnaire, selected sample areas and is currently collecting relevant data.

Iraq

WLI's irrigated benchmark in Iraq is located in Abu- Ghraib (Fig. 8). Major water related challenges in the area include low water productivity associated with traditional irrigation methods, declining water quality and water resources.

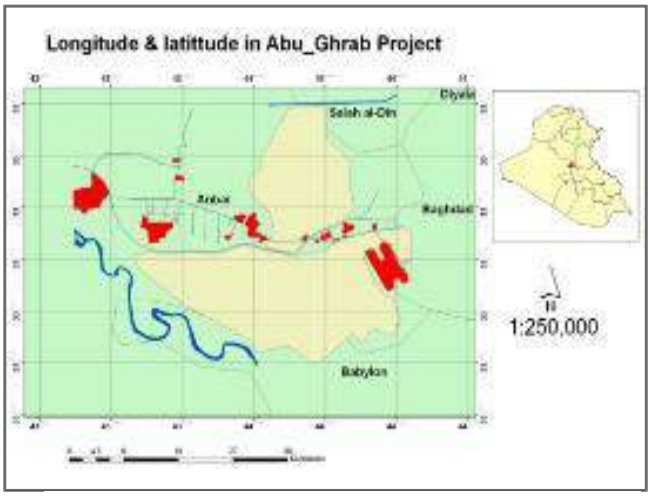


Figure 8: WLI Benchmark sites in Egypt

Fresh water was supplied to Abu Ghraib in February of 2017, after several months of restrictions resulting from the war. Farmers' reliance on brakish and other marginal water sources thus slightly declined during this period.

Approved workplan for the fiscal year focuses on pilot-testing water and land management strategies to increase water productivity and yield of important cash crops such as tomatoes. Socio-economic activities focused on developing strategies for enhanced engagement of women in agriculture. Below is a brief summary of the progress made under each activity during the reporting period.

1. **Use of mulches to improve tomato and water productivity under surface and sub-surface drip irrigation**

This activity builds on research results achieved in the previous year. Physical and chemical analysis were conducted on soil samples collected from depths of 30 cm. The seedlings were planted in two sites on selected farmers' fields (Figure 9). One of the plots was irrigated using sub-surface drip irrigation, while the other was irrigated using the conventional surface drip irrigation method. Each plot was in turn divided into two mini-plots to assess the plants response to mulching with PVC – black cover, application of different levels of irrigation - half and full volume, and use of different water quality – including the use of brackish water with ECiw of 3.20dS/m. Fertilizers were applied as fertigation in equal rate to each treatment. The team continues to monitor and document results of the experiment.

Fig.9: Experiment on mulching

2. **Minimize impact of brackish irrigation water on tomato crop by using manure to improve water productivity**

The first experiment involved two plots allocated by local farmers. The plots were planted with tomatoes and irrigated with half and full volume of brackish water (3.5 dS/m) using sub-surface drip irrigation. Urea (46% N) and Phosphorus fertilizers were also applied during the reporting period. The team continues to monitor the progress of the experiment.

3. **Increase water efficiency of cucumber by using liquid and solid compost fertilizers under protected agriculture**

The study aimed to assess the effect of applying selected fertilizers on the growth of cucumbers – an important cash crop for farmers in the area. Farmers' fields in Hactria and Share districts of Abu Ghraib were used for this experiment (Fig. 10). The greenhouse was divided into two plots and were planted with cucumbers. Solid and liquid composts were applied on the two plots respectively, and both plots were fully irrigated. The team continues to monitor the growth of the cucumbers and water use efficiency.

Fig.10: Experiment on growing cucumbers using different types of

Under the **Socio-economic component**, the team focused on developing strategies to enhance women's participation in agriculture to improve rural livelihoods. A questionnaire was developed to collect relevant data on current forms of women's engagement in the sector, and to identify opportunities for empowerment. Data collection is currently underway (Fig 11).

Fig. 11: Completing surveys in Abu-Ghraib

Jordan

The Muhareb watershed serves as the WLI benchmark site effectively representing the Badia environment (Figure 12). Rainfall in the area is scarce (annual mean below 200 millimeters) and highly erratic. Other challenges relate to unsustainable management of fragile natural resources including over-grazing and associated policies.

WLI in Jordan supports holistic research on watershed management that considers upstream and downstream hydrological regimes and their relationships. Research in the benchmark site is conducted in close collaboration with the National Center for Agricultural Research and Extension (NCARE) and in coordination with other ICARDA projects supported by the United States Forest Service (USFS), and Arab Fund for Economic and Social Development (AFESD).

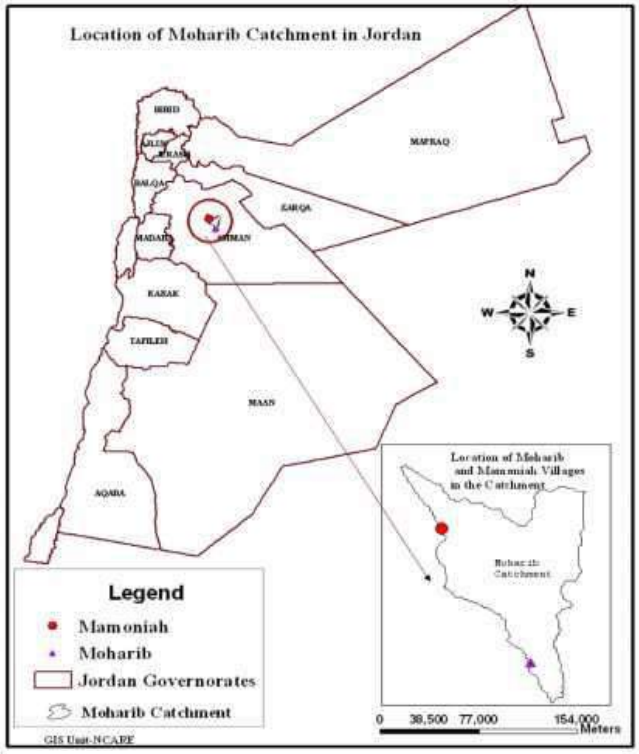


Fig. 12: WLI Benchmark site in Jordan

Activities approved for the FY mainly build on results achieved in FY 2016 and focus on interception, deceleration, and retention of runoff in upstream areas to enhance water infiltration and *in situ* storage.

1. **Maintenance of micro-water harvesting structures**

During the reporting period, the team maintained existing marabs, contour ridges and strips in Majedya area, and prepared the area for planting shrubs. Excess soil and weeds in furrows were removed so the water will not be blocked and spill over the ridges and break them. In addition, vallerani contour ridges were implemented on 10 dunums (1 ha) in Majedya. Data recorded in the data loggers for runoff devices were downloaded after each rainfall event. Samples and amounts for runoff water from barrels connected to the runoff plots were collected and analyzed in the soil and water lab at NCARE after each significant rainfall event.

2. **Bio-physical characterization of the modeling watershed**

The study was conducted to assess the effect of selected water harvesting interventions on the sediment quantity and quality, run-off, as well as crop productivity. Soil samples were collected and analyzed at the soil lab at NCARE including TSS and NPK after each significant rainfall event. Water depth in barrels were measured and water samples were taken to be analyzed (TSS) – water level and water flow, and moisture data were also downloaded.

3. **New drought tolerant plants (Atriplex and Salsola) were planted using different water harvesting techniques**

Six new drought tolerant fodder shrubs including Atreplixhalimus, Atreplixnumilaria, Medigacoarboria, Astragulusspp, Mariana breifolia and Artimisiaherba alba were planted on December 11, 2016 at the benchmark site. The team continuously monitored their growth, adaptability, and survival rate reported at 95%. In addition, the team planted Retama and Cactus on 1 ha of land – and to date the survival rate is reported at 90%. Older sites with Atreplix and Salsola were also maintained during this period.

4. **Monitoring beneficial range vegetation indices**

Maps based on average Normalized Difference Vegitation Index (NDVI) values for two months were produced for Majediya and Muhareb sites using *Sentinel2 images* at 10m resolution and are presented below (Figure 13).

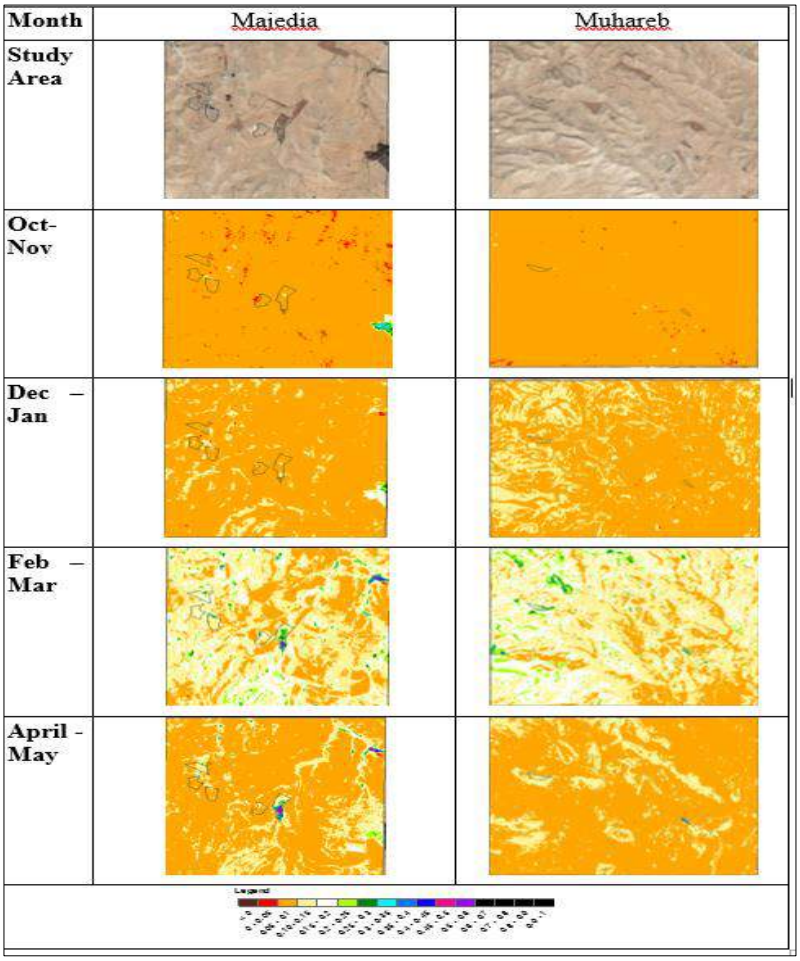


Fig. 13: Maps for monitoring beneficial range indices

Socio-economic component

The team participated in the regional training on Valuation of Ecosystem Services which was offered by Dr. Gregory Kiker from University of Florida and Dr. Monji Sghaier from Institut des Regions Arides (IRA), Tunisia. Based on the training the team developed a questionnaire which will be tested and conducted during the coming months. In line with the topic of focus for the year – "valuation of ecosystem services", WLI partnered with other ICARDA-led projects in the Jordan Badia, including 'the Sustainable Environment and Economic Development (SEED)' project which is also funded by USFS and USAID, organized an awareness-raising event on sustainable management of the Badia ecosystem in Al Majdiyah village.

Over 35 participants including primary school students aged between 6-14 years old, school staff, ICARDA scientists and others attended the workshop held *at Majdiyah Primary School*.

The sessions took the form of interactive discussions on important concepts, project interventions, and future implications. The students participated in role plays representing the Badia at different times including the past, present and the future to establish the fact that their environment changes over time due to natural and human actions. This session was then followed by a field visit to the project sites for practical demonstration of project interventions (Figure 14).

Fig. 14: Discussions during visit to the project

The half-day event enabled students to have a better understanding of:

- Jordan's vast Badia region commonly characterized by extreme water scarcity, erratic rainfall, and severe land degradation;
- pertinent challenges to improved livelihoods in the region including over grazing, unsustainable rangeland management practices;
- possible future scenarios for the Badia in light of projected effects of climate change and human interventions; as well as
- proven water and land management technologies and recommended ecosystem management practices including various water harvesting techniques and planting of climate resilient rangeland species to increase vegetation cover and reduce soil erosion.

The event was well received by the school and the community in general.

The WLI also collaborated with other projects supported by US Forest Services and AFSED to promote income generating activities in the benchmark site. In this regard, the team plans to hold focus group discussions with women groups in the area to identify key areas of interest and to provide required technical support. Progress made in this regard will be included in the final report.

Lebanon

El Qaa village, located in the northern Bekaa Valley, serves as one of the rainfed benchmark sites for WLI (Fig. 15). Among the main challenges in the area are - water scarcity and deteriorating water quality due to declining groundwater levels and decrease[1] in the flow of the Orontes River that originates in Lebanon but is shared with Syria; as well as low crop productivity and quality. The Lebanese Agricultural Research Institute (LARI) and the American University of Beirut (AUB) serve as the main WLI research partners in the country.

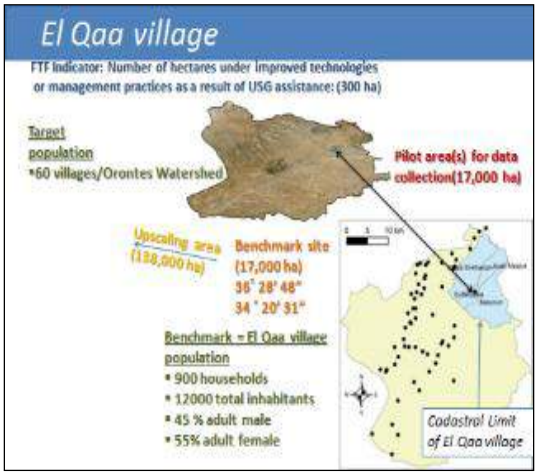


Fig. 15: WLI benchmark site in

Socio-economic research focused on assessing farmers' willingness to adopt a bundle of new technologies in the Beqaa. Below is a brief summary of activities conducted during the reporting period. Research efforts in FY 2017 focus on improving water and crop productivity, introduction and promotion of selected seed varieties and improved agricultural practices; and particularly on improving water productivity of a selected variety of *Rubuss* and *Strawberries.* Below is a brief summary of activities conducted during the reporting period.

1. **Rubus as potential use species for commercialization**

Rubus represent a large and diverse genus of flowering plants of which raspberries, blackberries, and dewberries are the most common and widely distributed varieties. Rubus was identified by the team as one of the under-utilized species that has great potential for commercialization and hence a source of alternative income for the communities in El Qaa and beyond, to assess and demonstrate the potential of this genus. An orchard with rubus plants of *Mora Triple Crown* variety was established in LARI's Tal Amara station (Fig. 16). The variety was developed through in-vetro plant cultivation by the Department of Plant Biotechnology, Tissue Culture Unit of LARI. Building on results of experiments conducted last year, the team planted 144 *Rubuss* plants in LARI's Tal Amara station. Foliar fertilizer 20-20-20 +TE was applied using drip irrigation system to promote new shoot regeneration; one mixed spray was used to contain Deltamethrin and Methodmyl insects and arachnids. The plants were pruned to induce more vigorous new growth from the old branch of the plant and ensure good yield in the

Fig. 16: *Rubus* plantation at Tal Amra

[1] The river is decreasing due to population growth resulting in increased demand and use of the river for irrigation.

summer. The team continues to monitor the progress of the plants and will report final results in its next report.

2. **Production of certified strawberry plantlets (Fragaria ananassa) using tissue culture techniques in Lebano**

Strawberry cultivation in Lebanon began in the early sixties and has substantially evolved during the late eighties to become a major horticultural crop. While most of the produce is domestically consumed, it is also exported to Arab gulf countries.

Serious problems affect the availability of strawberry plantlets for Lebanese farmers. In fact, in order to get their plantlets some farmers import high cost plantlets. Other farmers select their plantlets from their field or buy uncertified plantlets from local markets which may cause significant problems including spread of fungal, viral diseases and others. In this context, the project aims to start the production of certified strawberry F0 plantlets by using tissue culture techniques in the department of Plant Biotechnology, Tissue Culture Unit at Tal Amara station (LARI). The plan is to distribute them to some NGOs and farmers to do the Vegetative multiplication in the field in order to produce the F1, F2 and F3 plants intended for the production of fruits.

Four strawberry varieties were selected in February 2017 based on their good characteristics: Albion, Camarosa, Festival and Jawhara. Fifteen plants of each variety were planted as mother plants in March 2017. Drip irrigation system was used with two drippers for each plant providing eight liters of water per hour. In vitro plantlets were acclimatized in the conditions of a special greenhouse in order to produce and certify type F0 Plantlets. F0 plantlets will be propagated in Tal Amara field in order to produce plants of the following generations: F1, F2 and finally F3 plants that will be used for the production of strawberry fruits. The team continues to monitor the progress of the plants and will report final results in its next report.

Palestine

The benchmark sites of Tammun (Atuf) and Hebron (Adh dharuyya) in the West Bank serve as WLI's benchmark sites for WLI (Fig. 17). Research efforts in the area are pursued in close partnership with the National Agricultural Research Center (NARC), Hebron University (HU) and two non-governmental agricultural research organizations - Land Research Center (LRC) and the Applied Research Institute Jerusalem (ARIJ).

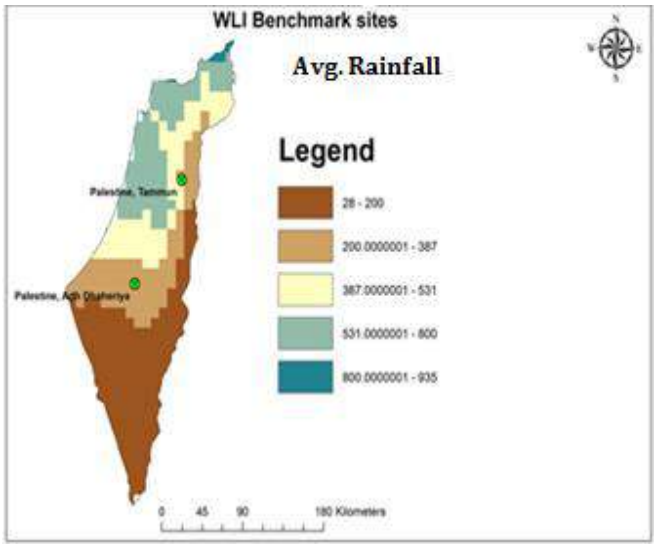


Fig. 17: WLI benchmark site in the West

In 2017, the team focused on out-scaling innovative agricultural practices that were either developed or refined through WLI's support, including – promotion and adoption of high yielding drought tolerant forage crops and selected water harvesting interventions, demonstration of best agro-practices for growing Medicinal and Aromatic Plants (MAP), RHEM modeling to assess the out-scalability of proven soil and water conservation measures, and empowering women and enhancing farmer's skill to adopt these practices. Below is a brief summary of activities conducted during the reporting period.

1. **Distribution and multiplication of high yielding and drought tolerant forage crops/species and their wild varieties**

The study focuses on assessing the potential impact of drought tolerant forage crops/species and their wild relatives on reducing grazing pressure on rangelands and feed cost; and their contribution to improving animal nutrition.

During the reporting period, the team conducted the following activities:

- 8000 m^2 planted with high yield locally adapted forage seeds pre-selected by NARC, ICARDA, and their partners in two areas: Arraba, and Beit Qad as shown in table one. The best multiply varieties and crops will be distributed to the key farmers.

- 44 m^2 was replanted with 11 native seeds/species (wild relatives forage seeds) in order to multiply and to demonstrate themat NARC's Beit Qad agricultural station. These seeds were collected from three Governorates: Jenin, Jericho, and Hebron. Table 1 shows the names of planted seeds, collection site and the area.

Progress of these drought tolerant and wild relatives of forage crops will be evaluated and multiplied and demonstrated in order to encourage their adoption by farmers and different stakeholders; and to introduce into the Palestinian forage production system.

- In 2016 25 lines (25 m^2) of new varieties of Lathyrus from ICARDA were planted in Beit Qad agricultural station. 8 new varieties (8 lines) were selected and replanted during the reporting period covering a total area of 40 m^2. Their growth under the Palestinian local conditions were monitored, and essential data such as flowing date, plant height, etc. was recorded (Tables 2-3).

Table 1: Types of planted drought tolerant forage crops, area, and location.

Crop	Common Name	Scientific Name	Area in m2		Total Area (m2)
			Atuf	Arraba	
Vetches	French Vetch (Improved)	Vicia narbonensis	1000	1000	2000
Vetches	Pitter Vetch (Improved)	Vicia ervilia	250	750	1000
Lathyrus	Lathyrus (Improved)	Lathyrus sativus	500	1000	1500
Barely	Reehane	Hordium vulgare	1000	-	1000
Wheat	Heitia beda	Triticum durum	-	250	250
Wheat	Kahatat	Triticum durum	-	250	250
Wheat	Ammar	Triticum durum	1000	1000	2000
Total Area (m2)					8000

Table 2: Types of planted wild relatives forage seeds, collection site, and area that replanted in Beit Qad demonstration site.

Crop	Common Name	Collection site	Area in m2
Vetches	Common Vetch (Wild)	Attara, Jenin	4
Vetches	Common Vetch (Wild)	Jadida, Jenin	4
Lathyrus	Lathyrus (Wild)	Attara, Jenin	4
Lathyrus	Lathyrus (Wild)	Sanur, Jenin	4
Lathyrus	Lathyrus (Wild)	Wadilqilt, Jericho	4
Lathyrus	Aseiba'a (Wild)	Jadida, Jenin	4
Peas	Peas (Wild)	Attara, Jenin	4
Peas	Peas (Wild)	Jadida, Jenin	4
Peas	Peas (Wild)	Banina'im, Hebron	4
Broad Bean	Broad Bean (Wild)	Banina'im, Hebron	4
Broad Bean	Broad Bean (Wild)	Jadida, Jenin	4

2. **Demonstrate best agro-practices for growing Medicinal and Aromatic Plants (MAP)**

This activity builds on efforts initiated last year including the mobilization of communities through campaigns to collect seeds of selected wild medicinal and aromatic plants, and exploring the best methods to domesticate them. In this regard, ten plant species including *Achillea fragrantissima (*قيصوم*), Artemisia sieberi* (herba Alba) (الشيح), *Arum palaestinum (*لوف*), Crocus hyemalis (*الزعفران*), Cyclamen persicum (*قرن الغزال*)Ephedra foeminea* (علد، ايفيدرا), *Gundelia tournefortii* (عكوب), *Malva Parviflora* (خبيزة), *Teucrium captitatium (polium)* (الجعدة), *Sisybrium irio (*الحويرة*) w*ere selected from Jenin, Tubas, and Bethlehem governorates.

The team continues to explore appropriate methods for domesticating these MAPs, and identify potential market linkages to support their adoption by the community. Towards this end, the following activities were conducted during the reporting period:

- Cleaning process for the selected seeds in ARIJ and in NARC.
- Planting of the collected seeds in Khallet Haddad, Beit Fajjar, Wadi Fukin in Bethlehem Governorate, and Wadi el Kuf nursery in Hebron Governorate, to optimize the best agro practices.
- Replanting the seedlings obtained from Wadi el Kuf nursery in home garden (expected time in September). To support this activity, a proposal will be submitted to FAO concerning domestication of medicinal and aromatic plants in home garden by Ms. Roubina Ghattas - ARIJ in cooperation with WLI partners. The proposal is in the evaluation stage now.

3. **Up-scaling results and experience on selected water harvesting techniques**

Up-scaling of selected water harvesting techniques in the southern benchmark were led by LRC, while similar efforts were led by ARIJ in close cooperation with NARC in the northern benchmark. Different suitable water harvesting techniques including contour-bench terraces, cisterns, semi-circular terraces, V- shape terraces; eye brow- left, and rock terrace were considered under this activity.

The activity was implemented on about 3.5 hectares at Adh Dhahiriya watershed site including Sumara/Alburje. The site also serves as a demonstration site where field farm schools will be organized to encourage farmers and different stakeholders to adopt these techniques.

4. **Modeling water harvesting**

This activity begun in FY 2016 as part of the Modeling Regional Thematic Group through which the team receiving training on RHEM – a Rangeland Hydrology and Erosion Model developed by Dr. Mark Weltz from USDA-ARS.

Runoff, erosion, and infiltration rates were monitored regularly from three experiment plots established in Atuf, Tubas, and in Jerico; and a rain-station that was purchased and installed at the Tubas site. Soil sample were taken in order to determine soil moisture and soil texture. Sedimentation was measured from the collected water runoff samples.

The team is also collaborating with WLI partners in Jordan in terms of experience sharing as they both have similar agro-ecosystems and face similar challenges. The team is supported by ICARDA's Dr. Stefan Strohmeier and Dr. Kossi Drs. Kossi Sayiro Nouwakpo rangeland hydrology and soil erosion specialist and a collaborator with Dr. Mark Weltz form USDA Great Basin Rangeland Research (GBRR) unit, Reno, Nevada. Dr. Kossi will be visiting both teams in July to assess progresses made and give directions on future steps.

5. Empowerment of women and creating market linkages

With increasing pressure on agricultural land due to increasing population size and geo-political conditions, livelihood improvement is more plausible through diversification and intensification as opposed to expansion. The team, in full recognition of this fact, strives to improve farmers' income by improving their efficiency in generating income. This year the team aims to promote technologies that will reduce costs of agricultural production thereby increasing farmers' profit margin.

Figure 18: Greenhouse in Jalamah

During the reporting period the team focused on reducing the cost of fertilizers by cutting back on rates of application and strategically selecting from a variety of fertilizers to be used. Fertilizers are not only essential inputs but also one of the most expensive ones, as all fertilizers used in Palestine are imported. Farmers often use compound fertilizers which are expensive, but less efficient requiring frequent and higher dosage which in turn negatively affect the soil. Through the support of WLI, NARC in collaboration with ARIJ and CARE is promoting an alternative fertilizer Mono Fertilizer (MF) through demonstrations in two greenhouses owned by women engaged in growing and marketing tomatoes in Jalamah and Deir Abu Da'if villages in Jenin District (Fig. 18). MF is less costly, has higher levels of purity and water-solubility, and is a more efficient source of N, P, and K for plants. The selected greenhouses were divided into two equal parts. MF was applied on one part and conventional fertilization was applied on the other to serve as control. The site will serve as a demonstration site for other farmers in the area and the final results will be packaged and shared with other relevant stakeholders.

Tunisia

Water availability in Tunisia is estimated at 390 m3 per capita, which is a lot lower than the average per capita consumption level in the MENA region (FAO, 2014). The figure is expected to decrease with projected Climate Change (CC), unsustainable water management practices, and the natural growth of population. WLI project in Tunisia aims to improve rural livelihoods through improved water management and agricultural production systems by pilot testing and out-scaling proven CC adaptation strategies and assessing the costs and benefits of improved interventions in three sites - along a north-south decreasing precipitation transect (Fig. 19).

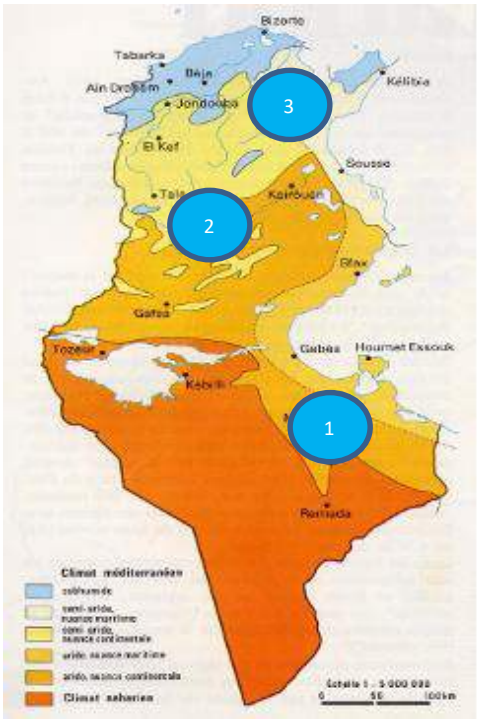


Fig. 19: WLI benchmark sites in

1. Oum Zessar Watershed in Medenine (#1)
2. Zoghmar Hadjeb-Jelma Watershed, Sidi Bouzid Governorate, and
3. Ben Khaled in Nabul Governorate (#3)

The project's objective is effectively aligned with national climate change adaptation strategies that, among other things, aim to improve water productivity and save water resources. Activities planned for the year focus on both on farm and watershed level strategies, including modeling on-farm water management systems using Aquacrop, assessment of the potential as well as effectiveness of improved practices in Southern Tunisia, application of regulated deficit irrigation, and promotion of supplemental irrigation to improve water use efficiency of barley in semi-arid areas of the country. Socio-economic related activities include assessment of livelihood vulnerabilities in selected communities, as well as assessment of the role of relevant institutions in the promotion and adoption of proven technologies.

Research activities are undertaken in close collaboration with Institut des Regions Arides (IRA), Institute National Agronomique de Tunisie (INAT), and Institut National de la Recherche Agronomique de Tunisie (INRAT).

Below is a brief summary of activities conducted during the reporting period.

1. Modeling on-farm soil and water management practices

1.1. Conservation Agriculture (CA)

The Agricultural Production Systems Simulator (APSIM) modelling framework was used to study the long term effects of large-scale adoption of different conservation agriculture (CA) packages for growing

cereal in the semi-arid regions of Tunisia. Simulation scenarios for CA packages were based on the crop growth model APSIM which was calibrated and validated using several climatic and bio-physical data collected from experimental trials that were conducted during three years in three semi-arid regions of Tunisia. The current CA package practiced by most farmers in Tunisia was used as a starting point for the design of the Business As Usual (BAU) scenario. Optimistic scenarios were also considered to account for potential CA practices recommended by the different agronomic studies conducted in Tunisia as well as in North Africa.

Three scenarios were simulated: i) farm practice without CA (conventional system); ii) no tillage (NT) scenario where NT will be considered as the only conservation practice undertaken by farmers; and iii) a more optimistic scenario considering NT + enhanced residue (RES) management (1500 Kg/ha of residue as mulch). All simulations were conducted under climate change scenarios in order to be able to identify comparative possible mitigations of CA alternatives. Results confirm the existing literature about the potential impact of conservation agriculture in semi-arid areas and clearly revealed that the average yield of wheat and barley are respectively higher under NT and NT+RES compared to the average yields obtained under CT scenario, since early years of adoption. Also, results showed the mitigation of climate change effects on wheat and barley yields in Tunisia is possible through the adoption of CA practices in semi-arid areas. Particularly, the combination of no tillage and permanent soil cover with residue (two principals of CA) was shown to be very effective in enhancing yields.

1.2. Water harvesting modelling for ecosystem services assessment

Water harvesting practices, especially when implemented at the watershed level, have been proven as effective ways to conserve and make efficient use of scarce ecosystem services. During the reporting period the team built a modelling framework to assess the large-scale effect of their adoption, collected various related data, and are in the process of parametrizing the model.

1.3. On-farm water management using Aquacrop model in Southern Tunisia

A new version of Aquacrop that includes a salinity component was calibrated and validated for potatoes irrigated with four treatments (100%, 80%, 60% and 40% of the water requirement). The The model was suitable for the simulation of the potato yield in the climatic conditions of the study area. An acceptable goodness of fit was found between observed and simulated values. Both the model and the observed data found that 100% (FI) and 80% (DI80) of the water requirements were most efficient in the use of water for potato under saline conditions and are recommended to be used as adaptation option for the changed climate.

2. Assessment of the potential and effectiveness of improved practices in southern Tunisia

2.1. Irrigation scheduling and deficit irrigation

The potential and effectiveness of improved practices in water management in small scale irrigation schemes were assessed in selected sites. The study specifically looked at irrigation scheduling and deficit irrigation for vegetables (potato, fava beans, carrot and pepper). To this end, 10 farmers were selected in

Medenine governorate to demonstrate to local farmers the benefits of adopting water saving techniques and technology packages (deficit irrigation and irrigation scheduling), including conserving water resources and improving land productivity.

Field trials on drip irrigation management with saline waters (ECi ~ 1.5 to 5.7 dS/m) were also demonstrated and assessed in selected farms on potato, fava beans, carrot, and pepper crops. The study focused on irrigation management based on irrigation sheets developed and made available to farmers. Results of plots where the sheets were applied were compared to those obtained under farmer's practices. Data has been collected for the experiments conducted on potato, fava beans and carrot and the analysis of the data is in progress.

2.2. Application of regulated deficit irrigation

Water availability during the irrigation season is often characterized as unreliable with large fluctuations due to unplanned water cuts. This poses a serious threat to many crop production systems, and creates challenges for managing trade-offs among different stakeholders including the Ministry of Agriculture, Water User Associations (WUA), and farmers.

Previous WLI supported research results show that application of Regulated Deficit Irrigation (RDI) is appropriate for effective management of water scarcity. The approach consists of supplying the water requirement when the crop is less tolerant to water stress and a reduced percentage for the rest of the season. Obtained relationships between crop yield and water supply, provide valuable management tools for the different stakeholders. Planning restrictions of irrigation water are needed in order to avoid random water cuts.

To date several strategies for saving water and protecting the environment from soil salinisation and aquifer contamination have been implemented; including substantial government subsidies (up to 60% of the total cost of irrigation systems) extended to farmers who adopt drip irrigation. However, despite the modernization efforts, on-farm irrigation water applications still require improvement. This issue is addressed through the implementation of irrigation water balance-based scheduling techniques. Data on rainfall and production of olive and orange trees was collected in order to evaluate water productivity under rain-fed and irrigated conditions. The impact of deficit irrigation on yields are under investigation using collected data. Analysis of the data will be used to estimate yield loss in relation to water supply.

2.3. Supplemental irrigation as potential technology for improving water use efficiency of barley in the semi-arid regions of Tunisia

The scarcity of water and the uneven distribution of precipitation across time and space in the semi-arid regions of Tunisia are a very serious problem especially in recent years due to climate change. Therefore, controlled irrigation are vital for increasing crop yields and decreasing water use, among which, deficit irrigation/supplemental irrigation are the best technologies that are used to reduce water consumption, increase water use efficiency (WUE), and subsequent use of that water for more efficient barley production.

To this end, 5 farmers were selected to implement demonstration trials to disseminate the results to local farmers. Data collection is in progress.

3. Livelihood Vulnerability assessment

Livelihood Vulnerability assessment was carried out in the watershed of Oum Zessar using the IPCC vulnerability index approach (Aribi, 2016). A socio economic data collection has been launched to carry out the evaluation of ecosystem services in the watershed of Zeuss Koutine.

4. Assessment of the role of extension institutions in technology dissemination

In the Northern Site (Nabeul), a structural framework of adaptation to irrigation water management techniques and the role of institutions in the dissemination of information were conducted. Results of the study will be reported at the end of the year.

Yemen

WLI's activities in Yemen focus on challenges related to groundwater depletion resulting from over-extraction of water for cash cropping; inequitable water distribution of flood water, and associated technical constraints including continued deterioration of irrigation infrastructure by flood waters.

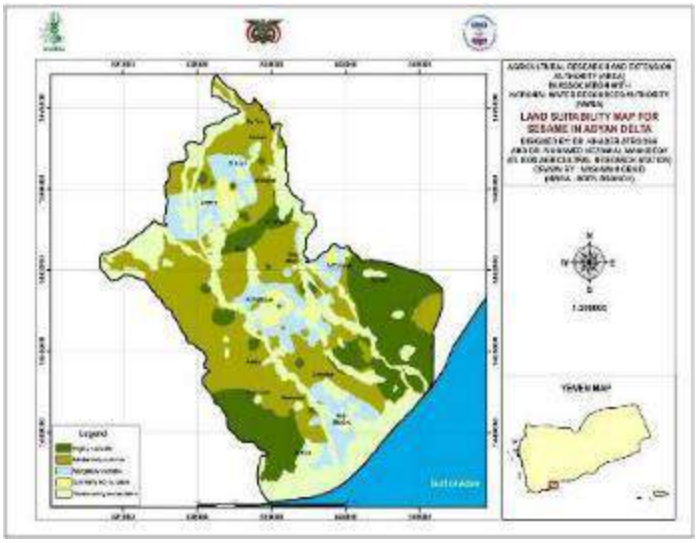


Fig. 20: WLI benchmark site in Yemen

WLI's research activities in Yemen focus in the Abyan Delta and are conducted in close collaboration with the Agriculture Research and Extension Authority (AREA) with Elkod Agricultural Research Station and the National Water Resources Authority (NWRA) – Branch of Aden serving as the main research partners on the ground (Fig. 20). Research efforts in the area continue to be stifled by security concerns but the team has proven persistent –working towards improved livelihoods in spite of the challenges. Activities planned for the year largely focus on technology dissemination efforts including dissemination of improved packages, and studies on dissemination strategies and adoption levels. Below is a brief summary of activities conducted during the reporting period.

1. **Maintenance and propagation of selected breed of sesame seeds**

An experiment for the maintenance and propagation of breed sesame Kod 94 was carried out at the field of the farmer Abdullah Al-Kor in Delta Lahj during the first agricultural season of 2017 to preserve its purity and to propagate its seeds (Figures 23 & 24). Phosphate fertilizer were applied at a rate of 150kg/ha after soil preparation was complete. Planting began on 15 March 2017 under the wells irrigation system. Nitrogen fertilizer was added at the rate of 120kg/ha urea divided into two equal additions, the first at the time of planting and the second at the stage when 50% of the field bloomed. Field inspection was carried out during the first stage of crop growth to remove abnormal and exotic plants. Additional periodic follow up were carried out to collect relevant data.

Fig. 23: Planting of sesame

Fig. 24: Flowering stage of sesame

1. **Dissemination of Clitoria forage**

Clitoria is known as a drought tolerant plant that can grow both under rainfed and irrigated systems. It has good nutritional value, high dry matter yield to meet the growing fodder demand in the area, and high water use efficiency. In FY 2016, the team identified four pioneer farmers who are willing to plant Clitoria and allow the research team to monitor the progress through data collection (Figures: 25-26). Data on groundwater discharge, date of irrigation, watering time and application during the planting, germination, replanting, weeding and flowering stages of the crop were collected.

Fig.25: **Planting of Clitoria**

Fig. 26: **Clitoria at flowering stage**

During the reporting period the team duplicated the experiment on another set of four farmers. The fields were planted and irrigated towards the end of the quarter and data on different agricultural operations and irrigation were also collected (Tables 3-6).

Table 3: Agricultural operations and data collection

Farmer	*Planting*	*Germination*	*Replanting*	*Weeding*	*Flowering*
Abdulbased Haddar Alsaqaf	*16/03/2017*	*26/3/2017*		*8/04/2017*	
Nasser Ahmed Alyafai	*07/03/2017*	*17/3/2017*	*19/3/2017*		*18/04/2017*
Saleh Ahmaed S. Alaulaqi	*07/03/2017*	*17/3/2017*	*20/3/2017*	*19/3/2017*	*18/4/2017*
Murshed Ibraheem	*06/03/2017*	*14/3/2017*			*21/3/2017*

Table 4: Application of Irrigation water for clitoria at Abdulbased Alhaddar Alsaqaf farm

Number of irrigation	*Date of irrigation*	*Average Plot Area, m2*	*Well Discharge, L/S*	*Watering Time, min*	*Water Application, mm*
1	*16/3/2017*	*48*	*10*	*4*	*75*
2	*27/3/2017*	*48*	*10*	*4*	*50*
Total					***125***

Table 5: Application of Irrigation water for clitoria at Nasser Ahmed Alyafai farm

Number of irrigation	*Date of irrigation*	*Average Plot Area, m2*	*Well Discharge, L/S*	*Watering Time, min*	*Water Application, mm*
1	*7/3/2017*	*30*	*7*	*4*	*56*
2	*30/3/2017*	*30*	*7*	*4*	*56*
Total					***112***

Table 6: Application of Irrigation water for clitoria at Saleh Ahmaed S. Alaulaqi farm

Number of irrigation	*Date of irrigation*	*Average Plot Area, m2*	*Well Discharge, L/S*	*Watering Time, min*	*Water Application, mm*
1	*7/3/2017*	*25*	*8*	*4*	*77*
2	*29/3/2017*	*25*	*8*	*4*	*77*
Total					***154***

The team will continue to monitor the progress throughout the remainder of the year to ensure proper adoption of the whole package, which will serve as a "showcase" for neighboring farmers and assist in the diffusion process of the forage.

2. **Assessment the current situation of the agricultural extension in Abyan Delta and its role to rationalize use of water**

The Abyan Delta is one of the most important agricultural areas in the southern coastal governorates, which depend on the availability of water resources for irrigation purpose, whether in form of spate water or groundwater. Therefore, adoption of proven water conservation technologies that reduce water loss without reducing yield is very critical. The Agricultural Extension Department in Abyan Delta is the main official body responsible for disseminating agricultural technologies. The research thus focuses on understanding the current role of the institution by surveying farmers and interviewing key personnel from the Institution. Data collection is currently underway, and results of the analysis will be presented at the end of the FY.

III. Capacity Building

Efforts to enhance knowledge, skills and qualifications of key stakeholders were undertaken during the reporting period. These, either took the form of technical trainings or field days organized to introduce new technologies and/or agricultural practices to local communities. Below is a summary of the various capacity building efforts carried out during the reporting period.

1. Non-degree trainings

The following non-degree trainings were provided during the reporting period.

- Improving water productivity by use subsurface drip irrigation: 2/5/2017. The training was offered to 12 (male) extension agents in Abu-Ghraib and focused on soil management and the use brackish water.
- Valuation of Ecosystem Services: March 6-9, 2017, Amman, Jordan. The training was provided by Drs. Gregory Kiker and Monji Sghaier

2. Degree training

These are done in collaboration with national universities and relevant researchers from ICARDA who supervise the student research. In Palestine, the following institutions and supervisors were selected.

- Center for Chemical and Biological Analysis - Al-Quds University; supervisor: Dr. Mohannad Qurie.
- Water and Environment Studies Institute - An Najah National University; supervisor: Prof. Marwan Haddad.
- Faculty of Agriculture in An-Najah National University; supervisor: of Dr. Heba Al-Fares.

The following dissertation studies supported by the Initiative were also completed during the reporting period.

- Aribi F. 2016. Evaluation de la vulnérabilité des moyens d'existence (livelihood) des ménages ruraux en zones arides tunisiennes. MSc thesis, INAT/IRA, 115 pp.
- Temani N. 2017. Impact of climate change on the potentials of arboricultural systems in Tunisia: case study of citrus. PhD thesis, INAT, Tunis.

IV. Upcoming Events

The following upcoming events are scheduled to take place in the remainder of the fiscal year.

- Trip to Palestine by Dr. Stefan Strohmeier to assist WLI team with RHEM modeling, May 2-4, 2017.
- The 11th Sharing Knowledge Foundation (SKF) Conference, May 13-16, 2017, Jordan
- CONSOWA Conference Spain to present WLI work in Jordan June 12-16, 2017
- RHEM Modeling, July 16-20
- Valuation of Ecosystem Services, August 6-11
- Project Development and Proposal Writing, September 2017
- Adopting best agro-practices for vegetables production and management, West Bank, Palestinian. The training targets key staff working in WLI partner institutions, extension agents at MoA and directorate levels, faculties of agriculture, and private sector. Actual date to be determined.

V. Conclusion

The WLI team has indeed implemented a variety of activities over the past six months despite security concerns in some of the partnering countries – especially Yemen and Iraq. Collaboration with international institutions and ICARDA scientists has also proven useful in building national capacity and stretching the research frontier. Increased regional collaborative research is expected to enrich the partnership amongst partnering countries and institutions, enhance their ability to learn from each other's experiences, and produce regional research outputs as international public goods.

Other strengths demonstrated over the period include – increased efforts to mobilize funds, out-scale proven technologies, and foster partnerships with donors, as well as research and development organizations. The team has also actively engaged in published research results and sharing them in various conferences. These efforts will continue over the coming six months to ensure effective implementation of planned activities for the year.

Appendix 1: Publications Completed, Under Development and Under Preparation

Authors	Title	Status
Abdeladhim M.A. et al.	An Integrated Cost–Benefit and Livelihood Approach for Assessing the Impact of Water Harvesting Techniques (WHTs) on Livelihoods: A Case Study in the Oum Zessar Watershed, South-East Tunisia	In: Ouessar et al. 2017 (eds). Water and Land Security in Drylands: Response to Climate Change. Springer, 348 pp. DOI:10.1007/978-3-319-54021-4, pp: 303-316.
Abdeladhim M.A. et al.	Assessing the Impacts of Climate Change on Sustainable Development at the Regional Level: A Case Study in Medenine, South-East Tunisia	In: Ouessar et al. 2017 (eds). Water and Land Security in Drylands: Response to Climate Change. Springer, 348 pp. DOI:10.1007/978-3-319-54021-4, pp: 317-332.
Annabi, M., et al. 2016	Elaboration d'une carte du statut organique des sols du Nord de la Tunisie: Un outil intéressant pour la prise de décision.	Annales de l'INRAT. Volume spécial Innovations. Volume 89: 55-57.
Cheikh M'hamed, H., et al. 2016	L'agriculture de conservation est un système de production permettant d'améliorer l'efficience de l'utilisation de l'eau et de la fertilité du sol.	Annales de l'INRAT. Volume spécial Innovations. Volume 89: 68-71.
El Mokh et al.	Calibration of salinity stress parameters of AquaCrop for barley under different irrigation regimes in a dry environment	In: Ouessar et al. 2017 (eds). Water and Land Security in Drylands: Response to Climate Change. Springer, 348 pp. DOI:10.1007/978-3-319-54021-4, pp: 45-55

Hachani A. et al.	A Study of Water Stress on Olive Growing Under the Effect of Climate Change in South East of Tunisia.	In: Ouessar et al. 2017 (eds). Water and Land Security in Drylands: Response to Climate Change. Springer, 348 pp. DOI:10.1007/978-3-319-54021-4, pp: 1-16.
Lasram et al.	Effect of high temperature stress on wheat and barley production in Northern Tunisia	In: Ouessar et al. 2017 (eds). Water and Land Security in Drylands: Response to Climate Change. Springer, 348 pp. DOI:10.1007/978-3-319-54021-4, pp: 27-34.
Nagaz et al.	Potatoes response to irrigation regimes using saline water	Irrigation and Drainage Journal (2016). 65: 654-663.
Nagaz et al.	Response of vegetable crops to irrigation regimes using saline waters	In: Ouessar et al. 2017 (eds). Water and Land Security in Drylands: Response to Climate Change. Springer, 348 pp. DOI:10.1007/978-3-319-54021-4, pp: 129-139.
Nagaz et al.	Impact of deficit irrigation on yield and fruit quality in orange (citrus sinensis l. osbeck cv. meski maltaise) in southern Tunisia.	Accepted for publication in ICID2015 special issue Irrigation and Drainage Journal

Abdulla. A. Mohamed Muflahi and Ahmed Saleh Basuaid. 2017. Effect of nitrogen fertilizer and its application efficiency on two local sorghum cultivars Sorghum bicolor L. Moench. *Journal of Agricultural Science, Vol. 9, No. 4*; Published by Canadian Center of Science and Education. (http://www.ccsenet.org/journal/index.php/jas/article/view/65636)

Samia Akroush1, Boubaker Dehehibi2, Bezaiet Dessalegn3, Omamah Al-Hadidi1&MalekAbo-Roman. 2017. Factors Affecting the Adoption of Water Harvesting Techniques : A Case Study of Jordanian Arid Area. *Sustainable Agriculture Research; Vol. 6, No. 1;*