Water Benchmarks of CWANA

Community-Based Optimization of the Management of Scarce Water Resources in Agriculture in CWANA

Second Phase
1st Annual Progress Report
2010-2011

Project Manager: Theib Oweis
Project Coordinator: Mohammed Karrou
Badia Benchmark Coordinator: Yasser Mohawesh
Irrigated Benchmark Coordinator: Hamdy Khalifa
Rainfed Benchmark Coordinator: Bahri Abdeljabar

ICARDA International Center for Agricultural Research in the Dry Areas

Community-Based Optimization of the Management of Scarce Water Resources in Agriculture in West Asia and North Africa

Water benchmarks

Phase-II

Annual reports and work plans

November 2011

Contents

EXECUTIVE SUMMARY

West Asia and North Africa (WANA) region is characterized by low and high fluctuation of the precipitation and scarce water resources. Moreover, climatic models predict for this zone even lower rainfall with a 20% reduction in the absolute amounts and an increase of temperature by 2 ^{o}C in the next 15 years and 4 ^{o}C by the end of the century. All this will have more negative impacts on natural resources (water and land) and agricultural production.

Taking into consideration the constraints described above, the long-term development goal of the project is the improvement of rural livelihoods in the dry areas of WANA by enhancing the productivity of agriculture based on the efficient and sustainable management of the scarce water resources from rainfall, groundwater and surface sources. The immediate purpose of the project is to develop and test, with the full participation of rural communities, water management options that will increase water productivity, optimize water use and that are economically viable, socially acceptable and environmentally sound in the main agro-systems prevailing in the region, Irrigated, Rainfed and Badia (Steppe).

The project has been conducted in the Irrigated Benchmark (Old, Marginal and New lands in Egypt) and Satellite (Sudan and Iraq) sites, the Rainfed benchmark (Tadla region in Morocco) and satellite (Tunisia and Algeria) sites and the Badia Benchmak (Al Majdyya and Al Maharib in Jordan) and Satellites (Syria and Libya) sites.

Among the techniques/technologies tested and developed with farmers during the first phase of the project are raised bed and deficit irrigation in the irrigated benchmark sites, early planting, supplemental irrigation and other crop management techniques (nitrogen and varieties) in the rainfed benchmark site and on-farm water harvesting systems in the Badia benchmark sites.

During the second phase of the project, the activities are divided into 3 components: 1) Fine-tuning, out-scaling and dissemination of the outputs of the first phase, 1) Modeling watershed management (in Jordan), water allocation at canal and basin levels (in Morocco) and Water and nutrients flows at the tertiary canal level (in Egypt) and 3) economics, institutional and policies of water use.

The 2010-11 preliminary data in Egypt showed that, although the raised bed system saves water and improves water productivity, both the parameters of the system (length and depth of the furrow, width of the bed) and the components of the conventional agronomic package, including mechanization, need to be adjusted and adapted to this new technology. In fact, a raised bed machine was introduced to Egypt and modified to meet the local soil conditions. Trials showed that furrow length of 50 m, bed width of 130 cm and application of 100% crop nitrogen requirements increased water productivity of wheat and sugar beet in Old lands.

In New lands, it was shown that it is possible to adopt deficit irrigation and apply 25% less fertilizers without wheat yield reduction.

In the salt-affected areas (Marginal lands), the application of bio-fertilizers and organic matter with gypsum can help reduce the effect of salinity.

The raised bed was also tested in irrigated satellite sites of Sudan on wheat at the farm level and of Iraq on wheat and sorghum. It was confirmed that the technology increases yield and saves water. The economic evaluation conducted in Sudan has shown that the farmers' return of wheat under the raised bed is significantly higher than under the flat method practiced in the Gezira region.

In the benchmark site of Morocco, studies of the response of wheat, maize and pepper to different levels of supplemental irrigation were conducted and the information will help evaluate the trade-off between yield and water productivity and also serve the water allocation modeling purpose. Positive response to the increase of water level was observed; however, preliminary data available are not enough to quantify yet the trade-off mentioned before.

In the rainfed satellite site of Tunisia, experiments and secondary bio-physical data were collected to calibrate and validate the Aquacrop model that will be used to develop scenarios of growth and management of wheat and faba bean under different agro-climatic condtions.

In the case of the rainfed satellite site of Algeria, an experiment was conducted on the response of durum wheat to different supplemental irrigation levels and nitrogen rates; but, because the season was very rainy, only the response to nitrogen was observed.

In the case of the badia benchmark sites data of on-farm demonstration trials showed that improved barley crop management produced an economic grain yield in Marabs; while farmers fields outside marabs failed. The existing check dams and cisterns in the benchmark sites were evaluated and plans of their rehabilitation and management have been developed. Moreover, livestock stocking rate in shrubs fields (atriplex and salsola) under different contour ridges systems was studies. The health and pregnancy status of the livestock was checked and improvement actions were implemented (vaccination, synchronization for estrus, treatments…).

For the satellite site of Syria, the effects of different combinations of contour ridges (manual, intermittent, continuous) and spaces between ridges on soil moisture, shrubs seedlings survival and grazing capacity were evaluated. Preliminary data are presented in the report; but, more investigation is needed before drawing solid conclusions.

In Morocco, Egypt and Jordan, the teams conducted demonstration trials on the technologies developed during the first phase and field visits (days) to these trials were organized for framers.

Concerning the modeling activities, all the partners reviewed the existing models and identified the appropriate ones. In Egypt, after the sensitivity analyses of many models, the SPAW and Cropsyst were selected. Cropsyst was calibrated using the experiments data and a high relationship between the observed and predicted yields and water use was observed. Also, sensitivity to nitrogen application was noticed. In Jordan, SWAT model was selected for watershed management. Runoff and sediments accumulation under different methods of land management (with and without contour ridges, with and without shrubs) were monitored and measured and data will be used, in modeling. In the case of Morocco, equations of an economic model were developed and detailed surveys were conducted to collect data required by the model. The results of the experiments will be also used for this purpose.

In the case of the socio-economics, institutions and policy work, all the partners conducted surveys to characterize the sites and identify the constraints. In Morocco, different tools have been used to analyze the economic values and the impacts of specific policies on the adoption of water management technologies. Among these models are the econometric model and the household production and consumption model structure. For the institutional aspect, Rainbow diagram, Problem tree and Stakeholder Profile tools were used to evaluate the role water users association in improving efficient water management practices and adoption of supplemental irrigation and associated technologies. Also, a model to see if payment of ecosystem services can secure irrigation water in Tadla region (case of drip irrigation) is under test. Promising preliminary results are presented in the report.

BACKGROUND

Water scarcity in West Asia and North Africa (WANA) is a well-known and alarming problem. Today the issue is of increasing concern to national governments and research institutions. Increasing water scarcity is threatening the economic development and the stability of many parts of the Arab world. With rapidly growing demand it seems certain that water will increasingly be reallocated from agriculture to other sectors. Moreover, opportunities for the significant capture of new water are limited. While gains in efficiency are potentially available from improved distribution and use of water in fully irrigated agriculture, a great proportion of the region's agricultural livelihoods is based on dry land farming systems where production is dependent on low and extremely variable rainfall.

To ensure food security and better livelihoods of the poor in these areas, more food must be produced with less water; this is increasing agricultural water productivity. Improved water management technologies have been developed and tested with full participation of farmers during the first phase of the project, but the adoption at large scale is limited because the process requires time and more appropriate policies have to be identified and adopted.

The first phase of the project "Options for Coping with Increased Water Scarcity in Agriculture in West Asia and North Africa" alt. title: “Community-Based Optimization of the Management of Scarce Water Resources in Agriculture in West Asia and North Africa” began in 2004 with the aim to find ways to increase the adoption of improved technologies, and thus improve water productivity and livelihoods, in environments where water is scarce. The project targeted three environments: marginal rangelands (steppe), rainfed cropping systems, and irrigated areas. In each environment, a pilot research site was established and new technologies were tested and demonstrated to communities in the Benchmark sites. Two or more ‘satellite’ sites were characterized for complementarities and wider dissemination.

The project is addressing a variety of natural resource conservation and sustainable utilization which centered on water scarcity. Such approaches is of a long term nature which requires more time to fully utilize its outputs, maximize its benefits and realize the anticipated impacts. Especially important in this regards are the challenges that are faced when working with farmers and herders communities and when enabling policies need to be introduced and adopted by the countries. The extended time is needed to disseminate and transfer the technologies developed and or adapted during the first phase to farmers and other stakeholders in the participating countries. In addition some further testing and validation of potential technologies, policies and institutional setups is required. The project should also enhance the national and regional networks on water management, in particular establishing functional linkages with relevant national development projects. The project is developing a scaling-up plan to go beyond the benchmarks for wider dissemination of the outputs. A new phase will be needed to realize the results of this plan. During this new phase an ex-post adoption and impact assessment of the project outputs would be conducted. The analysis of the policy and institutional setups will need to be enhanced and discussed further with all stakeholders for possible implementation. It is expected that NARS adopt and institutionalize the benchmarks as permanent integrated field labs and continue to support them from own resources to serve national and regional development. A second phase will enable the benchmarks to better establish and will give NARS the opportunity to further institutionalize them. The interactions between local communities and other stakeholders with the project reflect the potential contribution of the project to improved water management and better livelihoods of the rural communities.

GOAL AND PURPOSE

The long-term development goal of the project is the improvement of rural livelihoods in the dry areas of WANA by enhancing the productivity of agriculture based on the efficient and sustainable management of the scarce water resources from rainfall, groundwater and surface sources.

The immediate purpose of the project is to develop and test, with the full participation of rural communities, water management options that will increase water productivity, optimize water use and that are economically viable, socially acceptable and environmentally sound.

SPECIFIC OBJECTIVES

Objective 1: Scaling-out phase I outputs

To develop and implement methods for the efficient scaling-out of the technological options and knowledge developed during the project.

Objective 2: Development and dissemination of integrated sustainable water management options

- To develop integrated technical, policy and institutional options (TIPOs) for sustainable water management to facilitate the rural communities' role in conserving water and improving their livelihood.

Objective 3: Monitoring of technology transfer, adoption and impact

- To evaluate the consequences of implementing 1st phase's results at various benchmarks environments and determine the effectiveness of the project in realizing its goals of productive and sustainable water use, technology generation, transfer, and income and welfare improvements.

Objective 4: Policies and institutions

- To develop a policy and institutional framework for the implementation of appropriate water saving strategies that will conserve scarce water resources and promote the conservation of natural resources.

Objective 5: Capacity Building

- To enhance the capacity of NARS and other stakeholders for conducting adaptive and participatory research, for scaling-up and scaling-out the outputs and for monitoring and evaluation of the project including technical, policy and socio-economical aspects.

IRRIGATED BENCHMARK AND SATELITE SITES

A. IRRIGATED BENCHARK SITE OF EGYPT

I. PROGRESS

Introduction

Fully irrigated areas in WANA are associated with the permanent availability of water resources. These areas provide most of the food because irrigation permits more intensive agriculture. Recently, the demands of expanding populations have increased the pressure to increase production from these systems, threatening their sustainability. Lower quality water is being widely used without proper management causing salinity and deterioration of the environment. The irrigated areas will continue to be vital for food security in the region. To meet increasing demands for food, many countries of the region, such as Egypt and Syria, are expanding their irrigated areas. However, with decreasing water resources for agriculture the only water that can be made available for new lands is the water that can be saved. Saving water in irrigated areas is a top priority almost everywhere in the world, but is of particular importance in the dry areas where water scarcity is extreme and increasing.

The Nile valley is a typical and may be the largest irrigated area in the region. Egypt is expanding irrigated areas while water resources are not increasing. Sustainability is being threatened by excessive pressure and changing land use. Low quality water is being used and sustainability is being threatened.

A benchmark site in Egypt was chosen that is representative of irrigated areas in the region with research results transferable to other irrigated areas of WANA. The project 1st phase focused on improving irrigation methods and management to improve water productivity and developing packages to sustainably improve farmers' income. Benchmark site was established in Egypt with satellite sites in Iraq and Sudan.

During the 1st phase, the project achieved several short and medium term objectives. However, more times as well as skilled human and financial resources are needed to fine tune the new developed technologies and calibrate/validate decision making tools and models. Moreover, a second phase is needed to upscale the findings at institutional level and out-scale the results to other similar locations and countries. To show the impacts at larger level (country, region), the project needs to be linked to the countries development projects.

Component I: Interventions fine tuning, out scaling and dissemination

<u>Part 1: Fine tuning of the interventions</u>

Part 1.1. Old land

Field experiments were conducted during the 2010-2011 winter season in the old land site at Zankalon Water Research Station, Water Management Research Institute (NWRC) in the East Nile Delta region. The site is located at 30^o 35' N. latitude and 31^o 30' E. longitude with an elevation of 9 m above mean sea level. The experimental plots soil is mostly heavy clay.

Activity 1: Nitrogen management under mechanized raised bed technology of winter (wheat and sugar beet) crops in old land.

1. Objectives:

- To determine the optimal furrow spacing and length.
- To evaluate the effect of furrow spacing (raised bed width) and furrow length on water/nutrients dynamics and water productivity**.**
- To determine optimal rates of nitrogen application under different raised bed width.

2. Methodology:

2.1 Field management:

Wheat crop		**Sugar beet crop**	
Date	**Practice**	**Date**	**Practice**
11-13/10/10	Soil plowing	9-24/10/10	Soil plowing
16/10/10	Laser leveling	16/10/10	Laser leveling
13/11/10	P application (200 kg P_2O_5 15%/fed) K application (50 kg K_2O 48%/fed)	17/10/10	P application (200 kg P_2O_5 15%/fed) K application (50 kg K_2O 48%/fed)
13/11/10	Establishment of furrows and raised beds	19/10/10	Establishment of furrows and raised beds
14/11/10	Wheat sowing (45 kg/fed)	04/11/10	Sugar beet sowing
14/11/10	Sowing Irrigation (1st Irrigation)	04/11/10	Sowing Irrigation (1st Irrigation)
18/12/10	Weed control (chemical pesticide)	21/11/10	2nd Irrigation
21-28/12/10	Weed control (hand weeding)	12/12/10	Hoeing
12/01/11	Fertilizer application (Urea – 1st dose)	25/12/10	Plant thinning
13/01/11	2nd Irrigation	26/12/10	Fertilizer application (Urea– 1st dose)
21/02/11	Fertilizer application (Urea – 2nd dose)	26/12/10	3rd Irrigation
21/02/11	3rd Irrigation	22/01/11	Hoeing
21/03/11	4th Irrigation	31/01/11	Fertilizer application (Urea – 2nd dose)

28/04/11	Soil and Plant samples	31/01/11	4th Irrigation
03/05/11	Harvesting	16/02/11	Hoeing
		07/03/11	5th Irrigation
		20/03/11	Weed control (hand weeding)
		07/04/11	6th Irrigation
		28/04/11	7th Irrigation
		16/05/11	Soil and Plant samples
			Harvesting

2.2. Treatments and experimental design

2.2.1. Treatments

- Raised Bed Width: BW1 = 70 cm and BW2 = 130 cm
- Furrow Length: FL1 (short) = 25 m and FL2 (long) = 50 m
- Nitrogen rates: N1 = 100%, N2 = 85%, and 70% of the recommended rate.

2.2.2. Experimental design

The experimental design is a split-split plot with 3 replications. Raised bed width, length, and nitrogen levels are the main, sub- and sub- sub-plots, respectively.

3. Results/Achievements

3.1. Soils, water and agro-climatic data

3.1.1. Soil and irrigation water samples analysis

The soil texture at the experimental site is clay, the pH value is about 8.0, the average total soluble salts value is 1.23 dS/m and the average water holding capacity is 19.64% (Table 1). The irrigation water analysis and composition are presented in table 2.

Table 1: Main soil physical and hydro-physical characteristics at the experimental site

Depth (cm)	Particle size analysis				FC (%)	WP (%)	AW (%)	Bulk density (g/cm^3)	EC (dS/m)	pH
	Sand	Silt	Clay	Texture						
0 – 20	25.80	28.90	43.51	Clay	43.51	23.55	19.96	1.25	1.40	8.10
20 – 40	25.12	30.10	42.50	Clay	40.50	21.06	19.44	1.27	1.22	8.00
40 – 60	26.90	31.50	40.50	Clay	37.12	17.59	19.53	1.35	1.25	8.01
60 – 80	29.78hyu	31.50	37.12	Clay	36.25	16.62	19.63	1.40	1.05	8.02
Mean	26.90	30.50	40.91	Clay	39.35	19.71	19.64	1.32	1.23	8.03

Table 2: Chemical analysis of irrigation water

Sample	EC	Cations (meq/l)				Anions (meq/l)			
	(dS/m)	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}
1	0.41	1.60	1.71	1.35	0.25	-	3.40	0.73	0.78
2	0.39	1.58	1.69	1.39	0.27	-	3.48	0.70	0.75
3	0.37	1.71	1.76	1.37	0.32	-	3.50	0.76	0.90
Mean	0.39	1.63	1.72	1.37	0.28	-	3.46	0.73	0.81

3.1.2. Agricultural meteorological data

Table 3 shows that the total rainfall was 26.40 mm. Reference evapotranspiration varied in average from 3.41 mm per day in November to 7.37 mm per day in May with around 4-5 mm per day in March and April. Maximum air temperature increased 13.64 ^{o}C in January to around 20 ^{o}C in April and May.

Table 3: Average monthly climatic values at the experimental site

Date	Air temperature (^{o}C)			RH	ET	Total Rain
	Tmin	Tmax	Tmean	(%)	(mm/d)	(mm/mon.)
NOV. 2010	12.16	19.43	21.20	61.36	3.41	-
DEC. 2010	9.35	23.25	16.40	62.48	2.13	0.50
JAN. 2011	6.38	20.38	13.64	62.45	2.65	1.30
FEB. 2011	7.61	21.64	14.63	59.25	2.98	-
MAR. 2011	7.32	22.93	15.12	55.87	3.76	15.00
APR. 2011	10.68	27.56	19.03	54.80	4.91	9.60
MAY 2011	13.8	31.77	22.48	50.74	7.37	-

3.2. Wheat Crop

3.2.1. Yield and yield components

Results indicated that the combined effect of furrow length, width and nitrogen level on wheat grain yield was significant. The combination of furrow length of 50 m, raised bed width of 130 cm and the application of 100% of nitrogen requirements can be recommended for optimum wheat production in the Old Land site (Table 4).

Table 4: Effect of furrow length and width and nitrogen level on grain and straw yields and yield components of wheat crop in (2010/2011)

Treatments		Plant height (cm)	Number of tillers/plt.	Spike length (cm)	Number of grains/spike	Grains weight/spike	1000-grains weight (gm)	Number of spikes/m^2	Grain yield (t/ha)	Straw yield (t/ha)
Length (m)	L_1 - 25m	107.1	3.87	13.28	53.42	2.65	47.09	444.06	8.159	11.721
	L_2 - 50m	109.8	4.03	13.49	54.47	2.73	49.51	486.22	8.643	12.103
	F- test	**	*	**	*	*	**	**	*	**
Width	W_1 - 65cm	106.8	3.84	13.20	53.16	2.63	47.45	449.06	7.819	11.790
	W_2 - 130cm	110.2	3.97	13.57	54.74	2.76	49.16	481.22	8.982	12.035
	F_1 test	**	*	**	**	**	**	*	**	**
N	N_1 - 100%	109.7	4.00	13.77	54.93	2.78	50.49	488.16	8.869	12.052
	N_2 - 85%	108.9	3.94	13.49	54.30	2.71	48.84	467.33	8.539	11.949
	N_3 - 70%	106.7	3.77	12.90	52.62	2.59	45.57	439.92	7.793	11.737
	F. test	**	**	**	**	**	**	**	**	**
Interactions	LW	*	N.S	N.S	N.S	N.S	N.S	N.S	N.S	*
	LN	N.S	N.S	N.S	N.S	N.S	N.S	N.S	**	N.S
	WN	N.S	N.S	N.S	N.S	N.S	N.S	N.S	**	N.S
	LWN	N.S	N.S	N.S	N.S	N.S	N.S	N.S	*	N.S

3.2.2. Applied irrigation water, consumptive use, and water use efficiency

Results in Table 5 indicate that increasing furrow length to 50m resulted in saving 9.3% (452 m^3/ha) as compared to the 25m length. Also, increasing raised bed width to 130cm resulted in saving 18% (916 m^3/ha) of the applied irrigation water as compared to the 65cm width. Data showed also that increasing furrow length to 50m and width to 130cm improved the water productivity to about 2.0 kg grain/m^3 of applied irrigation water (Table 5).

Table 5: Effect of furrow length and width and nitrogen level on some water relations of wheat crop in (2010/2011)

		Applied Water (m^3/ha)	Water Saved		Water Consumptive use (m^3/ha)	IWUE (Kg/m^3)	WUE (Kg/m^3)
			%	(m^3/ha)			
L	**L_1- 25m**	4857.15	-	-	3709.0	1.711	2.201
	L_2 - 50m	4404.76	9.31	452.39	3243.0	1.991	2.670
W	**W_1- 65cm**	5089.28	-	-	3559.0	1.543	2.215
	W_2- 130cm	4172.62	18.01	916.66	3393.0	2.159	2.655
N	**N_1- 100%**	4821.42	-	-	3553.0	1.866	2.519
	N_2- 85%	4650.80	3.56	171.43	3486.0	1.873	2.459
	N_3- 70%	4420.54	8.31	400.81	3388.0	1.815	2.327

IWUE = Irrigation water use efficiency (kg grain/m^3 applied irrigation water)
WUE = Water use efficiency (kg grain/m^3 consumed water)

3.3. Sugar Beet Crop

3.3.1. Yield and yield components

Data showed that there was a significant interaction between furrow length (50m) and nitrogen level (100%) as well as between raised bed width (130cm) and nitrogen level (100%) on sugar yield (Table 6). From the obtained results it could be concluded that using furrow length of 50m, raised bed width of 130cm and 100% of the recommended N-fertilizer is the best practice to obtain optimum sugar beet yield in the Old Land.

Table 6: Effect of furrow length and width and nitrogen level on sugar beet yield and quality in 2010/2011

Treatments		Root diameter (cm)	Root length (cm)	Root Yield (t/ha)	Sucrose Percent (%)	Purity (%)	Sugar yield (t/ha)
L	L_1-25m	12.32	34.62	77.94	20.0	79.85	15.60
	L_2-50m	12.56	35.93	82.65	20.35	79.60	16.84
	F- test	N.S	*	*	N.S	N.S	**
W	W_1-65cm	11.73	33.84	74.40	19.85	79.95	14.79
	W_2-130cm	13.16	36.71	86.18	20.50	79.50	17.65
	F_1 test	**	**	**	**	*	**
N	N_1-100%	12.83	35.74	85.47	19.71	79.16	16.86
	N_2-85%	12.52	35.25	80.40	20.22	79.68	16.32
	N_3-70%	11.98	34.85	75.00	20.59	80.34	15.48
	F. test	**	N.S	**	**	**	**
Interactions	LW	N.S	N.S	N.S	N.S	N.S	N.S
	LN	N.S	N.S	**	N.S	**	**
	WN	N.S	N.S	N.S	N.S	**	*
	LWN	N.S	*	N.S	N.S	N.S	N.S

3.3.2. Applied irrigation water, consumptive use, and water use efficiency

Results revealed that increasing furrow length to 50m saved about 415m^3/ha. Also, using the raised bed (130cm) saved 1587 m^3/ha of the applied irrigation water as compared to the furrow width of 65cm (Table 7). Data showed also that increasing furrow length to 50m long and furrow width to 130cm increased water productivity values to 1.255 and 1.4 kg root/m^3 of applied irrigation water, respectively.

Table 7: Effect of furrow length and width and nitrogen level on some water relation of sugar beet crop in 2010-2011 growing season

Treatments		Applied water (m^3/ha)	Water Save		Water consumptive use (m^3/ha)	WUE$_f$ (kg/m^3)		WUE$_c$ (kg/m^3)	
			(m^3/ha)	(%)		Root	Sugar	Root	Sugar
L	L_1 - 25m	7161.8	-	-	5094.9	1.108	0.223	1.642	0.330
	L_2 - 50m	6746.9	414.92	5.79	4777.2	1.255	0.256	1.768	0.361
W	W_1- 65cm	7748.0	-		5533.5	0.964	0.192	1.418	0.282
	W_2-130cm	6160.7	1587.41	20.48	4338.3	1.400	0.287	1.990	0.408
N	N_1 - 100%	7048.0	-		5063.1	1.234	0.245	1.732	0.342
	N_2 - 85%	6948.0	-		4898.7	1.189	0.239	1.686	0.343
	N_3 - 70%	6867.0	-		4845.8	1.123	0.233	1.696	0.351

Part 1.2. New land

The experiments for the new land were conducted at Al-Entelak area, West Nubaria Region, Rural Development Project which is located in the West desert at Km 72 Alexandria-Cairo desert road. The soil of experimental plots is sandy.

Activity 1: Sprinkler irrigation and fertilizer management of wheat crop in sandy soil

1. Objective:

- To set appropriate tools and management of irrigation water and fertilizers under sandy soils.

2. Methodology:

2.1. Treatments and experimental design

2.1.1. Treatments

Irrigation amounts

- I_1 = application of irrigation to keep soil moisture tension below 10 kPa;
- I_2 = Application of irrigation when soil moisture tension reaches 15 kPa;
- I_3= Application of irrigation one day after reaching soil moisture tension of 15 kPa.

Nitrogen rates

- N_1 = 100% recommended rate;
- N_2 = 75% recommended rate.

2.1.2. Experimental design

The experimental design is a randomized complete block design (RCBD) with 3 replications.

2.1.3. Field management

Cultural practices

- Wheat crop (Variety: Giza 168);
- Sowing date: 01/12/2010;
- Planting rate: 22g/m^2 = 92 kg/feddan;
- Planting was done by weighing seeds for each experimental treatment and were equally distributed by hand (broadcasting).

Soil moisture monitoring and irrigation

Soil moisture content was monitored by soil moisture sensors placed at the active root zone level, and readings were recorded daily.

Irrigation scheduling was based on actual soil water depletion in the field according to the following soil moisture tensions:

- I_1 = irrigation to keep soil moisture tension below 10 kPa.
- I_2 = irrigation when soil moisture tension reaches 15 kPa.
- I_3= irrigation one day after reaching soil moisture tension of 15 kPa.

Fertilizer was added with irrigation water (fertigation).

Two N-fertilizer levels were tested:

N_1 (120 kg N/feddan) = recommended.

N_2 (90 kg N/feddan) = 25% less than recommended.

Other fertilizer elements including P, K, and microelements as well as weed control chemicals were added as recommended. Fertilizer doses were applied using the fertigation technique according to the recommendations of Ministry of Agriculture and Land Reclamation for wheat crop in the new lands. The fertilizer quantities were divided equally to 12 doses and were applied by using the fertilizer tank through the mini-sprinkler system. Fertilizer application started on 15/12/2010.

3. Results/Achievements

3.1. Reference evapotranspiration and soil and water composition

Daily reference evapotranspiration in the site of the experiment (Table 8) varied in average from 1.6 mm in December to 5.4 mm in April with 3.1 mm in February.

Table 8: Average daily ET_0 values during wheat growing period

Month	Average daily ET_0 (mm)
December 2010	1.6
January 2011	2.7
February 2011	3.1
March 2011	4.4
April 2011	5.4

The soil texture at the experimental site is sandy and is slightly alkaline (average pH values were between 8.03 and 8.07). The EC values are between 1.48 and 1.51 dS/m. Sandy soils are very poor in NPK (Table 9).

Table 9: Soil chemical analysis

Depth (cm)	EC (dS/m)	pH	Available (ppm)			Soluble Cations (meq/L)				Soluble Anions (meq/L)		
			N	K	P	Ca	Mg	K	Na	Cl	HCO_3+CO_3	SO_4
0-30	1.48	8.03	8.87	201.74	5.07	7.20	3.97	0.66	3.20	4.00	3.20	7.82
30-60	1.51	8.07	4.50	174.07	2.00	7.37	3.93	0.61	3.34	4.50	2.00	8.75

Irrigation water composition is presented in table 10.

Table 10: Analysis of irrigation water

EC (dS/m)	pH	Soluble Cations (meq/L)				Soluble Anions (meq/L)		
		Ca	Mg	K	Na	Cl	HCO_3+CO_3	SO_4
0.89	8	3	2	2	1.9	1.5	3	4.4

3.2. Wheat yield and yield components

Results indicated that there was no significant effect of the irrigation and nitrogen treatments on the examined yield component parameters (Table 11). Average plant height values varied between 83.0 cm for the I1N1 treatment and 73.3cm for the I3N2 treatment. The highest no. of tellers/plant (7.0) was recorded for the I3N1 treatment, while the lowest (5.0) was recorded for the I2N2 treatment. The highest dry matter of 86.19% was recorded under the I3N2 treatment.

Table 11: Effect of irrigation and nitrogen on plant height, numbers of tillers and spikes per plant and dry matter

Treatment	Plant height (cm)	# of tillers/plant	# of spikes/plant	Dry matter (%)
I1N1	83.00 ± 4.4 a	6.67 ± 1.5 a	6.17 ± 1.2 a	79.04 ± 11.6 a
I1N2	81.00 ± 1.7 a	5.33 ± 1.5 a	5.00 ± 0.9 a	72.94 8.6 a
I2N1	76.67 ± 2.9 a	6.00 ± 1.0 a	5.83 ± 0.3 a	84.83 ± 1.0 a
I2N2	80.00 ± 1.0 a	5.00 ± 1.7 a	5.00 ± 0.5 a	73. 05 ± 11.8 a
I3N1	82.67 ± 2.5 a	7.00 ± 3.5 a	6.5 ± 0.5 a	74.37 ± 9.1 a
I3N2	73.33 ± 5.8 a	5.67 ± 0.6 a	5.17 ± 0.3 a	86.19 ± 6.1 a

Results showed also that there was no significant difference between wheat grain yields under the tested treatments. However, the results indicate that irrigation one day after reaching soil moisture tension of 15 kPa with 90 kg N/fed will save 1220 m^3/fed of applied water and improves the water productivity without significant effect on grain yield (Table 12). The results indicated that water productivity improved in the deficit irrigation treatments (I3N1 & I3N2). Also, nitrogen fertilizers can be reduced by 25% without affecting the yield significantly in all treatments included under irrigation treatments.

Table 12: Effect of tested variables on wheat grain yield, applied irrigation water and water productivity

Treatment	Wheat yield (kg/fed)	Applied water (m^3/fed)	Water productivity (kg/m^3)
I1N1	1810.2 ± 283 a	3050.25	0.59
I1N2	2156.0 ± 142 a	3050.25	0.71
I2N1	2352.0 ± 428 a	2440.20	0.96
I2N2	2315.6 ± 163 a	2440.20	0.95
I3N1	2080.4 ± 526 a	1830..15	1.14
I3N2	1857.8 ± 613 a	1830.15	1.02

Part 1.3. Salt-affected soils

The experiments weres conducted in South El-Hussainia Agricultural Research Station Farm, (ARC) which is located in the East Nile Delta region in salt affected soils. The soil of the experimental plots is mostly silty-clay.

Activity 1: Nitrogen and salinity management under mechanized raised bed technology of winter (wheat)) crop in salt-affected soils

1. Objectives:

- To determine optimal rates of nitrogen application under different raised bed width.
- To monitor salinity build-up under mechanized raised-bed system.
- To minimize salinity build-up under mechanized raised-bed system.

2. Methodology:

2.1. Treatments

- Soil amendments: A- Gypsum B- Gypsum + Organic Matter
- Raised bed width: BW1 = 0 cm, BW2 = 70 cm, and BW3 = 100 cm.

- Fertilizer rates: F1 = 75% N rate, F2 = 100% N rate, F3 = 75% N rate + Bio-fertilizer, and F4 = 100% N rate + Bio-fertilizer.

2.2. Field management practices

The main field management practices used in the experimental site are presented in table 13.

Table 13: Main management practices

Date	Practice
23-24/11/2010	Land preparation
26/11/2010	Gypsum and Organic matter applications
29/11/2010	Wheat sowing and sowing irrigation (1st irrigation)
28/12/2010	1st dose of N-fertilizer application
28/12/2010	2nd Irrigation
05/01/2011	Biofertilizer application
29/01/2011	2nd dose of N-fertilizer application
29/01/2011	3rd Irrigation
08/02/2011	Biofertilizer application
22/02/2011	3rd dose of N-fertilizer application
22/02/2011	4th Irrigation
01/03/2011	Collecting plant samples for NPK analysis
09/03/2011	5th Irrigation
26/03/2011	6th Irrigation
23-24/04/2011	Collecting soils and plant samples before harvest
25/04/2011	Harvest

3. Results/Achievements

3.1. Soil chemical and physical analysis

Soil samples were collected for physical and hydro-physical analysis (particle size distribution, bulk density and total porosity, develop soil-moisture retention curve, and pore size distribution). Observation wells for measuring water table depth and fluctuations were installed. Also, soil samples were collected for chemical analysis (EC, pH, cations, anions, and SAR). The results of the analyses are presented in table 14.

Table 14: Main soil physical and chemical characteristics at the experimental site:

Depth (cm)	Particle size analysis				Bulk density (g/cm^3)	Total porosity	$CaCO_3$ (%)	OM (%)	EC (dS/m)	SAR
	Sand	Silt	Clay	Texture						
Mean	33.67	12.32	54.01	Clay	1.10	58.53	8.38	0.62	18.80	19.48

3.2. Wheat grain yield

Results in tables 15 and 16 show that there are no significant effects of the tested treatments on wheat grain yield under the salt affected soils conditions. Nevertheless, data indicated that applying the biofertilizer with 100% of the recommended N-fertilizer resulted in the highest grain yield of 1339.89 kg/fed. Also, applying organic matter with gypsum tended to have higher grain yield than the application of gypsum alone. The highest grain yield of 1375.17 kg/fed was obtained under the flat soil (WB1) as compared to the other two raised bed treatments.

Table 15: Wheat grain yields (kg/feddan) as affected by the treatments

Treatment	**Gypsum**				**Gypsum + Compost**			
	W1	**W2**	**W3**	**Mean**	**W1**	**W2**	**W3**	**Mean**
F1	1177.32	1000.34	767.83	981.83	1509.10	855.72	1053.73	1139.32
F2	1179.08	1244.81	1140.51	1188.13	1166.36	997.15	1168.64	1110.71
F3	1444.06	1219.94	1232.04	1298.68	1444.28	1102.60	1366.25	1304.38
F4	1543.09	1105.95	1356.78	1335.27	1542.80	1312.79	1738.81	1531.46
Mean	1335.89	1142.76	1124.29	**1200.98**	1415.63	1066.92	1331.86	**1315.52**

Table 16: Main effects of the factors studied

Fertilizer treatments:	**Average grain yield**
F1:	1328.59 kg/fed
F2:	1049.99 kg/fed
F3:	1226.39 kg/fed
F4:	1339.89 kg/fed
LSD (0.05):	342.64 kg/fed
Furrow width:	
BW1:	1375.17 kg/fed
BW2:	1104.81 kg/fed
BW3:	1228.07 kg/fed
LSD (0.05):	360.17 kg/fed
Soil amendment:	
Gypsum:	1200.87 kg/fed
Gypsum + OM:	1271.45 kg/fed
LSD (0.05):	483.87 kg/fed

Rice crop

Results of the effect of tested treatments (cultivation methods: farmer-flat vs. furrow and fertilizer treatments: bio+75% N, 100%N, and bio+100%N) on rice grain yield are presented in Table 17. Results indicated that there was no significant effect of the tested treatments on rice grain yield. Nevertheless, the furrow growing method had 10% higher yield than that of the farmer-flat method. Also, the highest average rice grain yield of 1029.88 kg/fed was obtained from the bio+75%n fertilizer treatment.

Table 17: Effect of tested treatments on rice grain yield (kg/fed)

Fertilizer – F treatments	Furrow method (M1)	Farmer method (M2)
Bio+75%N	1149.45	910.32
100% N	1010.20	982.81
Bio+100%N	1015.57	979.49

Part 2. Out scaling and dissemination

Two field days were organized on March 28 and 29, 2011 for dissemination of the activities conducted in the New and Old lands. Farmers from El-Bustan area, Sharkia and Port Said Governorates, officials, extension agents, researchers from ARC, NWRC, and ICARDA attended the field days.

A harvest day at salt affected soils location (South El-Hussainia station) for the harvesting of rice crop was held on September 28th 2011. Farmers from the area and from Port Said governorate, extension agents and the researchers attended the field day.

Component II: Modeling water, salinity and nutrient flows in a unit irrigated area

1. Introduction

Poor irrigation management is one of the important problems associated with the irrigated agriculture in the dry areas. It increases water losses by evaporation from the soil surface, runoff and deep percolation below the root zone and resulted in low crop return. Thus, there is a significant need for establishment of efficient, economic and sustainable irrigation management to maximize crop return per unit of water applied. Water availability over the different growth stages, soil salinity and water logging are the key factors affecting sustainable crop production in the dry areas. Managing water and soil salinity as a result of different irrigation and drainage practices affects potential crop yield, and long term sustainability.

Advances in computer technology in recent decades have provided improvements in mathematical modeling of crop, soil and climate systems. Mathematical models that deal with water and solute transport in the unsaturated or variably saturated zone, along with yield response models can be useful in assessing the impact of different irrigation and drainage practices on crop yield. This is of particular value in regions where water and salinity are the most limiting factors for agricultural production.

The task of the modeling component is focusing on conducting case studies at the level of tertiary canal. The aim of these case studies is to find a satisfying answer to the question "How to maximize water productivity of certain watershed by improving water budget?". This question should be answered through achieving the following objectives:

- To establish efficient, economic and sustainable irrigation strategies that maximize water productivity, with minimum levels of environmental hazards;
- To provide training on data collection and analysis, and the use of the mathematical modeling approaches in irrigation water management.

In this component, the intention is to use mathematical and biophysical modeling techniques to simulate different options and scenarios to optimize water productivity in order to enhance crop-yield production, save water, and minimize the harmful environmental impacts. One of the expected results of this activity is to develop "Integrated Modeling Framework" to analyze water productivity and environmental influences of irrigation practices, at both field and watershed scales. The best options and scenarios will be conveyed to the farmers in simple and applicable recommendations.

2. Activities

Five main activities were planned to be implemented under the modeling component, as follows:

- Activity 1: Site selection
- Activity 2: Models review and selection
- Activity 3: Data collection
- Activity 4: Model set up and calibration
- Activity 5: Capacity Building

The five activities were planned to be implemented according to the following time table

	Activities	2010						2011												2012												2013
		7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1
1	Criteria for site selection developed.	X																														
	Field visits to number of sites completed.				X																											
	Workshop to select the suitable site.																															
2	Models for the technical review identified.	X																														
	Technical review for the list of models completed.				X																											
	Model selection criteria developed																															
	Focal group meeting to select the suitable model.																															

- **Site Selection**
- **Models review and selection**

	Activities	2010						Month, 2011												2012												2013
		7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	1	1	1	2	3	4	5	6	7	8	9	1	1	12	1
3	Data required by the modeling approach identified.																															
	Data still need to be collected identified.																															
	Data collection completed.																															
	Data checking and analyzing completed.																															
4	Model set up completed.																															
	Sensitivity analysis runs completed.																															
	Initial model calibration runs completed.																															
	Final model calibration completed.																															

- **Data collection**
- **Model set up and calibration**

	Activities	2010						Month, 2011												2012												2013
		7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1
5	Development of set of different of irrigation and drainage scenarios.																															
	Model runs completed.																															
	Analysis of the results completed and finalized.																															
	Efficient irrigation strategies identified and agreed																															
	Final report submitted.																															
6	Short training course (two weeks) for number of engineers on modeling irrigation water management.				x																											
	Review of international postgraduate programmes completed.																															
	Students and universities identified.																															
	Students join selected institutions																															

- **Model application**

- **Capacity Building**

This report is covering the activities of the modeling component that were conducted from November 2010 to September 2011, according to approved timetable of the component activities.

3. Results/Achievements

The Modeling component group had attended several progress and follow-up meetings, after the inception workshop that was held on 27-28 March 2010, in Cairo, as listed below:

Date	Location	Attendance
11 July 2010	WMRI	Modeling Group+ Dr. Karrou
18 July 2010	ICARDA office	Modeling Group
18 August 2010	ICARDA office	Modeling Group
22 September 2010	ICARDA office	Modeling Group+ Dr. Karrou
20 October 2010	ICARDA office	Follow-up meeting of the three project groups with Dr. Karrou
1-2 December 2010	Amman- Jordan	1st regional meeting
13 January 2010	ICARDA office	Modeling Group
18 January 2011	AEnRI	Sensitivity analysis meeting
2 March 2011	ICARDA office	Follow-up meeting of the three project groups with Dr. Karrou
3 May 2011	ICARDA office	Modeling Group
23 May 2011	ICARDA office	Follow-up meeting of the three project groups with Dr. Oweis (IBM & WLI)
11 July 2011	WMRI	Modeling Group+ WLI group
23 August 2011	ICARDA office	Follow-up meeting of the three project groups (IBM & WLI)
20 September 2011	SWERI	Sensitivity analysis meeting
27 September 2011	AEnRI	Sensitivity analysis meeting

The modeling group activities were suspended from Jan 25 to the end of February, due to the political instability occurred in Egypt.

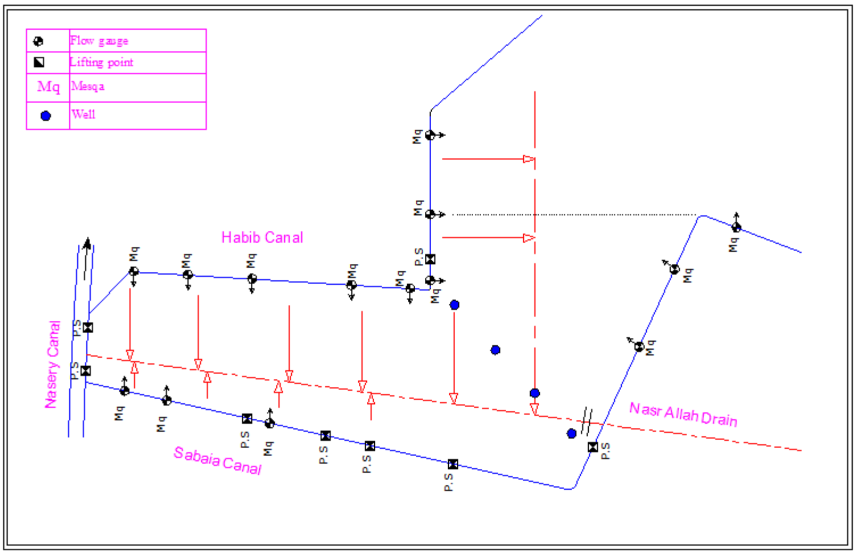
Activity 1: Site selection

The modeling activities started with selecting a representing pilot location for data collection and case study evaluation. The selection procedure is based on pre-determined criteria as listed below:

- Well-identified watershed
  - Separated and independent
  - Single irrigation source
  - Determinate drainage ways
- Representative site for the target region
- Assessable data collection
- Fulfilling modeling facilities (size, boundary conditions, data availability)

According to the activities presented in the implementation plan document, three pilot locations proposed to be selected in order to present the three case studies of old land, new land, and marginal land. Unfortunately, due to limitations of budget, only one location was selected this year to represent old land conditions, and the other two locations will be selected to represent the other cases in the following years. The old land location is selected in Behaira Governorate and very close to Damanhour city. The water source of the location is originally from El Nasery Canal then Sabya and Habib Canals. The location has only one main drain of Nasr Allah drain through several collectors as shown in the map below. The served area is 735 feddans. This area is a part of Nasr Allah Drain command area.

The old land location is selected and equipped with measuring equipments this year. The location now is on-board; field measurements are going to start shortly at the next winter season, and it will proceed until the end of the next summer season.



Activity 2: Models review and selection

This activity aimed to (i) set the framework of the modeling analysis; (ii) review the most important theoretical concepts of some existing irrigation water management models and their application for sustainable crop production; (iii) develop criteria for the modeling approach selection; (iv) select the most suitable model for the analysis; and (v) identify the data required by the modeling approach.

Set the framework of the modeling analysis

Identifying the case study concept, structure, and constrains was the first step in developing the framework of the modeling analysis. The watershed under analysis is represented by the agricultural region located at the tertiary canal zone. The area of the tertiary canal zone is about 100-300 feddans (42- 126 ha). This zone is has one general water supply point (tertiary canal), and one general drainage point (tertiary drain). The size, shape and number of the fields inside this zone are varying as a result of socio-economic conditions. Furthermore, the cultivated crops and management practices are varying too, from field to field. This kind of variation is producing a real challenge to analyze the overall water productivity and to find out the interactions between water management in the different fields of the tertiary canal zone. Figure 1 represents a simplification schematic model of the tertiary canal zone system.

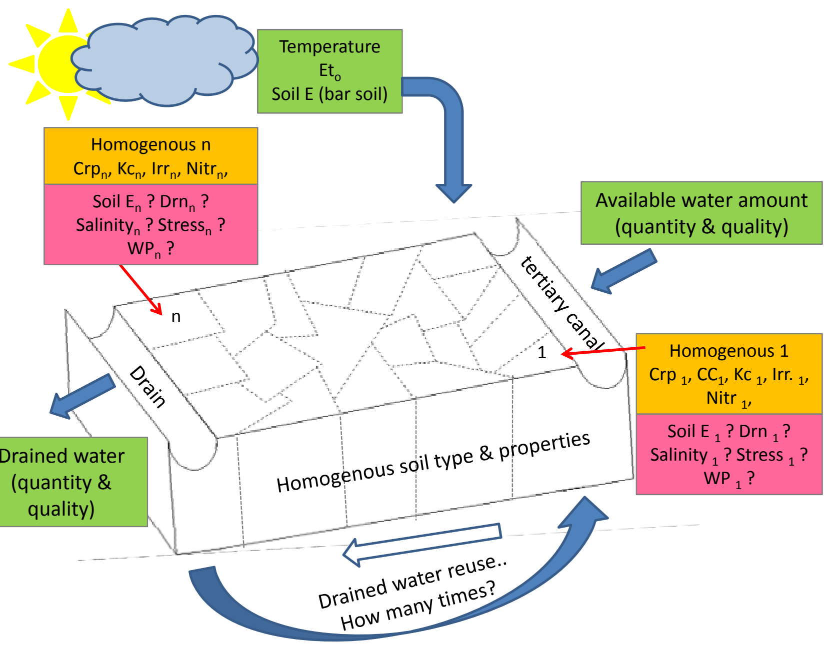


Figure (1): Simplification schematic model of the tertiary canal zone system, where: Crp = crop type, Kc = crop coefficient, Irr = irrigation application, Nitr = nutrition application, Soil E = soil evaporation, Drn = drained water amount, and WP = water productivity.

Accordingly, the tertiary Canal Zone, which is considered as a heterogonous unit, consisted of a number of homogenous units representing the fields that have almost the same crop type and management. The water productivity of each homogenous unite could be calculated by the following equation:

$$WP = \frac{\text{Production}}{\text{Water}_{\text{actual}}}$$

Whereas the environmental impact of irrigation management at this level is a function of water losses, salinity accumulation, nutrition application, ground water..etc. as well as, the overall water productivity of the tertiary canal zone (the heterogonous unit), could be calculated through up-scaling analysis, using the following equation:

$$WP_{overall} = \int_{1}^{n} (WP_{Homounits})$$

The overall environmental impact of the zone is a function of underground water interactions, salinity accumulation, overall WP…etc. Based on the aforementioned system, the modeling analysis will be conducted through two levels of analysis:

- On-farm modeling (analysis of homogeneous units at farm level),
- Up-scaling modeling (ensemble of the individually homogeneous unites to represent a spatially heterogeneous region).

The following Figure illustrates an example of similar type of analysis in a similar study.

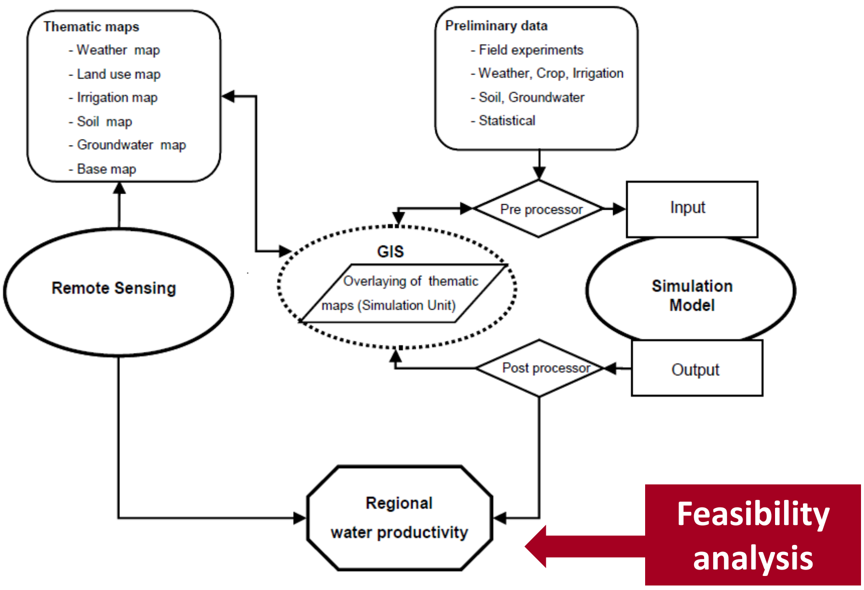


Figure (2): Example of the framework.
(Source: Singh, R. 2005. Water productivity analysis from field to regional scale: integration of crop and soil modeling, remote sensing and geographical information. Doctoral thesis, Wageningen University, Wageningen, The Netherlands.)

1. Review of the most important theoretical concepts of some existing irrigation water management models and their application for sustainable crop production.

First, a list of a commonly used crop and irrigation management models was prepared. Afterward, the models in the list were classified based on the model type, and the availability of literature reviews and information. The models were classified in five types: crop growth models, crop-water relationships models, water budget models, decision support system (DSS), and hydrological models. The following table presents the models' lists with type classification and the level of information and review availability of each model.

Model	**Information and review fulfillment**	**Model type**
1- WAVE	X	Crop-water model
2- SIMETAW	X	Crop-water model
3- Yield_stress	X	Crop-model
4- CropSyst	XXX	Crop-water model
5- DSSAT	XXX	Crop DSS model
6- SALTMED	XX	Crop-water model
7- AquaCrop	X	Crop-water model
8- CropWat	XXX	Crop-water model
9- SWAP	XXX	Water budget model
10- SPAW	XX	Water budget model
11- WEAP	XXX	Water balance DSS model
12- SIWARE	X	Hydrological model
13- SIRMOD	X	Hydrological model
14- IRDDESS	X	Hydrological model
15- HEC_RAS	X	Hydrological model
16- CANALMAN	X	Hydrological model
17- DMS	X	Hydrological model

2. Review of the models

In this activity, the models listed previously were subjected to a comprehensive revision in order to select the most efficient model/s that could comply with the objectives of the ongoing analysis. The results of this revision are presented in a literature review report/paper titled “Using modeling approach in agriculture water productivity analysis”. Besides conducting a comparison between the models, this review includes a comprehensive discussion of using modeling approach in developing efficient irrigation management options (Figure 3.)

Using modeling approach in agriculture water productivity analysis (TOD) | 2011

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Figure (3): Table of contents of the literature review report/ paper with the titled "Using modeling approach in agriculture water productivity analysis"

3. Developing criteria for the modeling approach selection.

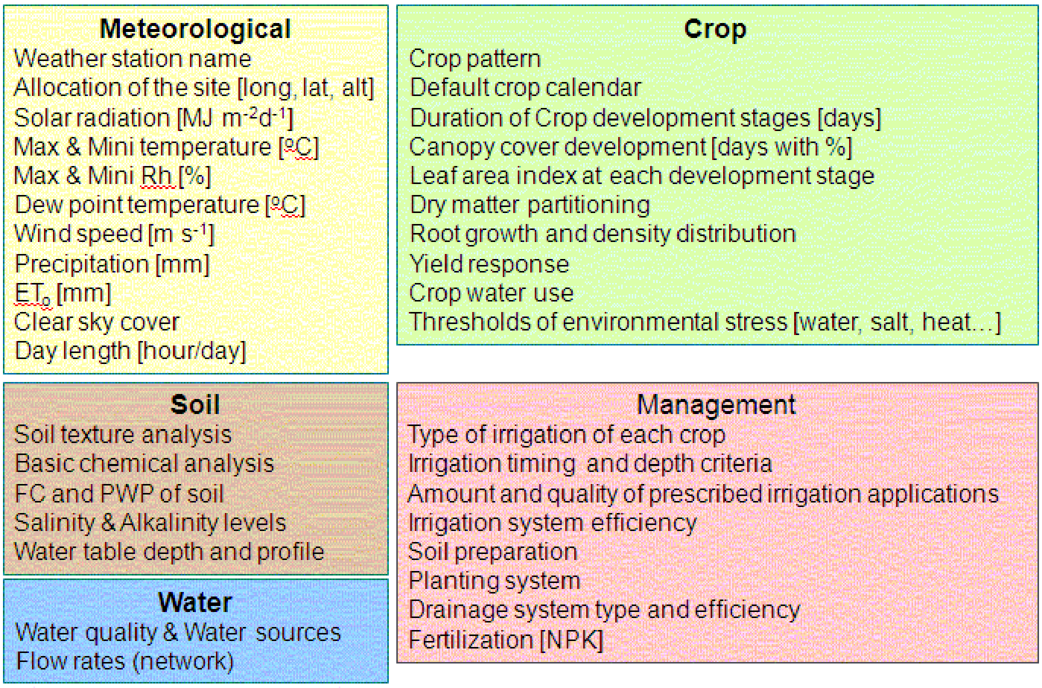
Developing evaluation criteria for model/s selection was one of the important technical activities. The developed criteria were focused on meeting the objectives of the study, the accuracy, and consistency of the evaluated model. The following points are the basic criteria used to evaluate the models:

- Meeting the objectives of the study, which are the following:
  - ✓ irrigation scheduling analysis;
  - ✓ crop-growth analysis;
  - ✓ water productivity analysis;
  - ✓ water stress;
  - ✓ soil water flow, soil heat flow (water budget physical analysis);
  - ✓ salinity build-up in soil;
  - ✓ salinity analysis (water quality and solute flow);
  - ✓ salinity stress;
  - ✓ hydraulic interactions;
  - ✓ examination of different scenarios of irrigation-management (surface irrigation);
  - ✓ nitrogen leaching (inorganic form) and accumulation & their effect on crop growth,
- Accuracy of the theoretical bases used on the model,
- Simulated crops,
- Calibration requirements,
- Model inputs,
- Model outputs format,
- Simulation running strength,

- Constrains and limitations of using the model,
- License,
- Interface simplicity,
- Availability of scientific review, case studies and technical assistants.

4. Select the most suitable model for the research.

Through models evaluation procedure, a list of the common and important inputs of the models was developed in the following Figure.



Furthermore, a simple aggregated statistical index was developed to identify the compatible model/s that could be used in this study. This index is determining the overall compatibility based on the evaluation criteria developed before. The Index ranged between 0 (not compatible at all) to 1 (highly compatible). In the table below the results of the evaluation for seven models which have the highest values of compatibility index. It could be concluded that SWAP, SPAW and CropSyst models have the highest compatibility index values, therefore the three models are currently used in sensitivity analysis, in order to define the final selection of the model/s from the three models, which will be used under the analysis framework.

Parameter	WAVE	SIMETAW	SWAP	SPAW	CropSyst	DSSAT	AquaCrop
1-Objective	7	5	9	9	8	5	5
2- Theory	6	4	9	8	7	4	4
3- Crops	6	5	8	8	8	8	6
4- Strength	5	2	10	10	10	5	5
5- constrains & limitations	6	2	8	8	8	5	5
6- inputs	9	9	8	8	9	9	9
7- outputs	5	5	10	10	10	5	5
8- license	0	10	10	10	10	10	10
9- Interface		6	9	8	6	6	9
10- The availability of scientific review, case studies and technical assistants	4	1	8	6	8	9	5
11- calibration		6	8	8	7	4	9
12- Error alerts & log files			9	9	5	9	5
Overall compatibility index 0 = not compatible 10 = highly compatible	**4.8**	**4.9**	**8.9**	**8.5**	**8.4**	**6.6**	**6.3**

Activity 3: Data collection

Data collection activity covered two levels of data groups on-farm data sets, and canal-zone data sets.

1. On-farm data sets level

At 13 Jan 2011 meeting, the modeling group discussed the required field data sets to be collected from the intervention locations, which is already cultivated for the winter season. The group reviewed the crop pattern, which is determined by the intervention group as follows:

season	Location	crops	Irrigation system
Winter	Old land	Wheat- sugar beet	Farrow irrigation
	Salt affected soil	Wheat	
	New land	Wheat	Sprinkler irrigation
Summer	Old land	Maize- rice	Farrow & basin
	Salt affected soil	Maize- rice	irrigation
	New land	Maize- peanut- tomato	Drip irrigation

The group discussed the main pattern that will be considered for the modeling analysis at the irrigation zone level (tertiary canal). The group agreed to consider the major crops representing the majority of the cultivated area of the irrigation zone, considering the minor areas as "other crops".

The group reviewed a draft list of the proposed parameters of data to be collected from the field experiments. The list included six groups of parameters of (i) weather data, (ii) soil data, (iii) water data, (iv) crop data, (v) management, and (vi) data needed for up-scaling. The final version of the list was translated into Arabic and circulated to both the modeling and intervention groups.

The final data list includes the following parameters:

- Weather data: daily data of each location for the following parameters:
  - ✓ Air temperature (maximum – minimum) [^{o}C]
  - ✓ Relative humidity (maximum – minimum) [%]
  - ✓ Wind speed [m s-1]
  - ✓ Solar radiation [MJ m-2d-1]
  - ✓ Precipitation [mm]
  - ✓ Pan evaporation [mm/day]

- Soil data:
  - ✓ Soil texture
  - ✓ Soil-water relationship curve (saturation point- FC- PWP)
  - ✓ EC
  - ✓ pH
  - ✓ Soluble cations (Ca^{++}, Mg^{++}, Na^{+}, K^{+})
  - ✓ Soluble anions (CO_3^{--}, SO_4^{--}, HCO_3^{-}, Cl^{-})
  - ✓ # Soil samples should be collected from three layers of 0-20 cm, 20- 40 cm, and 40- 60 cm.

- Water data
  - ✓ EC (Should be measured at every irrigation time at marginal land locations)
  - ✓ pH (Should be measured at every irrigation time at marginal land locations)
  - ✓ Soluble cations (Ca^{++}, Mg^{++}, Na^{+}, K^{+})
  - ✓ Soluble anions (CO_3^{--}, SO_4^{--}, HCO_3^{-}, , Cl^{-})

- Irrigation system
  - ✓ Irrigation system specification
  - ✓ Irrigation system efficiency
  - ✓ Irrigation applications
  - ✓ Drainage system specification
  - ✓ Drainage water amount after water saturation
  - ✓ Groundwater level
  - ✓ Depletion curve

- Management
  - ✓ Fertilizers used in preparation stage (rate & application)
  - ✓ Organic treatment application (if any)
  - ✓ Fertilization application

- ✓ The fraction of pest and disease infections

- Crop data:
  - ✓ Plants density
  - ✓ Sowing date
  - ✓ Spike emergence date (for 50% of the cultivated area)
  - ✓ Milky stage date (for 50% of the cultivated area)
  - ✓ Kernel stage date (for 50% of the cultivated area)
  - ✓ Vegetative data: 5 plants × 3 replicates/ fresh and dry weight
  - ✓ Maximum LAI
  - ✓ Crop-yield data: 3 experimental plots × 3 replicates
  - ✓ Total grain weight per plot
  - ✓ Straw weight

2. Canal-zone data sets level

Primary data collection, measuring devices installation, and site set-up were taken place this year at the old land location, as listed below:

- On 14 -15 June 2011, soil samples of 15 random points (sampling depth up-to 1.0 meter) were collected, and targeted now for mechanical and chemical analysis. Soil salinity will be analyzed after the end of the current summer season.

- On 20 June 2011, three thermo-manger devices were installed at Awad Allah Mesqa for two weeks. Sensors were installed on the gear box not the pipeline to save the free sensors to be used in other sites.

- Two accumulative pump operating-time measuring devices were bought, one is for diesel pump and the other one is for electricity.
- Automatic water level recorders were installed during the period of 25th -28th June 2011 at the following locations:
  - ✓ Two recorders upstream and downstream the intake of Sabaya Canal,
  - ✓ One recorder downstream Habib Canal (upstream water levels of Habib Canal equal upstream water level of Sabaya canal minus two centimeter),
  - ✓ One recorder on Nasr Allah Drain,
  - ✓ Reference level of Nasr Allah Drain Was corrected and calibrated.

- On 25th June 2011, discharges of the surface canals and drains was measured at the following locations:
  - ✓ Downstream the intake of Sabaya canal; four times per month,
  - ✓ Downstream the intake of Habib canal; four times per month,
  - ✓ Nasr Allah drain at the end point of the study area; four times per month,
  - ✓ El Ashrean drain (private with 85 feddans served area); as available.

- Starting from 18th July 2011, water quality samples were collected from the following locations:
  - ✓ Downstream the intake of Sabaya canal; four times per month,
  - ✓ Downstream the intake of Habib canal; four times per month,
  - ✓ Nasr Allah drain at the start point of the study area; four times per month,
  - ✓ Nasr Allah drain at the end point of the study area; four times per month.

- Pump operating-time for the current summer season collected as follows:
  - ✓ 21 pumps on 11 improved mesqa,
  - ✓ 13 portable pumps,

- Thermo-manger devices were installed on the improved mesqas on 21^{st} July 2011 and their data downloaded on 30^{th} – 31^{st} July 2011. The devices re-operated for another 14 days.
- Installation of measuring pressure connections inside the pipelines is completed.

- Collection of the crop pattern of the summer season of the study area is completed.
- On 25^{th} July 2011, four groundwater observation-wells were installed, and the data of the groundwater levels is collecting from 4^{th} August 2011.

- The integrated irrigation district of Kafr El Dowar cleaned Nasr Allah Drain, as well as offered the required maintenance for the collectors located in the study area.

Activity 4: Model set up and calibration

The group will start shortly an evaluation for historical existing data sets of the experimental locations, to be used in the models calibration.

<u>1. Sensitivity analysis</u>

Sensitivity analysis is running now aiming to define the final selection of model/s from the three models, which will be used in the analysis framework. Dr. Samiha and Dr. Samar take the responsibility of conducting the sensitivity analysis of CropSyst, SWAP and SPAW models. The analysis started with selecting and exchanging previous studies data sets to be used with the tested models. Four experiments of two crops were tested according to the following table:

Exp.No.	Location	Crop	Soil type	Irri. Sys.	Cultivation season	Planting date	Harvest date
1	Giza	Wheat	Old	Basin	2003/2004 2004/2005	15 Nov 2003 17 Nov 2004	20 Apr 2004 20 Apr 2005
2	Giza	Maize	Old	Furrow	2004 2005	19 Jun 2004 21 Jun 2005	15 Oct 2004 15 Oct 2005
3	El-Bustan (Nubaria), Behira	Wheat	New	Sprinkler	2002/200 2003/2004	20 Nov 2002 23 Nov 2003	20 Apr 2003 20 Apr 2004
4	El-Bustan (Nubaria), Behira	Maize	New	Drip	2003 2004	16 Jun 2003 25 Jun 2003	7 Oct 2003 25 Oct 2004

Weather data, soil mechanical and chemical parameters, and water management practices were the main inputs of the tested models. Maximum leaf area index (at anthesis), and degree days from planting to anthesis and physiological maturity were calculated for the two crops under the four experiments, as inputs of the models. Grain and biological yield of the two crops and consumptive water use were the main results of the simulated experiments, compared with the actual measured field data.

The complete results of the tested models are still under evaluation, and they will be presented shortly in details in special technical report of sensitivity analysis. The primary results showed very good presentation of both CropSyst and SWAP to the tested experiments; whereas, SWAP model has better ability to simulating water balance and salinity analysis.

During the simulation procedure, SWAP runs showed several types of running errors and frequent software crash due to programming problems. Therefore, the working team decided to exclude SWAP model from the tested models, and focus the sensitivity analysis of CropSyst and SPAW. Moreover, the working team conducted extra evaluation of SALTMED (2009) model, to be tested under the modeling study assumptions and conditions.

2. Preliminary calibration of the models

A preliminary calibration of the tested models (CropSyst, SPAW) is under progress, aiming to fine toning the results of the sensitivity analysis. The field data of the first winter season conducted under intervention group activities was used as the calibration procedure.

Introduction

Cropping system simulation models can be used to predict the effect of weather, soil properties, plant characteristics and management practices on the soil water balance, nutrient dynamics and growth of crops. Therefore, they can enhance our understanding of cropping systems performance under different water and nitrogen regimes. Models may also be used to assess the effects of management practices and plant characteristics on crop performance over a period that is long enough to characterize the climatic variability of a site (van Keulen and Seligman, 1987), leading to improvements in the efficacy of decision-making for fertilizer and water management. The increasing needs for more efficient management of crop production systems along with more consideration in environmental issues resulting from management decisions has necessitated the use of crop simulation models as additional management tools. Crop simulation models are the dynamic simulation of crop growth by numerical integration of constituent processes with the aid of computers (Sinclair and Seligman, 1996). In essence, they are computer programs that mathematically simulate the growth of a crop in relation to its environment. They often operate at time steps one or two orders of magnitude below the duration of the growing season and provide output data to describe attributes of the crop at different points in time (Matthews et al., 2000).

An example of these models is CropSyst (Stockle et al., 1994). It represents an effort to simulate the growth of single crops or crop rotations in response to weather/soil/management scenarios and provide an estimate of environmental impact (Stockle and Nelson, 1994; Stockle et al., 1994). The model can simulate the growth and yield of 10 different crops, with high degree of accuracy through calibration process. Calibration is very important procedure to be done to ensure the accuracy of the model prediction. Furthermore, suitable field experiments are required for model validation, a necessary step before model applications can be developed for a given region (Cabelguenne et al., 1990; Kropff et al., 1994; Lengnick and Fox, 1994). CropSyst model was calibrated in Egypt for three crops: wheat grown in old land (Khalil, et al., 2009) and in sandy soil (Ouda et al., 2010). Maize yield was also simulated calibrated using the model (Ouda et al., 2009). Furthermore, barley yield was calibrated by CropSyst (Ouda et al., 2010).

The Objective of this report was to calibrate CropSyst model for wheat grown in two sites in Egypt and for sugar beet grown in one site.

Materials and Methods

a. The old land site

a1. The field experiments wheat

A field experiment was conducted at El-Zankalon experimental farm in the growing season of 2010/11. Two strip lengths (25 and 50 m), two furrow widths (0.65 and 1.3 m) and three nitrogen treatments (100, 85 and 75% of the optimum dose) were the treatments in the experiment. Wheat was planted on the 14th of November and harvested on the 5th of May. Leaf area index was measured in three vegetative growth stages, as well as the date of these stages. Wheat grain and biological yields were measured at harvest and harvest index was calculated.

a2. The field experiment for sugar beet

A field experiment was conducted on sugar beet in the growing season of 2010/2011. The treatments were two strip lengths (25 and 50 m), two furrow widths (0.65 and 1.3 m) and three nitrogen treatments (100, 85 and 75% of the optimum dose). Sugar beet was planted on the 4th of November and harvested on the 18th of May.

b. The new land site

A field experiment was carried out for wheat at Nubaria experimental farm in the growing season of 2010/11. Wheat was planted on the 14th of November and harvested on the 5th of May. The treatments were three irrigation amounts (when soil tension reached 10 kPa, 15 kPa and one day after 15 kPa) and two nitrogen treatments (100, 75% of the optimum dose). Leaf area index was measured in three vegetative growth stages, as well as the date of these stages. Wheat grain and biological yields were measured at harvest and harvest index was calculated.

c. CropSyst model

c1. Model description

The CropSyst (Stockle et al., 1994) objective is to serve as an analytical tool to study the effect of cropping systems management on crop productivity and the environment. For this purpose, CropSyst simulates the soil water budget, soil-plant nitrogen budget, crop phenology, crop canopy and root growth, biomass production, crop yield, residue production and decomposition, soil erosion by water, and pesticide fate. These are affected by weather, soil characteristics, crop characteristics, and cropping system management options including crop rotation, variety selection, irrigation, nitrogen fertilization, pesticide applications, soil and irrigation water salinity, tillage operations, and residue management.

The water budget in the model includes rainfall, irrigation, runoff, interception, water infiltration and redistribution in the soil profile, crop transpiration, and evaporation. The nitrogen budget in CropSyst includes nitrogen application, nitrogen transport, nitrogen transformations, ammonium absorption and crop nitrogen uptake. The calculation of daily crop growth, expressed as biomass increase per unit area, is based on a minimum of four limiting factors, namely light, temperature, water, and nitrogen. Pala et al. (1996) suggested that minor adjustments of some of these parameters, accounting for cultivar-specific differences, are desirable whenever suitable experimental information is available. Details on the technical aspects and use of the CropSyst model have been reported elsewhere (Stockle et al., 1994; Stockle and Nelson, 1994).

c2. Model calibration

Input files required by CropSyst model for the two sites and cultivated crops (wheat and sugar beet) were prepared and used to run the model. For each treatment, one management file was prepared to represent each irrigation treatment. The date of each phenological stage was used to calculate growing degree days for that stage. Total biomass, grain yield, total and seasonal evapotranspiration, computed from the soil-moisture measurements from all the treatments, were used for model calibration. The values of the crop input parameters were either taken from the CropSyst manual (Stockle and Nelson, 1994) or set to the values observed in the experiments. The calibration consisted of slight adjustments of selected crop input parameters to reflect reasonable simulations. These adjustments were around values that were either typical for the crop species or known from previous experiences with the model.

c3. Statistical analysis

To test the goodness of fit between the measured and predicted data, percent difference between measured and predicted values for grain yield and biological yield in each growing season were calculated, in addition to water consumptive use. Furthermore, root mean square error (Jamieson, et al., 1998), which describes the average difference between measured and predicted values was calculated. In addition, Willmott index of agreement was calculated, which take a value between 0.0-1.0 and 1.0 means perfect fit (Willmott, 1981).

Results/Achievements

a. The old land site

a1. Wheat grain yield and water consumptive use

a1.1. CropSyst calibration

CropSyst model showed good agreement between measured and predicted values of wheat grain yield (Table 1). Low percentage of difference between observed and predicted values was obtained, as well as low root mean square error, i.e. 0.071 ton/ha. Furthermore, a close to 1 value of Willmott index of agreement was obtained, i.e. 0.998. Several publications highlighted the accuracy of the CropSyst model, such as Benli et al., (2007) and Singh et al., (2008). Both papers indicated that the model prediction gave low RMSE. Furthermore, Benli et al., (2007) stated that high Willmott index of agreement was obtained with a value of 0.98. Furthermore, Singh et al., (2008) indicated that CropSyst model was more appropriate than CERES-Wheat in predicting growth and yield of wheat under different N and irrigation application treatments, where RMSE was 0.36 ton/ha compared with 0.63 ton/ha for CERES-Wheat. In Egypt, CropSyst model was calibrated for wheat planted in clay soil (Khalil et al., 2009). Root mean square error was 0.015 ton/ha and Willmott index of agreement was 0.999.

The results obtained from the calibration of CropSyst model for water consumptive use revealed that the percentage of change between measured and predicted values was less than 1.0% (Table 1). Root mean square error was 0.416 mm and Willmott index of agreement was 0.999. Similar results were obtained by Wang et al., (2006), where RMSE was 0.07 mm for evapotranspiration and by Punnkuk et al., (1998), where it was 0.05 mm when CropSyst was used to predict evapotranspiration. Benli et al., (2007) stated that CropSyst model predicted water consumptive use reasonably well. The RMSE values were 11% of the average observed ET and the Willmott index of agreement (0.91) was reasonably close to 1. Root mean square error obtained for wheat grown in Egypt in clay soil was 0.569 and Willmott index of agreement was 0.999 (Khalil et al., 2009).

Table (1): Measured versus predicted grain yield and water consumptive use of wheat grown in 2010/11 growing season

	Grain yield (t/ha)			**Water Consumptive Use (mm)**		
Treatments	**Measured**	**Predicted**	**PC%**	**Measured**	**Predicted**	**PC%**
L1W1N1	8.16	8.15	0.24	393.65	393.30	0.09
L1W1N2	7.57	7.54	0.39	379.37	379.30	0.02
L1W1N3	6.47	6.41	0.99	372.98	372.60	0.10
L1W2N1	9.23	9.21	0.19	368.25	367.70	0.15
L1W2N2	8.85	8.80	0.51	361.90	361.60	0.08
L1W2N3	8.34	8.26	0.90	349.24	349.20	0.01
L2W1N1	8.64	8.53	1.26	333.02	332.40	0.19
L2W1N2	8.14	8.06	0.99	330.16	330.10	0.02
L2W1N3	7.59	7.55	0.47	325.93	325.90	0.01
L2W2N1	9.44	9.35	0.98	326.19	325.30	0.27
L2W2N2	9.26	9.18	0.95	323.02	322.80	0.07
L2W2N3	8.77	8.69	0.91	307.19	307.10	0.03
RMSE	0.071			0.416		
WI	0.998			0.999		

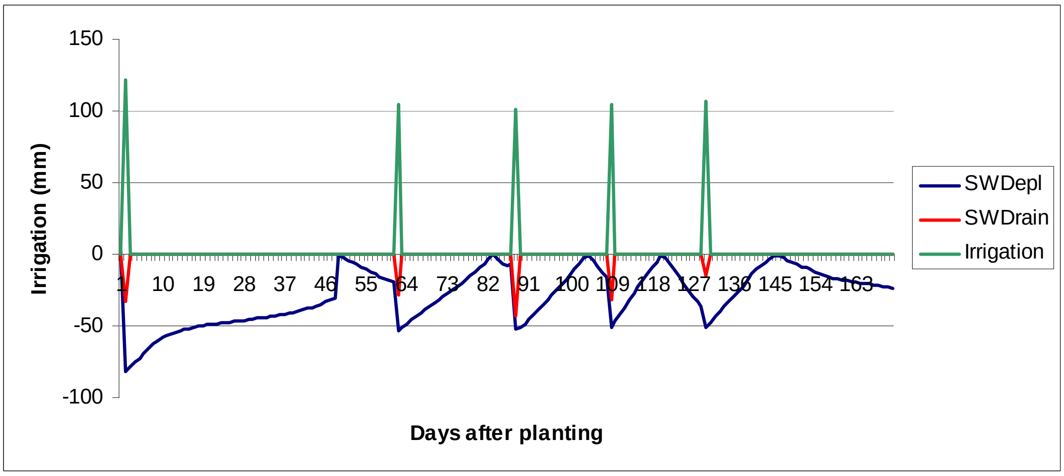
L1W1N1= strip length of 25 m, furrow width 0.65 m and 100% of optimum nitrogen dose; L1W1N2= strip length of 25 m, furrow width 0.65 m and 85% of optimum nitrogen dose; L1W1N3= strip length of 25 m, furrow width 1.3 m and 100% of optimum nitrogen dose; L1W2N1= strip length of 25 m, furrow width 1.3 m and 100% of optimum nitrogen dose; L1W2N2= strip length of 25 m, furrow width 0.65 m and 100% of optimum nitrogen dose; L1W1N3=

strip length of 25 m, furrow width 1.3 m and 100% of optimum nitrogen dose; L2W1N1= strip length of 50 m, furrow width 0.65 m and 100% of optimum nitrogen dose; L2W1N2= strip length of 50 m, furrow width 0.65 m and 85% of optimum nitrogen dose; L2W1N3= strip length of 50 m, furrow width 0.65 m and 75% of optimum nitrogen dose; L2W2N1= strip length of 50 m, furrow width 1.3 m and 100% of optimum nitrogen dose; L2W2N2= strip length of 50 m, furrow width 0.65 m and 85% of optimum nitrogen dose; L2W2N3= strip length of 25 m, furrow width 0.65 m and 75% of optimum nitrogen dose; PC%= percentage of difference between measured and predicted yield; RMSE= root mean square error; WI= Willmott index of agreement.

a1.2. Simulation of water balance

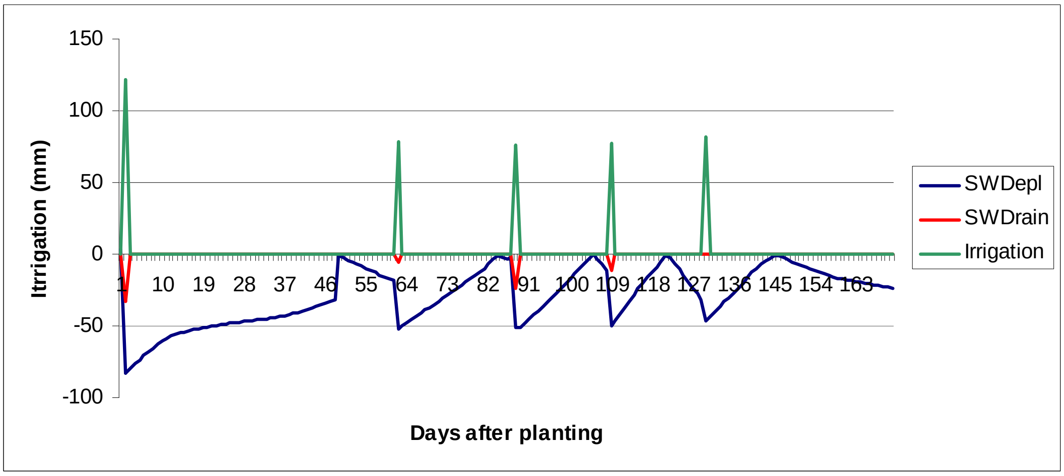
The model was used to simulate soil water drainage (SWDrain) and soil water depletion after the application of each single irrigation. Axis (X) in Figure (1) represents soil surface. When each irrigation was applied (green line), part of it was depleted by the growing plants (blue line). The other part was drained in the soil away from root zone (the red line). The first irrigation was 122 mm, which is higher than the rest of the other irrigations. However, the drained amount for this irrigation was lower, for example, than the third irrigation. This can be attributed to the fact that the land was dry and soil evaporation was high. Under planting wheat in strip length of 25 m and furrow width of 0.65 m, the drainage was the highest under the 3rd irrigation (43 mm), where it was applied on the 21st of February in the anthesis growth stage. The lowest amount of drainage occurred when the last irrigation was applied (15 mm) on the 7th of April during the grain filling period. The total amount of irrigation was 538 mm, which gave grain yield of 8.16, 7.57 and 6.46 ton/ha for N1, N2 and N3 treatments, respectively.

Figure (1): Soil water balance for wheat planted under strip length of 25 m and furrow width of 0.65 m in old land site



In the case of cultivating wheat under strip length of 25 m and furrow width of 1.30 m (Figure 2), the highest drainage occurred under the first irrigation and the lowest irrigation occurred under the second and the last irrigations. Comparing Figures (1) and (2), the drained water was lower under wider furrows than narrower furrows. Furthermore, the applied irrigation amount for this treatment was 438 mm, which gave grain yield of 9.23, 8.85 and 8.34 ton/ha for N1, N2 and N3 treatments, respectively.

Figure (2): Soil water balance for wheat planted under strip length of 25 m and furrow width of 1.30 m in old land site



With respect to longer strips (50 m) and narrow furrows (0.65 m), similar trend for drainage was observed, compared to short strips (25 m) and narrow furrows (0.65 m). However, the amount of drainage was lower (Figure 3). Furthermore, the obtained grain yield under this treatment was 8.64, 8.14 and 7.57 ton/ha for N1, N2 and N3 treatments, respectively with a lower amount of irrigation water equal to 482 mm.

Figure (3): Soil water balance for wheat planted under strip length of 50 m and furrow width of 0.65 m in old land site

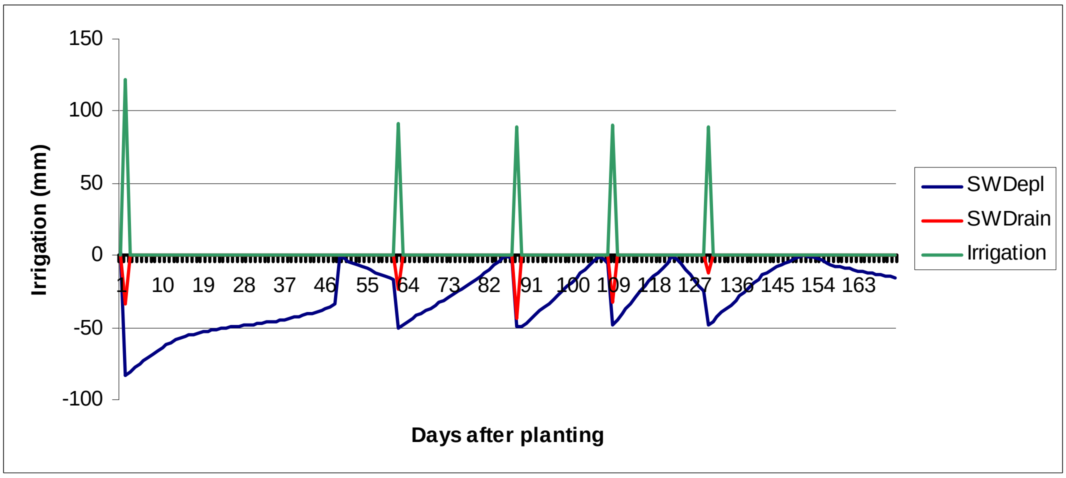
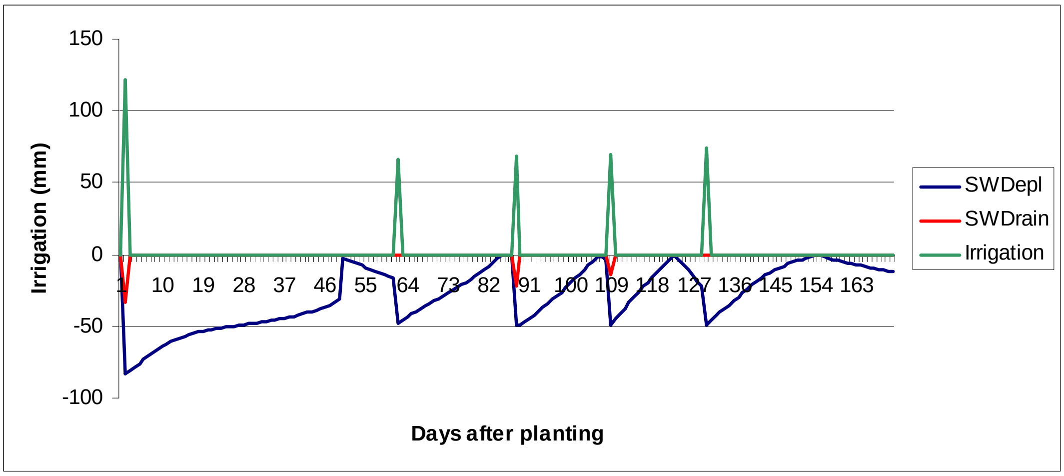


Figure (4) indicated that the applied irrigation amount under strip length of 50 m and furrow width of 1.30 m was the lowest in all the treatments. Furthermore, the drainage amounts were the lowest too. The irrigation amount was 401 mm, which gave a yield equal to 9.44, 9.26 and 8.77 ton/ha for N1, N2 and N3 treatments, respectively. It was the highest yield compared with the rest of the treatments.

Figure (4): Soil water balance for wheat planted under strip length of 50 m and furrow width of 1.30 m in old land site

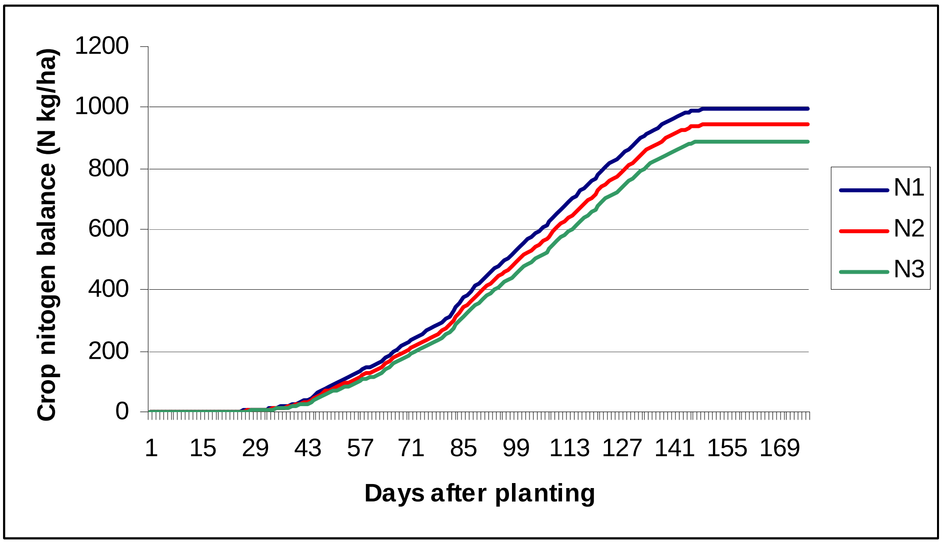


Results in the above Figures suggested that saving of irrigation water associated with high yield could be attained with the proper agricultural practices, i.e. long strips and wide furrow cultivation. Furthermore, these Figures could help in irrigation scheduling using deficit irrigation to reduce water losses by drainage and in the same time to avoid the sensitive growth stages to water stress. Under these circumstances, yield reduction could be minimized.

a1.3. Model sensitivity to nitrogen application

Figure (5) illustrates the sensitivity of the model to nitrogen treatments. N1 (100% of the optimum dose) gave the highest nitrogen balance. This treatment gave the highest yield of wheat under both strip length and furrow width treatments (Table 1). The amount of irrigation associated with that yield was variable depending on both strip length and furrow width. On the contrary, the lowest crop nitrogen balance was found for N3 (75% of the optimum dose), which resulted in the lowest yield. This low yield was produced by the same irrigation amount as the high yield. Results in this graph proved the capability of the model in predicting nitrogen level variability and its reflection on the final wheat yield.

Figure (5): Crop nitrogen balance as affected by nitrogen treatments



a2. Sugar beet roots yield and water consumptive use

a2.1. CropSyst calibration

Low percentage of difference between observed and predicted roots yield of sugar beet values was obtained, as well as low root mean square error, i.e. 0.110 ton/ha. Furthermore, a close to 1 value of Willmott index of agreement was obtained, i.e. 0.999 (Table 2). This result implied the accuracy of CropSyst model because there is a good agreement between measured and predicted values. Gholipouri et al., (2009) developed simple model to predict sugar beet yield. They stated that the simulated average root yield values were similar to observed root yield with root mean square error for roots yield being 3.97 ton/ha.

The results obtained from the calibration of CropSyst model for consumptive use revealed that the percentage of change between measured and predicted values was less than 0.25% (Table 2). Root mean square error was 0.395 mm and Willmott index of agreement was 0.999. Shrestha et al., (2009) reported that BUDGET model predicted sugar beet evapotranspiration with high degree of accuracy.

Table (2): Measured versus predicted roots yield and water consumptive use of sugar beet in 2010/11 growing season

	Grain yield (t/ha)			**Water Consumptive Use (mm)**		
Treatments	**Measured**	**Predicted**	**PC%**	**Measured**	**Predicted**	**PC%**
L1W1N1	77.75	77.73	0.02	595.27	595.10	0.03
L1W1N2	72.50	72.43	0.10	557.95	557.90	0.01
L1W1N3	63.30	63.22	0.13	564.47	564.40	0.01
L1W2N1	90.12	90.10	0.02	469.81	469.60	0.04
L1W2N2	85.50	85.32	0.21	438.29	437.90	0.09
L1W2N3	78.45	78.44	0.02	430.96	430.50	0.11
L2W1N1	83.00	82.88	0.15	536.50	536.20	0.06
L2W1N2	76.61	76.59	0.03	542.20	542.00	0.04
L2W1N3	73.25	73.13	0.17	523.68	523.40	0.05
L2W2N1	91.00	90.83	0.19	423.68	422.70	0.23
L2W2N2	87.00	86.98	0.02	421.05	420.90	0.04
L2W2N3	85.00	84.83	0.20	419.22	418.90	0.08
RMSE	0.110			0.395		
WI	0.999			0.999		

L1W1N1= strip length of 25 m, furrow width 0.65 m and 100% of optimum nitrogen dose; L1W1N2= strip length of 25 m, furrow width 0.65 m and 85% of optimum nitrogen dose; L1W1N3= strip length of 25 m, furrow width 1.3 m and 100% of optimum nitrogen dose; L1W2N1= strip length of 25 m, furrow width 1.3 m and 100% of optimum nitrogen dose; L1W2N2= strip length of 25 m, furrow width 0.65 m and 100% of optimum nitrogen dose; L1W1N3= strip length of 25 m, furrow width 1.3 m and 100% of optimum nitrogen dose; L2W1N1= strip length of 50 m, furrow width 0.65 m and 100% of optimum nitrogen dose; L2W1N2= strip length of 50 m, furrow width 0.65 m and 85% of optimum nitrogen dose; L2W1N3= strip length of 50 m, furrow width 0.65 m and 75% of optimum nitrogen dose; L2W2N1= strip length of 50 m, furrow width 1.3 m and 100% of optimum nitrogen dose; L2W2N2= strip length of 50 m, furrow width 0.65 m and 85% of optimum nitrogen dose; L2W2N3= strip length of 25 m, furrow width 0.65 m and 75% of optimum nitrogen dose; PC%= percentage of difference between measured and predicted yield; RMSE= root mean square error; WI= Willmott index of agreement.

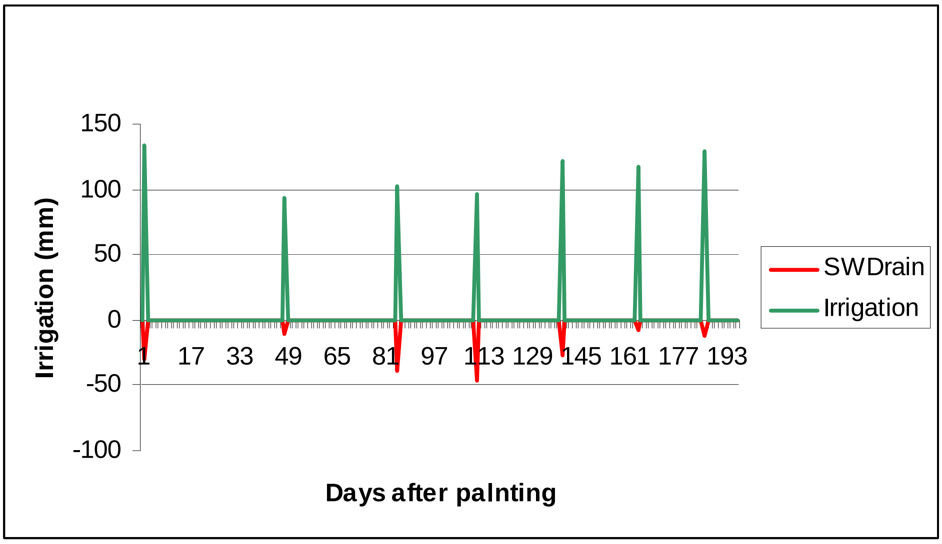
a2.2. Simulation of water balance

Figure (6) showed that the water drainage after the 4th irrigation was the highest. The lowest drainage was observed in the 2nd irrigation. Under planting wheat in strip length of 25 m and furrow width of 0.65 m, the total applied irrigation amount was 795 mm and the produced yield was 77.75, 72.50 and 63.30 ton/ha for N1, N2 and N3, respectively.

Figure (6): Soil water balance for sugar beet planted under strip length of 25 m and furrow width of 0.65 m in old land site

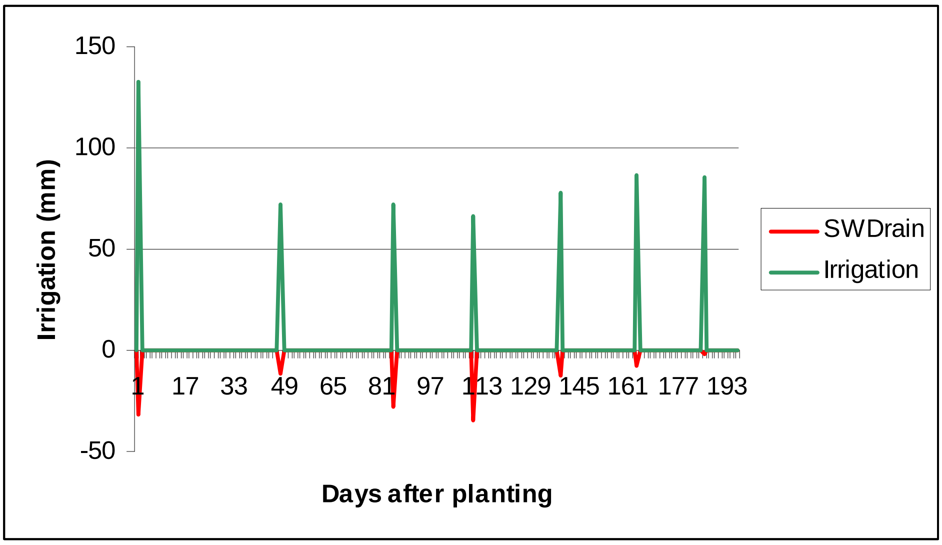
The amount of water that applied under cultivation on strip length of 25 m and furrow width of 1.30 m was 749 mm and gave root yield equal to 90.12, 85.50 and 78.45 ton/ha for N1, N2 and N3, respectively. The drainage of the applied irrigation water was reduced, compared with cultivation on strip length of 25 m and furrow width of 0.65 m, where it was very low for the 2nd, 6th and 7th irrigation (Figure 7).

Figure (7): Soil water balance for sugar beet planted under strip length of 25 m and furrow width of 1.30 m in old land site



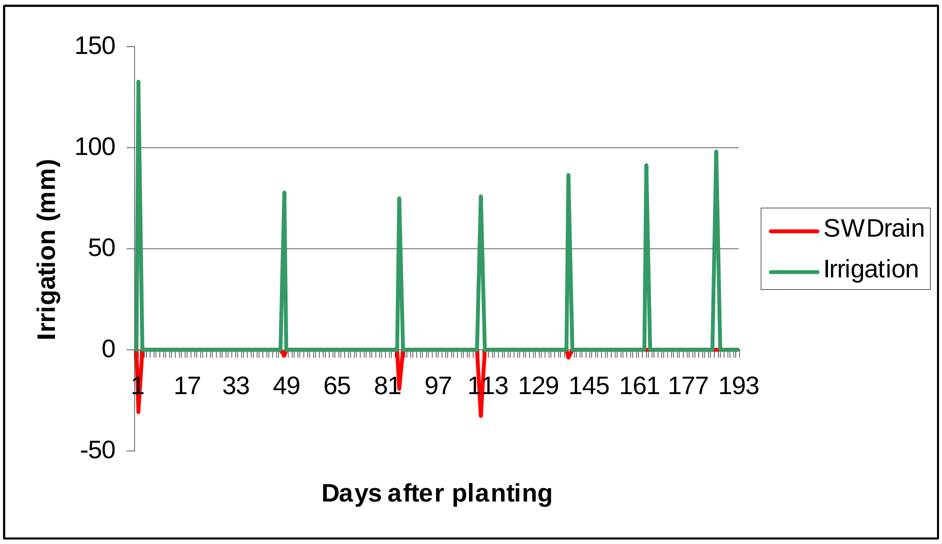
Lower drainage amount in the 2nd, 5th, and 6th irrigation was observed under cultivation on strip length of 50 m and furrow width of 0.65 m (Figure 8). The total irrigation amount was 638 mm and produced yield equal to 83.00, 76.61 and 73.25 ton/ha for N1, N2 and N3, respectively.

Figure (8): Soil water balance for sugar beet planted under strip length of 50 m and furrow width of 0.65 m in old land site



Under cultivation on strip length of 50 m and furrow width of 1.30 m, the total drainage amount was the lowest, i.e. 127 mm out of the applied amount of 594 mm. This amount of irrigation represented the lowest amount of all the treatments, yet produced the highest yield, i.e. 91.00, 87.00 and 85.00 ton/ha for N1, N2 and N3, respectively.

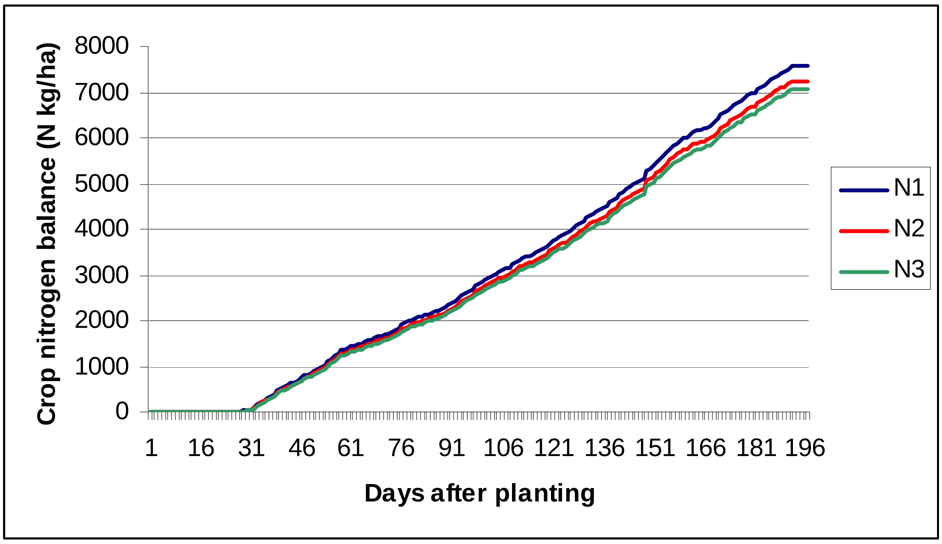
Figure (9): Soil water balance for sugar beet planted under strip length of 50 m and furrow width of 1.30 m in old land site



a2.3. Model sensitivity to nitrogen application

Figure (10) showed that N1 (100% of the optimum dose) gave the highest nitrogen balance and it gradually deceased as nitrogen application decreased. The roots yield associated with the three nitrogen treatments was 91.00, 87.00 and 85.00 tons/ha under N1, N2 (85% of the optimum dose) and N3 (75% of the optimum dose), respectively for sugar beet cultivated on strip length of 50 m and furrow width of 1.30 m. The Figure also showed that the curve of N2 and N3 was almost identical. The reduction in sugar beet yield as a result of N3 application, compared with N2 application was 2%. Therefore, it is better to apply N3 to sugar beet to reduce production costs and reduce ground water pollution by nitrogen fertilizer.

Figure (10): Crop nitrogen balance as affected by nitrogen treatments



b. The sandy soil site

b1. Wheat grain and biological yield

There were good agreements between measured and predicted values by CropSyst model. Percentage of reduction between measured and predicted for grain wheat was less than 1%. Root mean square error was 0.22 and Willmott index of agreement was 0.998. Lobell and Ortiz-Monasterio (2006) stated that CERES-Wheat model was able to predict wheat yield for the different irrigation trials quite well with a root mean square error of 0.23 ton/ha (Table 3).

Calibration of CropSyst for biological yield followed the same pattern as grain yield, where percentage of reduction between measured and predicted was low, root mean square error was low and Willmott index of agreement was close to 1 (Table 3). Singh et al., (2008) reported that RMSE between observed and predicted biomass by CropSyst was 1.27 ton/ha as compared to 1.94 ton/ha between observed and predicted biomass by CERES-Wheat. Ouda et al., (2010) reported that CropSyst model performance was highly acceptable, where RMSE was 0.137 and 0.0262 ton/ha between measured and predicted grain and biological yield, respectively. Willmott index of agreements was 0.9864 and 0.9721 for grain and biological yield, respectively.

Table (3): Measured versus predicted grain and biological yield of wheat grown in 2010/11 growing season

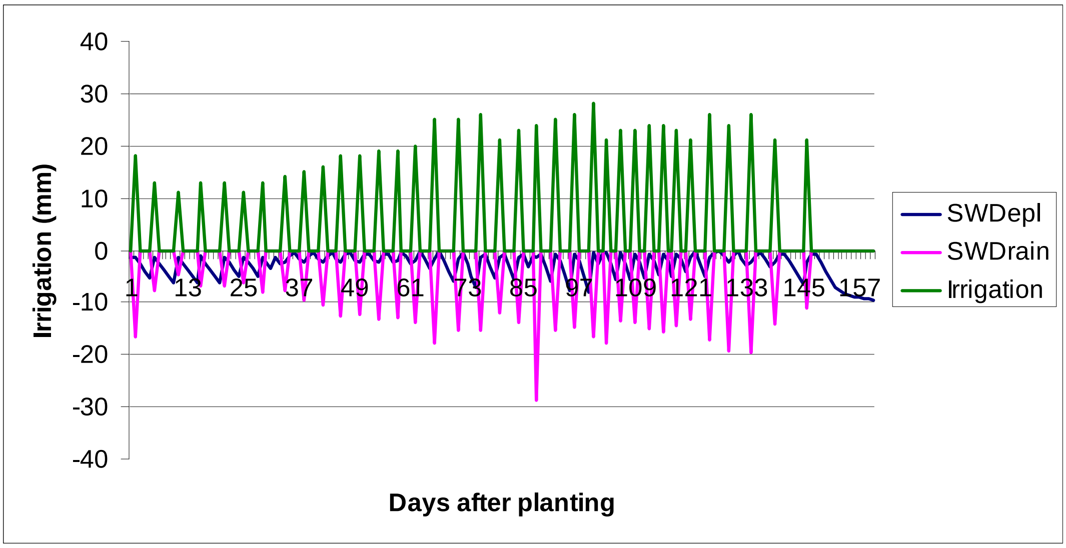
	Grain yield (t/ha)			Biological yield (t/ha)		
Treatments	**Measured**	**Predicted**	**PC%**	**Measured**	**Predicted**	**PC%**
I1N1	4.34	4.33	0.43	14.48	14.42	0.41
I1N2	5.17	5.14	0.65	17.25	17.14	0.64
I2N1	5.64	5.62	0.39	18.82	18.74	0.38
I2N2	5.56	5.54	0.26	18.52	18.48	0.26
I3N1	4.99	4.97	0.42	16.64	16.57	0.42
I3N2	4.46	4.45	0.15	14.86	14.84	0.15
RMSE	0.022			0.014		
WI	0.998			0.999		

I1N1= irrigation when soil tension 10 kPa and 100% of the optimum dose; I1N2= = irrigation when soil tension 10 kPa and 75% of the optimum dose; I2N1= irrigation when soil tension 15 kPa and 100% of the optimum dose; I2N2= irrigation when soil tension 15 kPa and 75% of the optimum dose; I3N1= irrigation when soil tension 15 kPa and 100% of the optimum dose; I3N2= irrigation when soil tension 15 kPa and 75% of the optimum dose.

b2. Simulation of water balance

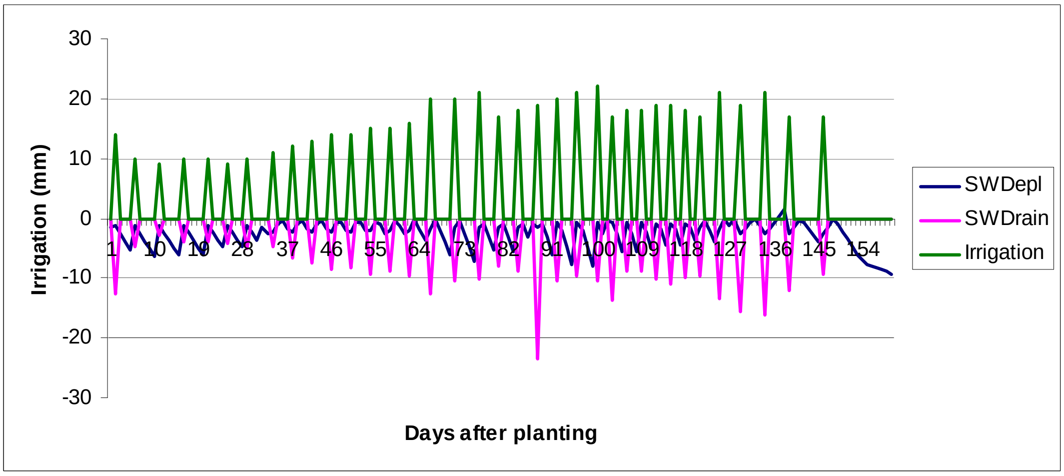
Nubaria soil is characterized by being sandy soil. Therefore water depletion is fast and this requires a large number of irrigations. Under irrigating wheat when soil tension was 10 kPa (over irrigation), Figure (11) showed that soil water drainage (SWDrain) was higher for the first irrigation. During the period 65-75 days after planting, three high irrigations were applied (heading stage). The highest value of drainage occurred 86 days after planting, where rain fell down in the following day and that increased the drainage amount. Furthermore, at the end of grain milk stage, the drainage was high for three irrigations (123-132 days after planting). The total amount of irrigation was 726 mm and resulted in grain yield of 4.34 and 5.14 ton/ha under N1 (optimum nitrogen applications) and N2 (75% of the optimum nitrogen applications) treatments.

Figure (11): Soil water balance for wheat irrigated when soil tension was 10 kPa



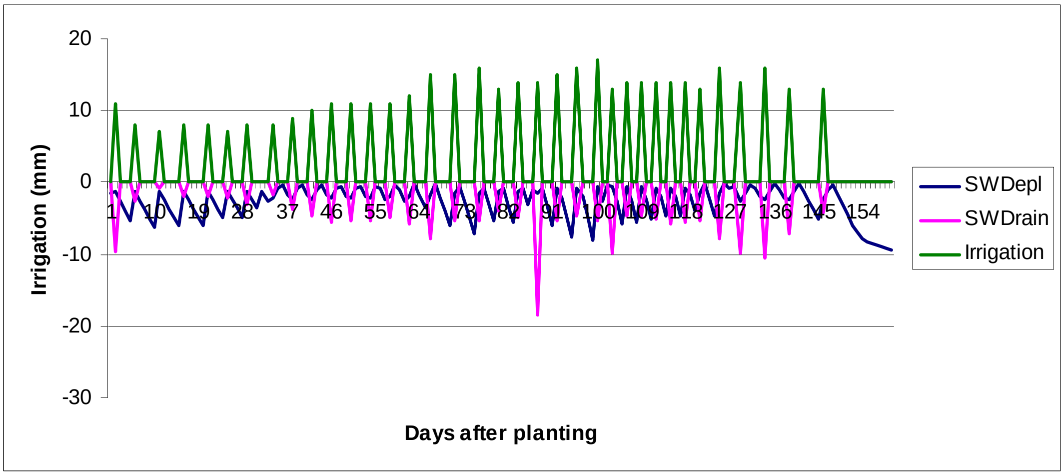
Similar trends were observed for water depletion under irrigating wheat when soil tension was 15 kPa. However, the applied water was lower, i.e. 581 mm and the produced yield was higher 5.64 and 5.56 ton/ha under N1 and N2 treatments, respectively (Figure 12).

Figure (12): Soil water balance for wheat irrigated when soil tension was 15 kPa



Lower depletion was observed under irrigating wheat one day after soil tension reached 15 kPa, where the applied irrigation amount was 436 mm and the produced yield was 4.99 and 4.46 ton/ha under N1 and N2 treatments, respectively (Figure 13).

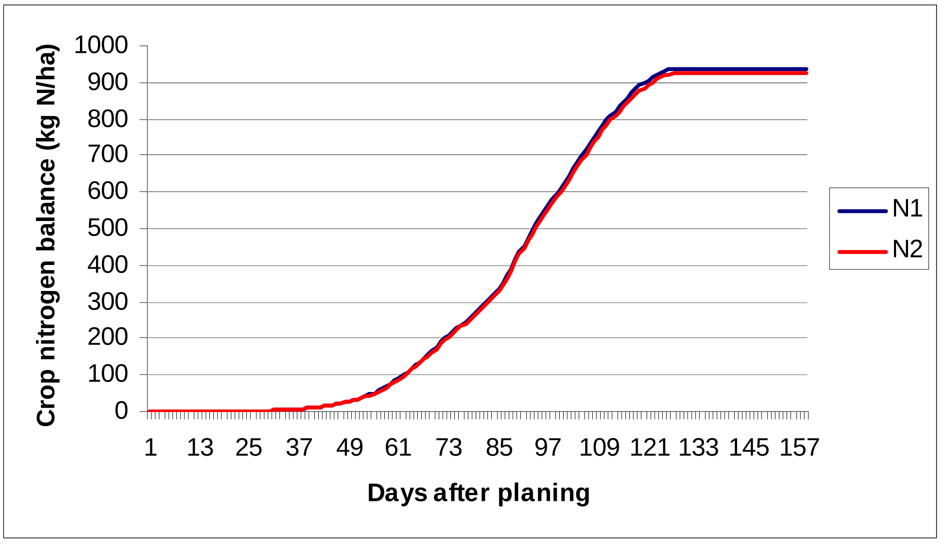
Figure (13): Soil water balance for wheat irrigated one day after soil tension reached 15 kPa



b3. Model sensitivity to nitrogen application

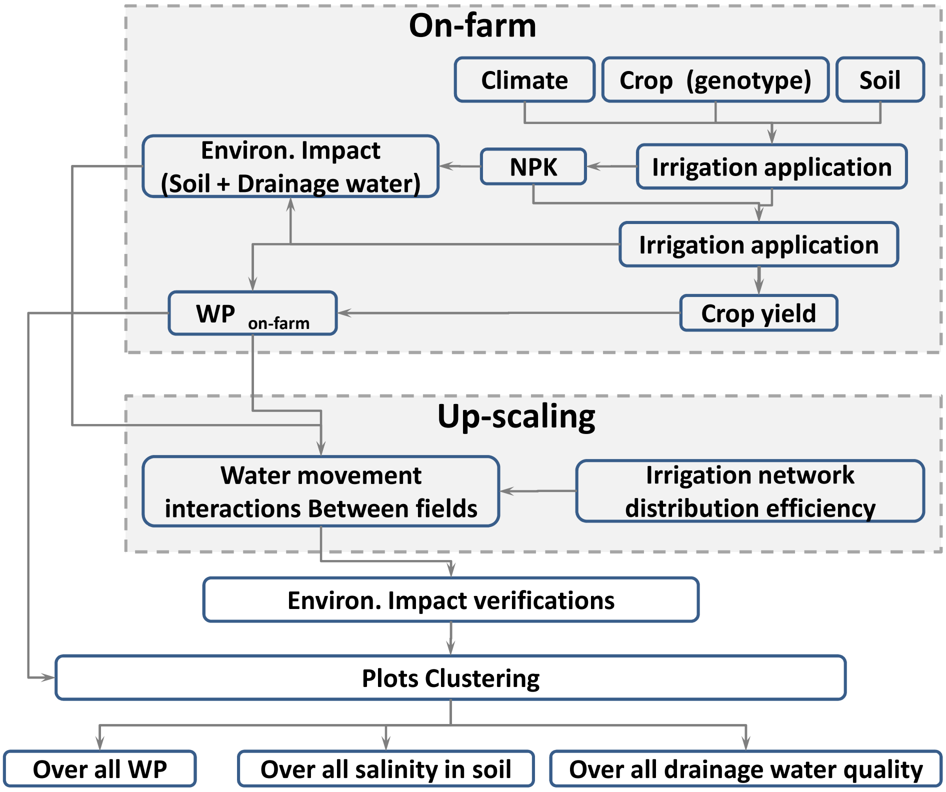
Figure (14) illustrates that crop nitrogen balance was almost identical under the two nitrogen treatments (N1 and N2) and the application of optimum irrigation water, where the produced yield was the highest, i.e. 5.64 and 5.56 ton/ha. This result suggestes that using 75% of the optimum nitrogen treatment could produce similar yield and similar crop nitrogen balance, compared to the application of optimum nitrogen treatment. Therefore, reducing the application of nitrogen could be beneficial to reduce ground water pollution and reduce production costs.

Figure (14): Crop nitrogen balance as affected by nitrogen treatments under optimum irrigation



Develop the final framework of the model analysis

The final general framework of modeling analysis was established through another meeting conducted at the NWRC at the last week of December 2010. Dr. Nahla, Dr. Shereef, and Dr. Samar outlined the final framework that will link the on-farm modeling level with up-scaling modeling level, which should be worked via one integrated user-friendly application. This framework is presented below.



Activity 5: Capacity Building

The Modeling component teamwork discussed and suggested to conduct a regional training workshop in Egypt. This training workshop is aiming to improve the capacity of the modeling component teamwork's at the different benchmarks sites under the project, in the field of water productivity modeling analysis. It is proposed to invite high level experts to cover the following topics:

- Advances on water productivity and water balance modeling analysis,
- The application of spatial analysis in water productivity analysis (from farm to regional scale),
- The linkage between on-farm models and spatial tools in water productivity analysis,
- SPAW and SALTMED model (as important examples).

This suggested training workshop could be held at the second week of December 2011.

Component III: Site Characterization Socio-economic Study:

#

Activity 1: Farm-level economic assessment of recommended water management technologies including deficit irrigation and raised-bed

Objectives:

- Analysis of farmer's perception, awareness and adoption of the recommended water management technologies.
- Identification of resource, policy and institutional constraints to further adoption of the recommended water management technologies
- Economic evaluation of the best-bets packages of water management technologies and their impact on productivity, efficiency, farmer's income, resource base and the environment

Methodology:
This activity was divided into 4 sub-actvities described below:

- Conduction of six participatory group discussions in the three agro-ecosystems in Egypt, Old Lands, Salt-affected Lands, and New Lands and two participatory group discussions for each agro-ecosystem (one in the benchmark Site of Phase 1 and the other one in the benchmark Site of Phase 2).
- Conduction of the socio-economic farm and household surveys.
- Conduction of an in-site training workshop on the Socio-economic and Household Surveys of the Project. The target group of this training was the enumerators who will collect the data needed for these surveys from the three benchmark Sites of the Project. This mission has to be carefully carried out since its outputs are very important to make the necessary modifications needed for the questionnaire as well as give the chance for the enumerators to get acquainted with the questions and seek clarification from farmers and researchers.
- Team meetings and meetings chaired by Prof. Aden Aw-Hassan, Director of ICARDA Social, Economic and Policy Research Program (SEPRP) to discuss aspects related to the conduction of the socio-economic farm and household surveys i.e. the sampling frame for the three target sites, sample size, the questionnaire .. etc. (a list of these meeting in details are in the Annex):

Description of the sub-activities:
A pair of participatory group discussions was conducted in each of the three agro-ecosystems in Egypt; Old Lands, Salt-affected Lands, and New Lands selected to conduct the current study. One participatory group discussion was conducted with farmers and other stakeholders at the three Sites of Phase I whereas, the other participatory group discussion was conducted with farmers and other stakeholders at the three sites of Phase II. In this regard, a checklist was prepared and used to be sure that all the questions that cover the needed information are included. Moreover, the participatory group discussion method was used to promote active involvement of farmers and stakeholders in identifying some aspects, especially the adoption of technologies recommended by phase I of the Water Benchmark Project (WBM). The key issues discussed

were: soil, irrigation, cropping pattern, income, adoption of technologies recommended by phase I of WBM, farmers' skills, awareness and attitudes, farmers' participation/associations, the role of rural women, livestock, labour, agricultural marketing, infrastructure and services, and main problems and challenges facing farmers.

As for the Old Lands' Sites, a participatory group discussion was conducted with farmers and other stakeholders in the site of Phase I located at Menoufia Governorate whereas, the other participatory group discussion was conducted with farmers and other stakeholders in the site of Phase II located at Sharkia Governorate. As for the Salt-affected Lands, a participatory group discussion was conducted with farmers and other stakeholders in the site of Phase I located at Damietta Governorate whereas, the other participatory group discussion was conducted with farmers and other stakeholders in the Site of Phase II located at Sharkia Governorate. As for the New Lands, the two participatory group discussions were conducted in the site of Phase I and Phase II located at Behaira Governorate as illustrated in Figure (1).

1 - Behaira Governorate (two PGDs)	4 - Menoufia Governorate (one PGD)
7 - Sharkia Governorate (two PGDs)	8 - Damietta Governorate (one PGD)

Figure 1: A map showing the locations where the six PGDs were conducted in the benchmark sites

The main results/achievements of this study are:

1. Results of the two participatory group discussions conducted at the Benchmark Sites in the Old Lands:

1.1. <u>First participatory group discussion</u>: It was conducted in 17/01/2011 with farmers and other stakeholders (i.e. manager of the agricultural co-operative and extension engineer in the studied area) at the Old Land Site of Phase I located at Kafr Abshish Village, Quesna

District, Menoufia Governorate in North Delta, Lower Egypt. Moreover, the total area of Kafr Abshish Village is about 245 Ha, out of which about 223 Ha of cultivated area.

A part of the Participatory Group Discussion conducted in Kafr Abshish Village.

Nevertheless, the attendants reported the following:

- Soils are mainly clay, either black heavy clay or light clay.
- El Menira Mesqa is the main source of irrigation water. However, Alatf and Om Ahmed Canals supply water irrigation to the main water irrigation source. Moreover, Alatf Secondary Canal retains two irrigation systems; the traditional non-improved systems and the improved systems. Besides, Alatf Secondary Canal passes through two governorates namely, Menoufia and Gharbia.
- Kafr Abshish Village is divided into two different groups based on the improvement status of El Menira Mesqa; the first group represents the improved mesqa and the other group represents the non-improved mesqa (traditional mesqa). Moreover, El Menira Mesqa which is fed from Alatf Canal represents the improved mesqa whereas, El Menira Mesqa which is fed from Om Ahmed Canal represents the non-improved mesqa (traditional mesqa).

Non-improved (traditional) Mesqa **Improved Mesqa**

The non-improved and improved mesqas in Kafr Abshish Village.

- Water flow is continuous in the improved mesqa whereas, it is based on irrigation cycle of seven days in the non-improved mesqa. However, water shortage occurs in common, especially in summer season. On the other hand, farmers usually use groundwater lifted from wells via lifting pumps when water shortage occurs. Besides, farmers suffer from low level of water irrigation in the upstream irrigation pipes. Nevertheless, traditional irrigation technique; flood irrigation is common.

Flood irrigation is common.

- Some Water User Associations (WUAs) are established.
- Tile drainage system is common. However, this system is not perfectly working due to poor installment and lack of supervision.
- Berseem and wheat are dominant in winter, covering about 60% and 40% of the total cultivated area in winter, respectively. However, maize is dominant in summer, covering about 70% of the total cultivated area. Besides, vegetables and cotton are also cultivated in summer, covering about 29% and 1% of the total cultivated area in summer, respectively.
- Berseem and wheat are the most profitable crops in winter since their net revenues are estimated at about L.E. 1641 and 1716 per Ha, respectively. However, maize and cotton are the most profitable crops in summer due o their net revenues which reach about L.E. 463 and1432 per Ha, respectively.
- Farmers usually use raised-bed technique and they intend to use it in the coming cultivation seasons. The main reasons behind this are the advantages they acquired from this technique since it is easy to apply, it does not require a large number of labour to prepare the land for cultivation, it saves time and labour needed for hoeing and weeding, it saves water irrigation as well as reducing the pump operating time, it saves some inputs i.e. fertilizers, and finally it increases the yields per planted area for some crops by about 10%, consequently increases the farmer's net revenue by about 22-47% (these percentages are roughly estimated by farmers).
- Farmers know water requirements for their cultivated crops. However, they depend on their own skills in irrigation. Besides, farmer's knowledge, perception and attitude are appropriate for different agricultural operations.
- Rural women help their husbands in performing some agricultural operations i.e. planting, fertilizing, weeding, hoeing, and harvesting as well as preparing the raised-beds. On the other hand, women play a vital role in disseminating recommended techniques. Besides, rural women can easily convince their neighbors with new techniques.
- Livestock is common.

The main problems and challenges facing farmers are:

- Insufficient water irrigation supplied for farmers located at the end of the canals.
- Poor and inefficient maintenance of irrigation canals and drains.
- Poor installment and lack of supervision on the tile drainage system.
- Insufficient agricultural financing and credit services.
- High prices of inputs, namely chemical fertilizers.
- Labour wages represent most of the variable costs for the main crops cultivated in the studied area.

1.2. Second participatory group discussion: It was conducted in 28/02/2011 with farmers and other stakeholders (i.e. leader farmer and extension engineer in the studied area) at the Old Land Site of Phase II, located at El Zankalon Village, Zagazig District, Sharkia Governorate at East Nile Delta, Lower Egypt. Furthermore, the total area of El Zankalon Village is about 1449 Ha, out of which about 1384 Ha of cultivated area, representing about 96% of the total area.

A part of the Participatory Group Discussion.

- Nevertheless, the attendants reported the following:
- Soils are mostly heavy clay.
- El Afandi Canal (fresh water) which is fed from Bahr Mouwes is the main source of water irrigation. However, the chemical analysis indicated that water in El Afandi Canal is suitable for irrigation purposes.
- Traditional irrigation technique; flood irrigation is common. Moreover, water shortage occurs in common, especially in summer season. Besides, high water table and soil salinity are common.
- The irrigation system is not improved yet and as a result, no Water User Associations (WUAs) have been established, yet.
- Agricultural drainage services are very poor and inefficient. However, tile drainage system exists. Besides, the tile drainage network needs maintenance.

- Wheat, berseem and vegetables are dominant in winter, covering about 54%, 28% and 18% of the total cultivated area in winter, respectively. However, rice, maize and vegetables are dominant in summer, covering about 55%, 27% and 18% of the total cultivated area in summer, respectively.
- Berseem and wheat are the most profitable crops in winter since their net revenues are estimated at about L.E. 1641 and 1255 per Ha, respectively. However, maize and rice are the most profitable crops in summer due o their net revenues which reach about L.E. 882 and 1308 per Ha, respectively.

El Zankalon Water Research Station

- Farmers usually use raised-bed technique but, traditional farmer's cultivation practice is common in rice cultivation. Nevertheless, farmers intend to use it in the coming cultivation seasons. The main reasons behind this are the advantages they acquired from this technique since it saves time and labour needed for hoeing and weeding, it improves plant distribution, it saves water irrigation by about 30% as well as saving irrigation costs by about 20%, as well as saving some inputs i.e. fertilizers by about 20%, and finally it increases the net revenue for some crops by about 10-25% (these percentages are roughly estimated by farmers). On the other hand, mechanical harvesting for some crops cultivated according to the raised-bed technique i.e. wheat is difficult. However, this problem can be solved via modifying the dimensions of the harvesting tractors.

Farmers using the raised-bed technique on wheat in El Zankalon Village

- Farmers know water requirements for their cultivated crops. However, they depend on their own skills in irrigation since they are aware of the proper time for irrigation according to each stage of growth. Besides, farmer's knowledge, perception and attitude are appropriate for different agricultural operations.
- Rural women help their husbands in performing some agricultural operations i.e. planting, weeding, and harvesting. On the other hand, women contribute to decision making for agricultural activities with their husbands and they play a vital role in disseminating new agricultural techniques. Besides, women can explain the advantages of using new agricultural techniques and they can easily convince their neighbors and friends with new techniques, especially when they go to the village market or during performing agricultural operations.
- Livestock is common.

The main problems and challenges facing farmers are:

- Insufficient water irrigation supplied for farmers located at the end of the canals.
- Non-improved irrigation system.
- Poor and inefficient agricultural drainage services.
- Difficulties in land leveling due to land fragmentation.
- Insufficient agricultural financing and credit services, especially for short and med-term loans.
- High prices of inputs, namely chemical fertilizers.
- Labor wages represent most of the variable costs for the main crops cultivated in the studied area.
- Lack of good varieties of seeds.
- Absence of effective marketing channels.
- Lack of the effective agricultural co-operatives.
- Lack of concentrated fodders i.e. bran and high costs and prices of fodders.
- Lack of veterinary care.
- Poor agricultural extension services.

2. Results of the two participatory group discussions conducted at the Benchmark Sites in the Salt-affected Lands:

<u>2.1. First participatory group discussion:</u> It was conducted in 19/01/2011 with farmers and other stakeholders at the Salt-affected Land Site of Phase II located at South El Husainia Plain, Sharkia Governorate, South of East Delta Region, Lower Egypt. However, the reclaimed area in East Delta Region includes six parts covering about 85 thousand ha.

A part of the Participatory Group Discussion conducted in South El Husainia.

Nevertheless, the attendants reported the following:

- Soil is mainly light-clay-salty, some areas are alkali, and others are mixed. Consequently, soil needs good washing to reduce salt concentration.
- Soil fertility is poor. Thus, crops' yields are very low. Besides, farmers burden high prices of inputs, especially for fertilizers. However, the average price per Ha varies according to the location, soil fertility, soil salinity, source of irrigation water, and quality of irrigation water.
- Al Salam Canal is the main source of irrigation water. However, three types of irrigation-water-quality prevail in South El Husainia Plain; mainly mixed water especially in winter rather than in summer, drainage water especially in summer, and fresh irrigation water abstracted from El Salam Canal.
- No quota of water irrigation allocated for the land after reclamation. Thus, water irrigation does not follow an irrigation schedule, resulting in some social problems among farmers. Besides, water shortage occurs due to insufficient water at the end of canals, especially in the villages located far from the main canal i.e. El Noras, El Etehad and El Amany Villages. Moreover, some irrigation outlets are located at higher level than canal water-level, thus, insufficient irrigation water is charged and lifted to farmers' fields at high costs.
- Traditional irrigation technique; flood irrigation is common. Besides, only 40% of the area is served by irrigation pumps. This case result in many problems i.e. irregular time for irrigation, delay in land preparation and crop cultivation, decrease crops' yields and decrease farm income. On the other hand, the power of the irrigation pump is insufficient to meet water irrigation requirements for different crops. Thus, farmers burden high irrigation costs, especially for fuel consumed for pumping operation.

- Some Water User Associations (WUAs) are established.
- Port Said Drainage Station is not working efficiently, and it is always out of order.
- Crop cultivation does not follow a certain crop rotation and the cropping patterns are not fixed. However, the main crops cultivated in winter 2009/2010 were sugar beet (50%), berseem (30%), wheat (10%), and other crops (10%) i.e. broad bean and vegetables (onion). Besides, the main crops cultivated in summer 2010 were rice (40%), cotton (40%), maize (10%), and other crops (10%) i.e. amshaut and vegetables i.e. tomato. Moreover, soil is not suitable to cultivate some other crops due to the relatively high level of salinity.
- Berseem and sugar beet (especially when manufacture contracts are correctly implemented) are the most profitable crops in winter since their total revenues are estimated at about L.E. 3360 and 1726 per Ha, respectively. Besides, their gross margins reach about L.E. 2627 and 680 per Ha, respectively. However, their percentages of total returns to variable costs are estimated at about 4.6% and 1.7%, respectively. On contrary, the average yield of wheat is very low, reaching about 0.75 ton as compared to Egypt's average yield of about 2.71 ton due to high soil salinity. Consequently, wheat is not profitable since the total revenue is estimated at about L.E. 473 per Ha whereas, the variable costs are estimated at about L.E. 582 per Ha. On the other hand, cotton and rice seem to be the most convenient crops in summer for most farmers since they believe in them as good sources of income due to their total revenues which reach about L.E. 2268 and 1764 per Ha, respectively. Besides, their gross margins reach about L.E. 916 and 790 per Ha, respectively. However, their percentages of total returns to variable costs are estimated at about 1.7% and 1.8%, respectively. On contrary, the average yield of maize is very low, reaching about 1.4 ton as compared to Egypt's average yield of about 3.4 ton due to high soil salinity thus, maize is hardly profitable.
- Farmers heard about the raised-bed and deficit irrigation techniques but, they never use them. However, some farmers have attended a workshop on the raised-bed technique in the Agricultural Research Center (ARC), Ismailia City and in Badr District at South of Tahrir.
- Farmers do not know water requirements for their cultivated crops. However, they depend on their own skills in irrigation.
- Most of the agricultural operations of the cultivated crops in winter and summer are performed by hired teenage girls. However, female labour represents 70% of total human labour. Moreover, some women who own farms manage and cultivate their farms by themselves. Besides, there are 30 female rural leaders.
- Livestock is common.

The main problems and challenges facing farmers are:

- Insufficient water irrigation.
- Poor and inefficient maintenance of irrigation canals.

Poor maintenance of irrigation canals in El Husainia.

- Poor and inefficient agricultural drainage services.
- Insufficient agricultural financing and credit services since merchants provide finance to small and poor farmers on restrictive conditions. These farmers never get a fair price to their crops. In addition, they get their inputs from these merchants at relatively high level of prices.
- High prices of inputs, namely chemical fertilizers.
- Graduates who sold their lands to other farmers still have negative impact on the new owners since these graduates have the rights to buy inputs at subside prices thus, creating problems for new owners.
- Absence of agricultural extension services due to insufficient members of the agricultural extension. Moreover, agricultural extension does not play a vital role in advising farmers to use new developed or modern farming practices or techniques.
- Absence of specialized health care services, especially for women.
- Poor and inefficient infrastructures.
- Lack of sufficient houses for households.
- Lack of means of transportation, especially in the evening.
- Long distance between houses and agricultural lands.

2.2. <u>Second participatory group discussion</u>: It was conducted in 9/02/2011 with farmers and other stakeholders (i.e. former chairman of the Agricultural Research Station at El Serw) at the Salt-affected Land Site of Phase I, located at El Serw, Zarka District, south Damietta Governorate in North Delta, Lower Egypt.

Nevertheless, the attendants reported the following:

- Soil is mainly salty since it is located nearby the Mediterranean Sea. Consequently, soil needs good washing to loose salt. However, soil is relatively damaged because of irrigating with saline irrigation water. Besides, maintaining higher yield levels in this area is endangered by the rising water table, soil salinity, pollution caused by heavy use of bad quality and quantity of irrigation water. Moreover, the average price per Ha is estimated at about L.E. 63-84 thousands.
- El Serw Drain is the main source of water irrigation, especially in summer. Besides, traditional irrigation technique; flood irrigation is common. Moreover, rotation is the system of irrigation for the irrigation canals. The on-going rotation is four days wet and six days dry. Nevertheless, water irrigation shortage usually occurs, especially in summer months i.e. May, June, July and August. Furthermore, weeds are found in some irrigation canals.
- The irrigation system is not improved yet. Thus, Water User Associations (WUAs) are not established. Moreover, farmers have no information about the improved irrigation system and Water User Associations (WUAs).
- Maintenance of El Serw Drain is poor and inefficient.
- Wheat and berseem are dominant in winter, covering about 50% and 40% of the total cultivated area in winter, respectively. Besides, other crops i.e. broad bean and vegetables cover about 10% of the total cultivated area in winter. However, farmers mainly cultivate two crops in summer; rice and cotton, covering about 50% and 40% of the total cultivated area in summer, respectively. Moreover, vegetables are also cultivated in summer, covering about 10% of the total cultivated area in summer. Nevertheless, soil is not suitable to cultivate some other crops due to the relatively high level of salinity.
- Berseem and wheat are the most profitable crops in winter since their total revenues are estimated at about L.E. 1848 and 1915 per Ha, respectively. Besides, their gross margins reach L.E. 1201 and 1172 per Ha, respectively. However, their percentages of total returns to variable costs are estimated at about 2.9% and 2.6%, respectively. On the other hand, cotton and rice seem to be the most convenient crops in summer for most farmers since they believe in them as good sources of income due to their total revenues which reach L.E. 4536 and 2205 per Ha, respectively. Besides, their gross margins reach L.E. 3186 and 672 per Ha, respectively. However, their percentages of total returns to variable costs are estimated at about 3.4% and 1.4%, respectively.

- Raised-bed technique is common in wheat and cotton cultivation. The main reasons behind this are the advantages farmers acquired from this technique since it saves time, energy, labour, water irrigation and inputs i.e. seeds, it enhances the drainage performance, and it increases the yields for some crops. On the other hand, this technique requires hiring more labour for weeding, thus increasing labour costs. Besides, some farmers have attended a workshop on the raised-bed technique in the Agricultural Research Center (ARC), El Serw Agricultural Station. However, the Agricultural Research Station in El Serw plays an important role in spreading and using the raised-bed technique among the target farmers via conducting workshops and group discussion meeting, publishing extension pamphlets and brochures distributed to promote the target farmers to adopt the raised-bed and deficit irrigation techniques.

Farmers using the raised-bed technique in El Serw.

- Farmers do not know water requirements for their cultivated crops. However, they depend on their own skills in irrigation.
- Most of the agricultural operations of the cultivated crops in summer i.e. rice and cotton are performed by hired teenage girls. However, female labour represents 30% of total human labour. Moreover, some women who own farms manage and cultivate their farms by themselves.
- Livestock is common.

The main problems and challenges facing farmers are:

- Poor and inefficient irrigation infrastructure.
- Poor and inefficient maintenance of irrigation canals.
- Poor maintenance of El Serw Drain.

Poor maintenance of El Serw Drain

- Insufficient agricultural financing and credit services.
- Absence of agricultural extension services.
- Spread of dangerous diseases i.e. liver and kidney failures among farmers due to the use of El Serw Drain as a main source for water irrigation in summer. However, El Serw Drain receives sewage of households. Therefore, El Serw Drain is a main source of such dangerous diseases.

3. Results of the two participatory group discussions conducted at the Benchmark Sites in the New Lands:

3.1. <u>First participatory group discussion</u>: It was conducted in 17/02/2011 with farmers and other stakeholders at the New Land Site of Phase II located at Salah Al Abd Village, El Bustan 3, El Entelak Zone, Wady El Natroun District, Behaira Governorate at West Delta, Lower Egypt. Moreover, the cultivated area of Salah Al Abd Village is about 819 Ha owned by 780 settlers of displaced farmers from the old lands; each settler holds about 1.05 Ha.

A part of the Participatory Group Discussion conducted in Salah Al Abd Village.

Nevertheless, the attendants reported the following:

- Soils are mainly sandy with sand fraction and soil is essentially desert sands with extremely low moisture retention capacity, high infiltration rates and virtually no intrinsic mineral fertility. Besides, soil is poor in the nutrient contents, especially potassium. Moreover, the average price per Ha varies according to the location, soil fertility and irrigation status. However, it is estimated at about L.E. 25-34 thousands.
- Nubaria Canal is the main source of water irrigation. However, two irrigation systems prevail, namely sprinkler and drip irrigation systems. Besides, sprinkler irrigation system is common in lands cultivated by field crops, representing about 50% of the total cultivated area in the Village. Moreover, drip irrigation system is common in lands cultivated by horticulture, representing about 50% of the total cultivated area in the Village.
- Rotation is the system of irrigation for the irrigation canals. The on-going rotation is three days wet and three days dry. However, water shortage occurs in common, especially in summer season and water irrigation supplied according to the rotation system is insufficient, especially for farmers located at the end of the canals. Moreover, big investors have the accessibility to use most of the water in the Canal but, settlers do not have this chance.
- Construction of canal lining is designed on the basis that irrigation occurs every day. However, lined canals do not have enough room for water irrigation according to the rotation system of irrigation; three wet days. Besides, electricity cuts off in the three wet days in common thus, decreasing the wet days to one or two wet days. On the other hand, each eight plots are irrigated at once. However, if one farmer owning a plot of these eight plots did not pay his bill of electricity consumption, Electricity Company cuts electricity off in the eight plots. Nevertheless, accumulating unpaid bills of electricity consumption for some farmers leads to cut electricity off and stop electric irrigation machines.
- High cost of electricity consumption for running electric irrigation machines is a big problem facing farmers since these costs reach about L.E. 600 for one plot (1.05 Ha). These costs are paid twice a year. Besides, farmers have to pay L.E. 200 and L.E. 200 for land guarding and other services, respectively.
- Some Water User Associations (WUAs) are established.
- There is no drainage system, whether open or subsurface.

- Selection of the cropping pattern is based on market conditions and crop labour requirements. However, about 50% of the total area is cultivated by vegetables and field crops i.e. maize, sesame, wheat, and berseem. Besides, about 50% of the total area is cultivated by horticulture i.e. citrus (40%), peach and apricot (10%). Particularly, berseem, wheat and vegetables (i.e. potato, bean, carrot, onion, garlic, pea, and artichoke) are dominant in winter, covering about 20%, 20% and 60% of the total cultivated area in winter, respectively. On the other hand, groundnut and vegetables (i.e. tomato, potato and bean) are dominant in summer, covering about 70% and 23% of the total cultivated area in summer, respectively. Besides, maize and sesame are also cultivated in summer, covering about 5% and 2% of the total cultivated area in summer, respectively.
- Some farmers heard about the deficit irrigation technique but, they never use it. However, they want to use this technique as long as it is useful. However, deficit irrigation technique is not common. However, agricultural engineers are trained on deficit irrigation technique to transfer this technology to farmers.
- Farmers are unaware of the time span required for irrigating their cultivated crops, and the proper time for irrigation according to each stage of growth. However, farmers stop irrigation for one plot depending on their experience and skills. In general, farmers depend on their experience and skills in performing different agricultural operations.
- Most agricultural operations are performed by family labour since labour shortage is common. However, some agricultural practices are performed by hired labour.
- Rural women help their husbands in performing some agricultural operations. However, they play a vital role in disseminating recommended techniques.
- Raising cows is common.

The main problems and challenges facing farmers are:

- Insufficient water irrigation supplied for farmers located at the end of the canals, especially in the villages located far from the main canal.
- Poor and inefficient maintenance of irrigation canals.
- Insufficient agricultural financing and credit services.
- High cost of electricity.
- High prices of inputs, namely chemical fertilizers.
- Labour wages represent most of the variable costs for the main crops cultivated in the studied area.

3.2. Second participatory group discussion: was conducted in 17/02/2011 with farmers and other stakeholders at the New Land Site of Phase I, located at Al Hussein Village, El Bustan 2, El Dalangat District, Behaira Governorate at West Delta, Lower Egypt. Moreover, the cultivated area of Al Hussein Village is about 1386 Ha owned by 660 settlers. Each farmer settled 2.1 Ha according to the Law of Lands Settlements. Thus, all settlers own the same land area; 2.1 Ha.

However, some settlers sold their lands to other settlers and preferred to return to their original places. Other settlers rented out their lands and preferred to return to their original places although they are still legally tied to their land. Nevertheless, most farmers were settled at the same time; in the years 1988 and 1989. The earliest arrivals were in 1988 and the latest in 1989. Furthermore, all settlers are university or high school graduates.

A part of the Participatory Group Discussion conducted in Al Hussein Village.

Nevertheless, the attendants reported the following:

- Soils are mainly sandy with sand fraction and soil is essentially desert sands with extremely low moisture retention capacity, high infiltration rates and virtually no intrinsic mineral fertility. Besides, soil is poor in the nutrient contents, especially potassium. Nevertheless, farmers add manure and chemical fertilizers to improve soil fertility, On the other hand, weeds are found. However, farmers apply both manual and chemical weed controls. Furthermore, nematodes, berseem and bean dodders are found. However, farmers apply both manual and chemical pest control. Moreover, the average price per Ha varies according to the location, soil fertility and irrigation system. However, it is estimated at about L.E. 29-42 thousands.
- El Bustan 2 Secondary Canal branching from Nubaria Canal is the main source of water irrigation. However, two irrigation systems prevail, namely sprinkler and drip irrigation systems. Besides, sprinkler irrigation system is used in lands cultivated by field crops, representing about 20% of the total cultivated area in the Village. Moreover, drip irrigation system prevails in lands cultivated by horticulture, representing about 80% of the total cultivated area in the Village.
- There is no rotation system of irrigation for the irrigation canals. However, shortage occurs in common, especially in summer season resulting in daily temporarily interruption of water supply from 10 a.m. until 3 p.m. moreover, high cost of electricity consumption for running electric irrigation machines is a big problem facing farmers.
- Some Water User Associations (WUAs) are established.
- There is no drainage system in the studied area, whether open or subsurface.

- About 20% of the total area is cultivated by vegetables and field crops i.e. maize, sesame, groundnut, wheat, faba bean and berseem. Besides, about 80% of the total area is cultivated by horticulture i.e. citrus (70%), peach, apricot and apple (10%). Particularly, wheat, faba bean, and vegetables (i.e. potato and bean) are dominant in winter, covering 25%, 15% and 60% of the total cultivated area, respectively. On the other hand, groundnut, maize and vegetables (i.e. potato and bean) are dominant in summer, covering about 80%, 10% and 10% of the total cultivated area, respectively.
- Wheat and faba bean are the most profitable crops in winter since their net revenues are estimated at about L.E. 302 and 273 per Ha, respectively. On the other hand, bean, groundnut and potato are the most profitable crops in summer since their net revenues reach about L.E. 483, 1205 and1134 per Ha, respectively.
- Farmers are aware of the deficit irrigation technique and this technique is common. Besides, some farmers are interested in using the deficit irrigation technique as long as it is useful. The main reasons behind this are the advantages farmers acquired from this technique since it saves labour by about 50%, it saves water irrigation by about 25% of water irrigation for traditional farmer's irrigation practice, it reduces irrigation time by about 25% since the irrigation time with this technique is estimated at 90 minutes, as compared to about 120 minutes for the traditional farmer's irrigation practice, it saves the use of some inputs i.e. chemical fertilizers and seeds by about 50%, and it prolongs the life span of irrigation machines by about 25% of the designed life span (these percentages are roughly estimated by farmers). On the other hand, some farmers reported that using this technique adds more annual costs of about L.E. 34 per one Ha for changing water hoses annually. However, the total costs of using this technique are estimated at about L.E. 1.7-2.1 thousands per one Ha.
- Farmers are unaware of the time span required for irrigating their cultivated crops, and the proper time for irrigation according to each stage of growth. However, farmers stop irrigation for one plot depending on their experience and skills. In general, farmers depend on their experience and skills in performing different agricultural operations.
- Most agricultural operations are performed by family labour since labour shortage is common. However, some agricultural practices are performed by hired labour.
- Rural women help their husbands in performing some agricultural operations. However, they play a vital role in disseminating recommended techniques.
- Livestock is not common.

The main problems and challenges facing farmers are:

- Insufficient water irrigation supplied for farmers located at the end of the canals.
- Poor and inefficient maintenance of irrigation canals.
- Insufficient agricultural financing and credit services.
- High cost of electricity.
- High prices of inputs, namely chemical fertilizers.

- Labour wages represent most of the variable costs for the main crops cultivated in the studied area.

Conclusions:

- The report of the participatory group discussions was completed and was delivered on a compact disk to Dr. Atef Swelam in 13/6/2011.
- The questionnaire of the socio-economic farm and household surveys is designed, revised and modified with ICARDA's H.Q.
- The pre-testing stage for the questionnaire was conducted in the three Sites and the questionnaire was revised and modified once more as a response for the problems faced the enumerators in collecting the data.
- An in-site Training Workshop on the Socio-economic and Household Surveys of both Projects was organized in El Hussinia Plain during the period 11-15, September, 2011

A part of the Training Workshop conducted in El Hussinia Plain.

- The adjusted version of the questionnaire was tested by the enumerators with farmers representing the Salt-affected Site and the final version of the questionnaire is ready for conducting household survey in the three benchmark Sites.
- The enumerators got acquainted with the questions of the adjusted version of the questionnaire.
- The sample for each of the three target Sites will be of 150-size, out of which 25% are women.
- The sample target area in the Old Land Site is El Zankalon Local Unit consisting of eight villages, out of which El Zankalon Village is the main village of El Zankalon Local Unit in Zagazig District, Sharkia Governorate at East Nile Delta, Lower Egypt. Besides, Bahr Mouwes Main Canal is the main source of water irrigation in the target Sites. The sampling frame is the command area surrounded by Bahr Fakhr Secondary Canal, Bahr Mouwes Main Canal, and Zagazig/Menya El Kameh Road.
- The sample target area in the Salt-affected Land Site is El Husainia Plain consisting of five villages located at Sharkia Governorate, South of East Delta Region, Lower Egypt. Besides, Al Salam Branch Canal is the main source of irrigation water for all of these

Villages except for El Rowad Village, where Al Sa'aidy Branch Canal is the main source of irrigation water. The sampling frame is the five villages located at South El Husainia Plain; El Rowad, El Ezdehar, Tarek Ben Ziad, Khalid Ben El Waleed, and El Salah.

- The sample target area in the New Land Site is El Bustan 1, El Bustan 2, and El Bustan 3 located at Behaira Governorate at West Delta, Lower Egypt.
- Three reports on the sampling frames, sampling process, physical description and the lists of holders for the three target Sites are being prepared.
- The plan of work for conducting the socio-economic farm and household surveys is set by the socio-economic team of WBM and WLI. According to this Plan, the surveys (including data collection, data entry, processing and analysis, and reporting) will be conducted in the three Benchmark Sites during the period 1/10/2011-31/3/2012.

Constraints:

The main constraints facing the Socio-economic Component in the current stage is the delay of some planned activities, especially for the socio-economic farm and household surveys that should have been started in 7/02/2011.

On the other hand, according to WBM Plan of Work (Socio-economic Component) for the year 2011/2012, Activity (2); Policy analysis of recommended water management should have been conducted during 2011/2012. However, due to the delay in conducting Activity (1); farm-level economic assessment of recommended water management technologies including deficit irrigation and raised-bed, conducting Activity (2) has not started yet.

Moreover, according to WBM Plan of Work (Socio-economic Component) for the year 2010/2011, Activity (1); farm-level economic assessment of recommended water management technologies including deficit irrigation and raised-bed will be conducted.

However, when I discussed this issue with Dr. Aden, he kindly advised me to conduct a baseline survey for the current situation in the three benchmark sites before conducting the Project. Afterwards, at the end of the Project, the farm-level economic assessment of recommended water management technologies should be conducted to aanalyze farmers’ perception, awareness and adoption of the recommended water management technologies.

Thus, the socio-economic team will be conducting the baseline survey for the current situation in the three benchmark Sites and the farm-level economic assessment will be conducted at the end of the Project.

The budget of conducting the surveys was discussed with Prof. Aden and Dr. Atef Swelam (as illustrated in Part B of the current Progress Report "Financial report for 2011"). Besides, the facilities needed for the socio-economic team (i.e. four laptops, a printer and a digital camera) was discussed and the team was asked to prepare the estimated budget for these facilities.

Annexes

A list of these meeting in details

1. **A joint team meeting** of the Socio-economic Components of Water Benchmark Project (WBM) & Water and Livelihood Initiative (WLI) in Egypt chaired by Prof. Aden Aw-Hassan, Director of ICARDA Social, Economic and Policy Research Program (SEPRP) held in 13/6/2011 at ICARDA Office in Cairo (**the minutes of this meeting is enclosed**).

   Attendees:
   - Dr. Atef Swelam
   - Prof. Nahla Zaki
   - Dr. Enas Moh. Abbas Saleh
   - Prof. Gamal Fawzy
   - Prof. Ali Ahmed Ibrahim
   - Prof. Hassan Abd El Magid
   - Dr. Halah Bassiony
   - Ms. Mayar El-Kheshen

   The main outcomes of this meeting are:
   - Conducting one survey for both of the WBM and WLI by making more modifications and additions to the questionnaire of the socio-economic farm and household surveys of WBM Project to be including questions related to the following issues of WLI then analyzing the questionnaire for both purposes:
     a. Existing sustainable water use technologies and land management practices in the three benchmark Sites.
     b. Existing options/interventions (technologies, institutions, policies) for water use efficiency (economic, social, technical and environmental) in the three benchmark Sites.
     c. Existing income-generating activities in the benchmark Sites.
   - Replacing El Boheya Site by Zankalon Site to conduct the activities of WLI in Old Lands in Egypt for the purpose of similarity in conducting the household surveys for WBM and WLI at the same time.
   - The ARC Group will be responsible for El Bustan Site, NWRC Group is responsible for Zankalon Site, and Zagazig University Group is responsible for El Hussinia Site.
   - Re-estimating the budget to be suitable for conducting this big survey.

2. **A team meeting** of the Socio-economic Components of WBM and WLI in Egypt held in 16/06/2011 at AERI for making more modifications and additions to the questionnaire of the socio-economic farm and household surveys.

   Attendees:
   - Dr. Enas Moh. Abbas Saleh
   - Prof. Gamal Fawzy
   - Prof. Ali Ahmed Ibrahim

- Prof. Hassan Abd El Magid
- Ms. Mayar El-Kheshen

The main outcome of this meeting is:

- The necessary questions related to the following issues of WLI are inserted in the questionnaire.

3. **A follow-up meeting** with the Socio-economic Components of WBM and WLI in Egypt chaired by Prof. Aden Aw-Hassan was held in 7/7/2011 at ICARDA Office in Cairo.

Attendees:

- Dr. Enas Moh. Abbas Saleh
- Prof. Gamal Fawzy
- Prof. Ali Ahmed Ibrahim
- Prof. Hassan Abd El Magid
- Dr. Halah Bassiony
- Ms. Mayar El-Kheshen

The main outcomes of this meeting are:

- The sampling frame was discussed. The teams brought maps of the study area which allowed them having an overview of the study areas.
- The three sampling areas; El Zankalon, El Hussinia and El Bustan were physically described and the team was asked to collect information on all the villages in the areas, and the number of households in each village to design weighted random sample. Besides, the team was asked to collect any specific characteristics of the sampling areas such differences in soil, access to irrigation and producers' types (i.e. investors, beneficiaries, graduates, etc.) in order to ensure that these differences are sufficiently represented in the sample for comparison.
- The team suggested organizing an in-site training workshop in September, 2011 for the enumerators who will collect the data needed for the Socio-economic and Household Surveys of WBM Project and WLI in the three Sites of Egypt. The team suggested a team from ICARDA HQ to participate in this event.
- Discussion of gender research was made with Dr. Halah Bassiony who took the gender training course in Aleppo. Inclusion of gender research was discussed, but the team suggested conducting this activity next year since this activity was not planned for the current year and there are no funds available for conducting it.

4. **A follow-up meeting** with the whole team of WLI in Egypt chaired by Prof. Prof. Nahla Zaki was held in 11/7/2011 at NWRC.

Attendees:

- Dr. Atef Swelam
- Dr. François Molle
- Dr. Samar El Taher
- Dr. Enas Moh. Abbas Saleh
- Prof. Gamal Fawzy

The main outcome of this meeting is:

- Presentations of the progress reports of the Bio-physical and the Socio-economic Components of WLI, obstacles, recommendations, and the Plan for the next coming three months.

5. **A general discussion** among the Socio-economic team, Dr. Atef Swelam, Prof. Mahmoud El Kholy, and the enumerators who will collect the data needed for the Socio-economic and Household Surveys of WBM and WLI in the three Sites of Egypt and chaired by Prof. Aden Aw-Hassan took place in 11/09/2011 during the in-site training workshop organized in El Hussinia Plain; the Benchmark Site representing the Salt-affected soil. The discussion focused on the main problems facing the farmers in the three target Sites and the suitable solutions for them. However, the main problems facing the farmers in the three target Sites are absence of equity in water distribution among farmers, absence of continuous water flow in the canals, unreliable water rotation, unsuitable irrigation and fertilization practices, and high cost of energy.

6. **A general discussion** among farmers from the Salt-affected Site, the Socio-economic team, Dr. Atef Swelam, Prof. Mahmoud El Kholy, and the enumerators who will collect the data needed for the Socio-economic and Household Surveys of WBM and WLI in the three Sites of Egypt and chaired by Prof. Aden Aw-Hassan took place in 13/09/2011 during the in-site training workshop organized in El Hussinia Plain. The discussion focused on the main problems facing those farmers and their needs. However, the main problems facing the farmers in the Salt-affected Site are:
   - Lack of efficient irrigation system.
   - Lack of efficient drainage systems especially in El Rowad Village where water salinity reaches high levels.
   - Lack of appropriate mechanization technologies and services introduced by Ministry of Agriculture.
   - Lack of inputs i.e. seeds and chemical fertilizers in the agricultural co-operatives.
   - Low quality of some inputs i.e. seeds agricultural gypsum.
   - Lack of veterinary services.
   - Lack of financing services.
   - Lack of income-generating activities i.e. rabbit boxes, poultry and livestock raising.

7. **A follow-up meeting** with the Socio-economic Components of WBM and WLI in Egypt chaired by Prof. Aden Aw-Hassan was held in 15/09/2011 during the in-site training workshop organized in El Hussinia Plain. The discussion focused on the main problems facing those farmers and their needs. However, the main problems facing the farmers in the Salt-affected Site are:

   The main outcomes of this meeting are:
   - The sampling frame for the three target Sites was developed and each of the team leaders was asked to prepare a documentation for the sampling process, the physical description of the target Site and the list of holders.
   - The budget of conducting the surveys was discussed with Prof. Aden and Dr. Atef Swelam.
   - The facilities needed for the socio-economic team (i.e. laptops, a printer and a camera) was discussed and the team was asked to prepare the estimated budget for these facilities.

8. **A general discussion** among other farmers from the Salt-affected Site, the Socio-economic team, Dr. Atef Swelam, Prof. Mahmoud El Kholy, and the enumerators who will collect the data needed for the Socio-economic and Household Surveys of WBM and WLI in the three Sites of Egypt and chaired by Prof. Aden Aw-Hassan took place in 15/09/2011 during the in-site training workshop organized in El Hussinia Plain. The discussion focused on the main problems facing those farmers and their needs. However, the main problems facing the farmers in the Salt-affected Site are:
   - Lack of efficient irrigation system.
   - Marketing problems.
   - Land rental problems.
   - Lack of inputs i.e. chemical fertilizers in the agricultural co-operatives.
   - Lack of efficient drainage systems especially in El Rowad Village where water salinity reaches high levels.
   - Lack of appropriate mechanization technologies and services introduced by Ministry of Agriculture.
   - Lack of financing services.
   - Lack of income-generating activities i.e. rabbit boxes, poultry and livestock raising.

9. **A team meeting** of the Socio-economic Components of WBM and WLI in Egypt was held in 22/09/2011 at ICARDA Office in Cairo to discuss about the plan of work for conducting the socio-economic farm and household surveys, the final version of the questionnaire and the sampling process.

10. **A follow-up meeting** with the Socio-economic Components of WBM and WLI in Egypt chaired by Prof. Aden Aw-Hassan was held in 1/10/2011 at ICARDA Office in Cairo.

    Attendees:
    - Dr. Enas Moh. Abbas Saleh
    - Prof. Gamal Fawzy
    - Prof. Ali Ahmed Ibrahim
    - Ms. Mayar El-Kheshen

    The main outcomes of this meeting are:
    - The sampling frames, sampling process, physical description and the lists of holders for the three target Sites are discussed and the samples of the three Sites are designed.
    - The final version of the questionnaire is revised, modified and approved.
    - The plan of work for conducting the socio-economic farm and household surveys is revised, modified and approved.
    - The plan of work for 2012 and the estimated budget related to conducting Activity 2; Policy analysis of recommended water management is revised, modified and approved.

II. PLAN OF WORK

Component I: Interventions fine tuning, out scaling and dissemination

Fine-tuning research activities in Old lands

Activity 1: Test and adapt the raised bed machine on winter (wheat, sugar beet and berseem) and summer (maize and cotton) crops under old and salt-affected lands conditions in Egypt Delta

Objectives:

- To determine the optimal bed width and furrow length
- To evaluate the effect of furrow spacing (raised bed width) and furrow length on water/nutrients dynamics and water productivity

Methodology:

Treatments

- Raised Bed Width: BW1= 0 cm, BW2 = 70 cm and BW3 = 130 cm
- Furrow Length: FL1 (short) = 25 m; FL2 (long) = 50 m

Experimental design

- The experimental design is a split-split plot with 3 replications. Raised bed width, length and furrow depth are the main, the split and the split plots, respectively.

Experimental Sites

- Experiments will be conducted in the experimental stations in Old and Salt-affected lands.

Activity 2: Nitrogen management under mechanized raised bed technology of winter (wheat and sugar beet) and summer (maize and cotton) crops in old and salt-affected lands

Objective:

- To determine optimal rates of nitrogen application under different raised bed width.

Methodology:

Treatments

- Nitrogen rates: N1 = 100% of recommended rate, N2 = 85% of recommended rate and N3 70% of recommended rate;
- Raised bed width: BW1= 0 cm, BW2 = 70 cm, BW3 = 130 cm.

Experimental design

- The experimental design is a split-split plot with 3 replications. Furrow length, Raised bed width and Nitrogen are the main, split and split-split plots, respectively.

Experimental Sites

- Experiments will be conducted in experiment stations in the Old and Marginal lands

Activity 3: Nitrogen and salinity management under mechanized raised bed in salt-affected Soils

Objective:

- To determine optimal rates of nitrogen application under different raised bed widths;
- To monitor and minimize salinity build-up under mechanized raised-bed system.

Methodology:

Treatments

Main Plots: Soil amendments: A=Gypsum vs B=Gypsum + Organic Matter;
Split plot: Raised bed width: BW0=0 cm, BW1=70 cm and BW2=100 cm;
Split-split plot: Fertilization: F1= 100% of recommended rate, F2= 75% of recommended rate F3= 100% N rate + Bio-fertilizer and F4 = 75% N rate + Bio-fertilizer.

Experimental design

- The experimental design is a split-split plot design with 3 replications. Soil amendments, raised bed width and fertilizer type are the main, sub-main and sub-sub plots, respectively.

Experimental Site

Experimental station in Marginal lands

Fine-tuning research activities in New lands

Activity 1: Sprinkler irrigation and fertilizer management of wheat, sugar beet and Potatoes in sandy soil

Objective:

- To set appropriate tools and management of irrigation water and fertilizers under sandy soils

Methodology:

<u>Treatments</u>

- Irrigation scheduling (amount and time of application): 75% of ETo, 100% of ETo and 125% of ETo based on Class A pan
- Nitrogen rates: N1 = 100% recommended rate, N2 = 75% recommended rate

<u>Experimental design</u>

- The experimental design is a split plot with 3 replications. Irrigation scheduling and fertilizer type are the main and the split plots respectively.

Activity 2: Drip irrigation and mulching of tomato and sugar beet

Objectives:

- To set appropriate tools and management of irrigation water and fertilizers under sandy soils
- To study the effect of soil mulching

Methodology:

<u>Treatments</u>

- Irrigation scheduling (amount and time of application): 75% of ETo, 100% of ETo and 125% of ETo based on Class A pan
- Nitrogen rates: N1 = 100% recommended rate, N2 = 75% recommended rate
- Soil mulching: With SM, Without SM

<u>Experimental design</u>

- The experimental design is a split-split plot with 3 replications. Soil mulching, irrigation scheduling and fertilizer type are the main and the split and split-split plots respectively.

<u>Experimental Sites</u>

- The investigations for the new land will be conducted at Al-Entelak area, West Nubaria Rural Development Project which is located in the West desert at Km 72 Alexandria-Cairo desert road. The experimental plots soil is sandy soil.

Data to be collected for the two activities: Same as the ones described in section A) above

<u>Dissemination activities</u>

Activity 1: Disseminate the findings from the first phase to the stakeholders in other similar Locations out of the benchmark sites

Objective:

- To rise the stakeholders' awareness about the developed technologies in the project phase-I.

Methodology:

- On-farm trials in collaboration with extension services; Conducting field days and Conducting harvest days

<u>Filed Sites:</u>

- Old land and salt-affected land: The technology to be disseminated is the mechanized raised best system

Targeted areas: Sharkia Governorate (Old land) and Eastern Delta Region (Salt-affected land)

Main Partners: ARC, NWRC, Extension Services (MALR and IAS), Development projects

- In New land: Technology: Proper sprinkler irrigation and fertilizers management to be wide disseminated to the farmers

Targeted areas: Al-Entelak Area, West Nubaria Rural Development Project

Main Partners: ARC, NWRC, Extension Services (MALR and IAS), Development projects

Component II: Modeling water, salinity and nutrient flows in a unit irrigated area

The working plan of the modeling component for the second year of the project (2011/2012) is identified in the original documents of Implementation plane of the project. According to this plan, the modeling component is going to fulfill the following activities:

- Activity 3: Data collection
- Activity 4: Model set up and calibration
- Activity 6: Capacity Building

By the middle of second year of the project the fifth activity of "Model application" is proposed to be started. The component activities objectives and the expected outputs are listed in the following table:

Activity	Objective	Expected output	Methodology
3: Data collection.	Provide the data necessary for the research especially that required by the model which will be used in the research.	• Set of data required by the mathematical modeling approach. • Data collection report.	A field data collection program will be carried out, data will be collected from the selected sites. Field data will be collected and measured at large number of locations in each site.
4: Model set up and calibration	set-up and calibrate the model with the data collected from the sites of interest in order to assess the model performance in terms of its potential in establishing efficient water and management strategies.	A set of values for the selected model parameters that provide the best performance in predicting soil moisture content, soil salinity and crop yield as well as the other system components in the sites of interest.	1. Required input data by the model 2. Long term sensitivity analysis 3. Initial model runs 4. Final model runs
5: Model application	apply the selected establish efficient, economic and sustainable irrigation management practices that maximize crop return per unit of water applied.	• Report summarizes the establishment of efficient, economic and sustainable irrigation management practice that improves crop return per unit of water applied in the areas under consideration and presents the results along with conclusions and recommendations. • A scientific solution	1. Sets of calibrated model runs will be carried out to evaluate different irrigation and drainage scenarios over long term simulation period. 2. Crop yield response to water stress, salinity and water logging will be used as an indicator for evaluating the performance of the different management scenarios. 3. The sustainability of

Activity	Objective	Expected output	Methodology
		(the efficient management) will be translated into a format that is easily understood and applicable by farmers to achieve sustainable water resources management.	irrigation scenarios will be considered along with the crop return per unit of water applied. 4. On the basis of the analysis of the different irrigation management scenarios considered, efficient, economic and sustainable irrigation management will be identified. 5. Workshop will be held to discuss findings.

Component III: Socio-economy

Activity 2: Policy analysis of recommended water management.

Objective:

The objective of this activity is to develop policy and institutional options component of the integrated technical and institutional options (TIPOs) for sustainable water management to facilitate the rural communities' role in conserving water and improving their livelihood.

Methodology:

Two principal methodologies will be used to analyze the impact of specific policies on adoption of water management technologies: econometrics to estimate production relationships and household whole farm modeling. This activity will benefit substantially from the survey data that will be collected for the first activity and therefore it is not planned to have separate survey here to collect primary data. Additional secondary data may be needed and will be collected. Specific policies to be considered can be identified with dialogues with policy-makers and other stakeholders. Some of these may include water charges and charging basis (volume, area, etc...), water trading rights, subsidies and incentives.

Milestones and dates of their implementation

Timeline	Tasks
April – May 2012	Review and analysis of secondary and published data on policy analysis of recommended water management
June – Sept. 2012	Building econometric models to analyze and estimate the impact of irrigation on farm income of households in the three benchmark sites
Oct. – Nov. 2012	Conducting a workshop for policy-makers and other stakeholders
March 2013	Final Report

B. IRIGATED SATELLITE SITE OF SUDAN

I. PROGRESS

Summary

Water productivity is a very important issue in the world. Sudan is not isolated from these problems and facing water deficits throughout the growing seasons. This project aims at increasing the impact of technologies that contribute to improved agricultural productivity, resource conservation and livelihoods in the selected sites. The fully irrigated agricultural production environment is addressed. The project demonstrates the efficiency of water through different planting methods in the Gezira scheme in the central plains of the Sudan. To ensure adequate scale of interventions, demonstration sites have been selected in the Gezira which represents the major wheat-based production system in the Central part of the country. The project interventions are designed to upgrade production practices and management aspects in order to achieve increased productivity in the selected sites. The raised bed was piloted on selected farmers' fields and compared with the traditional practices (cultivation on flat) to detect whether this technology realize its goal of productive and sustainable water use. The selected farmers effectively participated in all activities pertaining to implementation, operation and monitoring and evaluation process. Successful execution of the demonstration experiment and successful field days in the selected sites played a great role in raising farmers' awareness about the best bet technology. The marginal analysis showed that bed planting is superior to farmers' practices at both low and high input level. Results of the study conclude that high yield advantage and higher rate of return were realized by adopting the raised planting package. The study recommends repetition of the experiment for another two second seasons to scale out the improved technological packages. Policy intervention is also required in the area of input markets; delivery of essential inputs at the right time, quantities and at reasonable prices.

Introduction

In Sudan, crop production contributes approximately 45% of the gross domestic product originating in agriculture. Sorghum, millet and wheat are the main staple crops. Their production considerably declined from an average of 4.9 million metric tons in 2006-2009 to only 2.9 million metric tons in 2010; 42% reduction. During 2010/2011 season, wheat production estimated at about 292 thousand tons in an area of 435 thousand feddans (182.8 thousand ha) with average productivity of 1597 kg/ha during the season 2010/2011.
Management problems related to irrigation water, inadequate machinery for proper and timely land preparation, unavailability of certified seeds of improved varieties, inadequate fertilizer application, relatively high temperatures in Central Sudan and instability of polices regarding subsidy for wheat production are the major constraints of wheat production in the Sudan.
Water productivity is a very important issue in the world. Sudan is not isolated from these problems since it is facing water deficits throughout the growing seasons. The project aims at

increasing the impact of technologies that contribute to improved agricultural productivity, resource conservation and livelihoods in the selected sites. The fully irrigated agricultural production environment is addressed. The project demonstrates the efficiency of water through different planting methods in the Gezira scheme in the central plains of the Sudan.

Activity 1: Comparison of the raised bed system with flat system at the farm level

Objective:

The project interventions are designed to upgrade production practices and management aspects in order to achieve increased productivity in the selected areas through the scaling out and dissemination of the raised bed system.

Methodology:

The implementation of the study started with a series of preparatory meetings concentrated on one component which is the out-scaling and dissemination of the best bet package. A meeting with scientists and extension agent was held to select the demonstration site and pioneer framers. Community-based small-scale demonstrations of improved cultural practices and water management were carried out by researchers from Agricultural Research Corporation with the assistance of the extension services. The package was piloted on selected farmers' fields. The selected farmers effectively participated in all activities pertaining to the implementation, operation and monitoring and evaluation process. The comparison was made between participant farmers adopting the raised bed method and the neighboring farmers adopting flat method.

Results/Achievements:

As mentioned before, high temperature is the major limiting climatic factor for wheat production in Central Sudan. This year the mean temperature was higher than the long term average during November and December, and then it became lower later. Hot spells were noticed during February and the first days of March, coinciding with grain filling stages as shown in Figure 1.

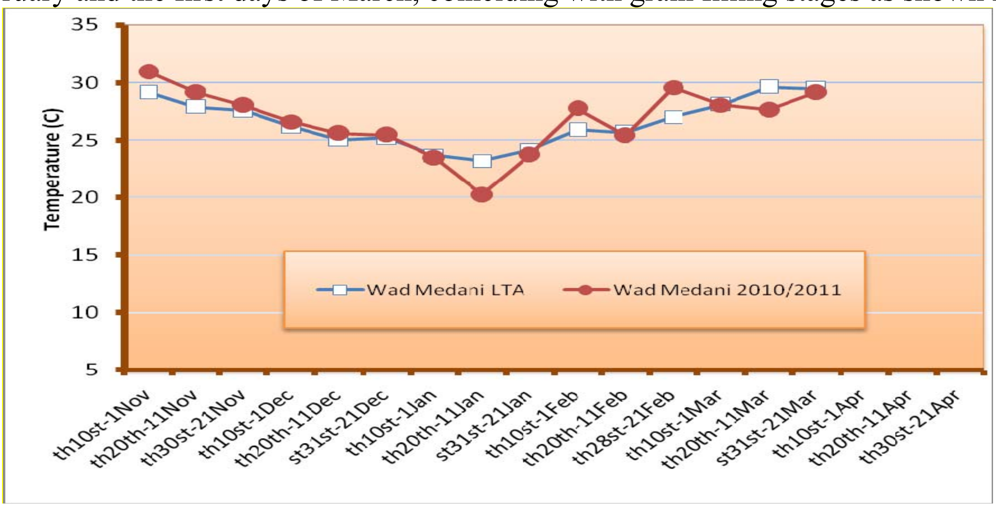


Figure 1. Thermal regimes and long term averages (LTA) in Gezira, 2010/2011.

Result of the marginal analysis showed that raised bed planting is superior to farmers' practices at both low and high input level as shown by the marginal rate of return which came out to be about 40. In addition to yield advantage, adoption of the raised- bed method has resulted in reduced cost of land preparation and reduced total cost, reducing water used and saving time of irrigation, easy water management, no over-flooding, conservation of water and realization of high rate of return (Tables 1 and 2).

Table 1: Financial benefit (SDG/feddan) of the raised bed planting of wheat in the Gezira, 2011.

Cost (SD/Gfed):	**Bed planting**	**On flat (high input levels)**	**The difference**	**On flat (low input levels)**	**The difference**
Land Preparation	45	80	35	45	0
Seeds (50 kg/feddan)	100	150	50	150	50
Sowing	30	50	20	30	0
Seed dressing (Gaucho)	30	30	0	30	0
Herbicides (Topic + 2-4-D) + Hand weeding	45	45	0	30	-15
Water fees (SDG)	40	40	0	40	0
Irrigation management	60	60	0	60	0
Fertilizer	172	200	28	140	-32
Preparation for harvesting	10	25	15	25	15
Harvesting	50	50	0	50	0
Sacks	52	44	-8	36	-16
Transport	40	33	-7	27	-13
Total Cost	674	807	133	663	-11
Productivity (tone/fed)	1.35	1.12	-0.23	0.85	-0.5
Price (SDG/tone)	900	900	0	900	0
Gross Benefit (SDG/fed)	1,215	1,008	-207	765	-450
Net Benefit (SDG/fed)	541	201	-340	102	-439
Break Even Price (SDG/ton)	499	721		780	
Break Even Yield (ton/fed)	0.75	0.90		0.74	

Table 2: Marginal analysis (SDG/feddan) of the improved package of wheat in Gezira

	Total cost	**Benefit**	**Marginal cost**	**Marginal benefit**	**Marginal rate of return**
Low input level (flat planting)	663	765			
Raised Bed planting	674	1,215	11	450	40.9
High input level (flat planting)*	807	1,008			

* Dominated for having high cost and less benefit

Generally, wheat yield in Gezira during this season ranged from 500 kg/ feddan to 2200 kg/feddan with an average of 1000 kg/feddan (Table 3). The average productivity was 850 and 1120 kg/feddan for low input and high inputs farmers, respectively. Average yield in the demonstration sites was 1350 kg/ feddan for raised bed and 1120 kg/ feddan for cultivation on flat. This variability in yield is due to variability in the adoption rate of the improved production practices starting from the selection of the improved variety, level of land preparation, water management, and the amount of the added fertilizers. In this respect variable amount of urea was applied; in the range between 50 to 150 kg / feddan.

Table 3: Average productivity of wheat under two planting method in the Gezira

	Minimum	**Maximum**	**Average yield**
Productivity (kg/feddan)	500	2200	1000

Regarding on-farm water-use efficiency in Gezira, it is worth noting that every 90 feddans (approximately 20 farms each of 4.5 feddan) in the Gezira scheme requires 36000 m^3 of water per irrigation during the peak requirements. This means that this area could be irrigated in seven days through the field out let pipes (FOPs) with discharge of 5000 m^3/day. Wheat requires eight irrigations; however due to the irrigation problems it uses only about 6 irrigation with an amount of 420 m^3 per irrigation with a total of 2520 m^3/feddan. Although raised bed irrigation used less water per unit area, there is some difficulties to assess the difference in the amount of water saved. Assuming that water consumption is the same, the water productivity in the raised bed is still higher than planting on flat at both low and high and input levels. Water productivity, defined in technical terms as kg of output per m^3 of water, was highest for raised bed (0.54 kg/m^3), followed by cultivation on flat at high input level (0.44 kg/m^3) and lowest for low input level (0.34 kg/m^3). Therefore, water yielded more output in raised bed compared to flat cultivation. Each additional m^3 of water yielded 0.54 kg of wheat. Bed planting method consumed less water compared to that on flat and therefore, water productivity was high. This clearly demonstrates the low ratios of water-use efficiency under flat cultivation. On the other hand, gross return per unit of water is high for the raised bed (0.48) followed by on flat (Table 4).

Table 4: Water productivity of wheat under two planting method in the Gezira

Items	**Bed planting**	**On flat (high input levels)**	**On flat (low input levels)**
Total Cost	674	807	663
Productivity (tone/fed)	1.35	1.12	0.85
Price (SDG/tone)	900	900	900
Gross Benefit (SDG/fed)	1,215	1,008	765
Water use (m^3/feddan)	2520	2520	2520
Gross benefit /m^3	0.48	0.40	0.30
Water productivity (kg/m^3)	0.54	0.44	0.34
Water productivity (SDG/m^3)	0.48	0.40	0.30

Another benefit of the demonstration is the strengthening of the technical skills and capacity in technology transfer and implementation for extension agents and farmers. This process enhances and promotes the dissemination of technologies to other relevant areas in the sense that non-participating farmers benefited through expanded opportunities of training and awareness' raising for investment in the improved technologies.

Conclusion

The best bet package for the promotion of improved agronomic practices to use more efficiently the scarce water resources was demonstrated in farmers' fields in two locations of the satellite site and proved to be superior to farmers' traditional practices. To enhance the productivity of wheat crop, the study recommends repetition of the experiment for another two second seasons to scale out the improved technological packages.

Constraints

The project faced the following constraints:

- Insufficient awareness of farmers on the raised-bed planting in the selected sites.
- Institutional constraints: The project encountered a problem of participation of the extension agent after training of trainers for some instability in the Gezira scheme at the commencement of the project; however effort was made to overcome the difficulties.
- Variable and low productivity of wheat and other rotational crops were caused by poor adoption of essential inputs and improved technology (fertilizers and efficiency of irrigation water, weeding) due to weak financial capability of farmers.

II. PLAN OF WORK

Activity 1: Development and dissemination of integrated sustainable water management options in the irrigated area (Gezira).

Objective:

- Evaluate, at the farm level, the effect of implementing raised bed system on the incomes and livelihood of communities in the Gezira area of Sudan.

Methodology:

- Demonstration trials will be conducted on the raised bed system at the farm level in collaboration with communities and compared with farmers practices on flat. Water productivity and financial returns will be calculated.

C. IRRIGATED SATELLITE SITE OF IRAQ

I. PROGRESS

Abstract

For fully irrigated area, Egypt was chosen as benchmark site and Iraq and Sudan as satellite sites. Research focused on better irrigation methods and management to improve water productivity and sustainability of use .The irrigation benchmark project has introduced a new method for planting crops, known as raised bed system. The raised beds technique was tested in Egypt. Because it can offer many advantages for irrigated areas of Iraq, two experiments were conducted to test this practice under local conductions. Data showed that the performance of wheat under raised bed method was better than traditional irrigation method of farmers. In fact, water productivity was higher. In the case of sorghum, the performance (weight of dry matter g/plant) in raised bed method was higher when the bed width was 75cm compared with 100 cm.

Introduction

Farmers in irrigated area of Iraq practice mainly surface irrigation. wheat is usually either planted mechanically (drill) with a row spacing of about 20cm or seeds are broadcasted manually on leveled soil surface and then incorporated by a shallow tillage operation. Sorghum is normally planted in closely spaced furrows. The whole field is flooded. This system is known to have a low water use efficiency.

The irrigation benchmark project has introduced a new method for planting crops known as raised bed system. The field has broader "crop strips" and fewer furrows. The raised bed technique was tested in Egypt. The new technique showed many advantages such as improving water use efficiency and reduce the cost of labor.

Because raised bed planting system can offer many advantages for irrigated areas of Iraq, experiments were conducted in the country to test its performance under local conductions. The overall objective of this project is to introduce and transfer, to the farmers of Iraq, the technology of planting crops (wheat and sorghum) on raised bed in order to increase crop productivity and water productivity.

Activity 1: Test of planting on raised beds

Two experiment were conducted, one on wheat and the other on sorghum.

Objective:

To evaluate the effect of furrow spacing (raised bed width), furrow width and furrow depth on yield and water productivity on wheat and sorghum.

Methodology:

1. Experiment on wheat

Because of the lack of machinery suitable for making beds and furrows, an alternative method was adopted. Wheat seeds were drilled on flat followed by the digging of irrigation furrows at approximately 150 cm intervals.

The width of the bed was about 100 cm. For comparison, traditional method of drilling seeds on flat surface was used.

The planting date was the first week of December, 2010 and the harvest was done on the second week of May 2011. The crop was irrigated six times. At harvesting, random samples were taken to measure kernel number per square meter, dry matter, grain yield. Irrigation water quantity was measured.

2. Experiment of planting sorghum

Sorghum was planted on raised beds, with different bed widths of 100 and 75 cm, furrow widths of 50 and 30 cm and furrow depths of 30 and 20 cm. The formation of beds and furrows was done manually .The planting date was on 15th of March, 2011 and harvest was on the first of July, 2011. Ten irrigations were applied during the season. Fertilizers and herbicides were applied according to the local recommendations. At harvest, random samples were taken to measure grain yield per hectare and biomass per plant. Water productivity was calculated.

Results/Achievements

The results of the experiment on wheat are illustrated in Table 1. Data show that the performance of wheat under raised bed method was better than traditional method. Dry matter of plants, grain yield, number of spikes/m^2, weight of grains per spike, weight of spikes/m^2, number of grains per spike were 16%, 18% , 9%, 44% , 12% , 19% were, respectively, higher under raised bed as compared to the traditional method. The 1000 seed weight and harvest index were almost equal in both methods of planting.

The total water consumed by wheat in the traditional method was about 450 mm; whereas in the raised bed it was only about 300 mm. The rainfall contributed by about 120mm. The water productivity in wheat planting in raised bed was 63% higher as compared with traditional method.

Table (1): Yields of wheat and components of yield, irrigation amounts and water productivity under traditional method of irrigation and raised bed method

Measurement	Tradition method	Raised bed method
Grain yield ton/h	3.400	4.00
Biological yield ton/h	8.120	9.400
No. spikes per m^2	212	232
No.grain per spike	53	63
Wt. of 1000 seed	32.8	32.0
Wt. of grain per spike	1.488	2.147
Wt of spike per m^2	510	570
H.I	42	43
Total water requirement (mm)	450	300
No. of irrigation	6	6
Depth of irrigation (mm)	75	50
Water productivity (hg/m^3)	0.8	1.3

Data on sorghum are presented in tables 2-5. The performance of sorghum plants (weight of dry matter g/plant and grain yield) under raised bed was higher when the bed width was 75cm compared with 100 cm; but when the furrow depth was increased from 30 to 50 cm, the dry matter showed little effect on dry matter.

One thousand seed weight of sorghum (Table 4)was neither affected by the bed width, furrow width nor by furrow depth.

Water productivity (Table 5) was higher by 6% than traditional method under bed width with 75cm compared with 100 cm and higher by 9% with furrow depth of 30 cm than 20 cm. When the bed width increased from 75 to 100 cm, no clear effect was observed.

Table (2): Performance of sorghum plant (dry matter g / plant) in raised bed method, with different bed width (BW 100 & 75 cm), furrow width (FW50 & 30 cm) and furrow depth (FD 30&20 cm)

Treatment	FD 30	FD 20	Mean	Mean
BW 100 , FW 50	450	250	350	325
BW 100 , FW 30	275	325	300	
BW 75 , FW 50	450	250	350	350
BW 75 , FW 30	400	300	350	
Mean	394	281		

Table (3): Sorghum grain yield (t/h) with different bed width (BW 100 & 75 cm), furrow width (FW 50 & 30 cm) and furrow depth (FD 30&20 cm)

Treatment	FD 30	FD 20	Mean	Mean
BW 100 FW 50	3.1	2.44	2.77	2.43
BW 100 , FW 30	1.42	2.74	2.08	
BW 75 , FW 50	2.86	1.93	2.40	2.17
BW 75 , FW 30	1.90	1.98	1.94	
Mean	2.32	2.27		

Table (4): Weight of 1000 seeds of sorghum (g) in raised bed method with different bed width (BW 100 & 75 cm), furrow width (FW 50 & 30 cm) and furrow depth (FD 30&20 cm)

Treatment	FD 30	FD 20	Mean	Mean
BW 100 , FW 50	26.9	24.2	25.6	25.1
BW 100 , FW 30	25.3	24.8	24.6	
BW 75 , FW 50	27.3	24.8	26.1	25.9
BW 75 , FW 30	24.5	26.8	25.7	
Mean	26.0	24.9		

Table (5): Water productivity of sorghum in raised bed method, with different bed width (BW 100 & 75 cm), furrow width (FW 50 & 30 cm) and furrow depth (FW 30&20 cm)

Treatment	FD 30	FD 20	Mean	Mean
BW 100 , FW 50	538	422	480	472
BW 100 , FW 30	400	527	464	
BW 75 , FW 50	619	418	519	500
BW 75 , FW30	470	490	480	
Mean	507	464		

Conclusions

Although the experiments on wheat and sorghum were not conducted in an ideal procedure because of lack of machinery for making beds and furrows, data showed some advantages of raised bed method as compared to the traditional method.

Constraints

The project faced one constraint and that is the lack of machinery for making raised beds and furrows, this will be overcome in the next season.

II. Plan of work for 2011/12

To have more consistent results, it was decided to conduct the same experiments in 2011-12.

Activity 1: Test of planting on raised beds in wheat
Two treatments will be compared on wheat and, the raised bed and the planting on flat.

Activity2: Adjustment of different elements of the raised bed technology in sorghum.

Two bed widths (100 cm and 75 cm), 2 furrow widths (50 and 30 cm) and 2 furrow depths (30 cm and 20 cm) will be tested in a split split plot design with 3 replications

RAINFED BENCHARK AND SATELLITE SITES

A. RAINFED BENCHARK SITE OF MOROCCO

I. PROGRESS

Introduction

Most of the agricultural area of WANA is rainfed and a large proportion of the region's agricultural livelihoods are based in dryland farming systems. While irrigated areas may produce far higher yields and marketable surpluses, the overall value of dryland production is much greater than its economic market value due to social and other indirect benefits associated with these systems. Rainfed production relies on low and extremely variable rainfall and, therefore, production is low and unstable. This is further affected by frequent droughts and continuing land degradation. Research has focused on ways to improve the water availability to crops in rainfed areas. Given the limited ability to utilize new sources of water in the region a major challenge is to sustainably enhance productivity by improving the efficiency of the on-farm use of the limited water resources available. One option that has the potential to provide large productivity gains is the use of supplemental irrigation in rainfed crops, provided that water is made available for irrigation.

In fact, in the first phase of the project, the research focused in using and optimizing limited water resources in supplemental irrigation and in developing improved crop management options to increase and stabilize yields and water-use efficiency.

There is however, some need to further refine the parameters regarding those options as they are disseminated to the farmers at a large scale within Morocco and outside the country to the satellite sites of Algeria, Syria, Tunisia and other areas that have similar bio-physical and socio-economic characteristics of the rainfed zone of Tadla; the host of the rainfed benchmark in Morocco. Moreover, tools to rationalize water allocation at a system level need to be fully developed. The basis has been laid for a model to base water allocation on economic returns to water.

Although new improved technologies proved to be successful at the farm level, impact would seem to be less at system/regional and national level. There are few signs of autonomous out-scaling taking place at a large scale. Clear system operation guidelines or manuals – tested and developed together with operators – have not yet been produced nor have policy guidelines been discussed or adopted. Work on the necessary institutional strengthening, defining partnerships, developing financial instruments and public information and identifying adapted policies of implementing the new water and land management technologies is needed.

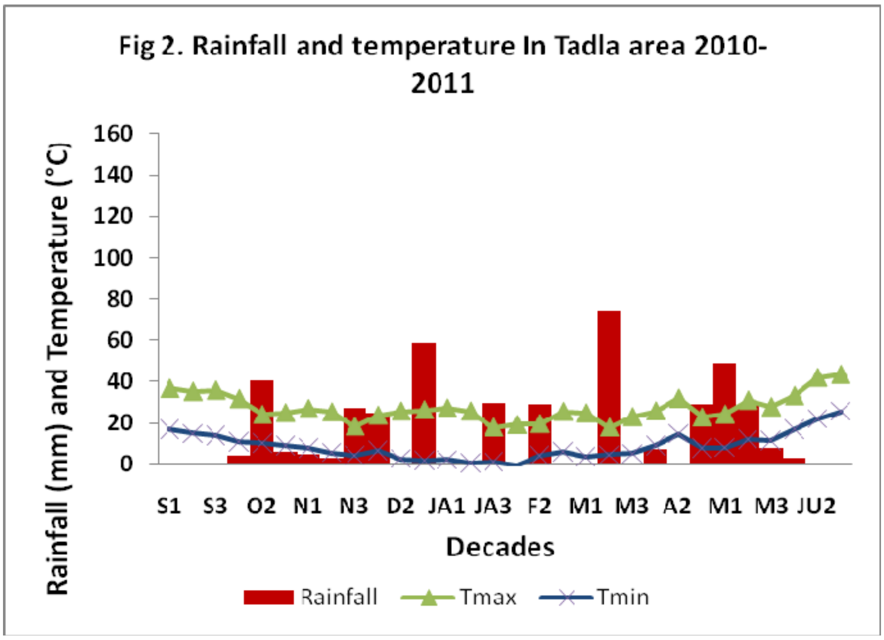
Component I: Fine tuning, out-scaling and dissemination of the first phase outputs

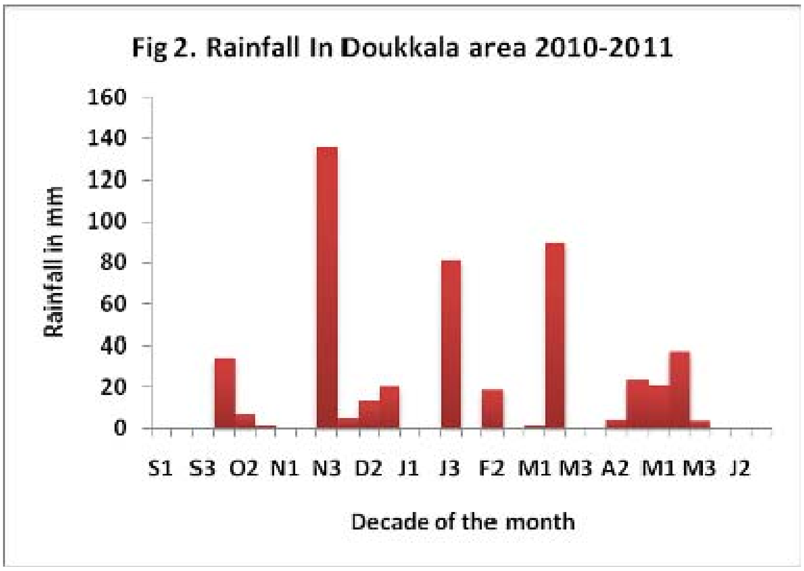
The fine tuning activities were conducted in Tadla region and the dissemination actions were undertaken in Tadla and Abda areas of Morocco.

Climatic conditions in the Tadla and Doukkala area

The prevailing climatic conditions during the crops growing season are summarized in Figures 1 and 2 for Tadla and Doukkala regions, respectively. The total amount of rainfall received from September 2010 to June 2011 is 430 mm in Tadla and 498 mm in Doukkala. These amounts exceeded the average rainfall calculated over more than 30 years in both regions. The rain distribution during the growing season was slightly different from one region to the other; but it did quietly cover the growth cycle of cereals. Indeed, a very heavy rain was registered in Doukkala during the third decade of November where the total amount was 136 mm. Moreover, we registered, in both regions, a heavy rain period during April and May in concomitance with the maturation phase of wheat grains. The harvest was consequently delayed and some damages such as late weeds infestation and grains quality deterioration were observed.

The temperature was quite adequate especially during the beginning of the season where it permitted a good establishment and favorable development of the crops in Tadla. The temperature amplitude was almost stable, but the minimum temperature was very low during January and February and certainly affected the seedlings growth. The lowest temperature was less than -3°C registered during the first week of February.





Activity 1: Fine tuning the interventions

Sub-activity 1.1: Planting date x irrigation regimes for maize, sugar beet and red pepper.

Objective:

- Improve land and water productivity and reduce the effect of climate variability and change.

Methodology:

Three Experiments were conducted in INRA experimental station of Afourer, in the Tadla perimeter, where the effects of planting dates and water regimes on sugar beet were evaluated. In maize, only water regimes were tested because the bad seedling establishment under early planting due to low seed germination. Also, in the case of red pepper, early planting was discarded because of the unavailability of seedling during that period.

The first planting date of sugar beet was on November 10, 2010, and the second date on December 15, 2010. The planting of maize was done on April 28, 2011. The planting date of pepper was on May 5, 2011. The experimental designs were the split plot in the case of sugar beet with planting date as the main plot and the complete bloc design with four replications.

The harvest of sugar beet was on June 30, 2011 and that of maize was August 8, 2011.
Water regimes were applied based on soil moisture content before each irrigation. The treatments applied in the three experiments are:

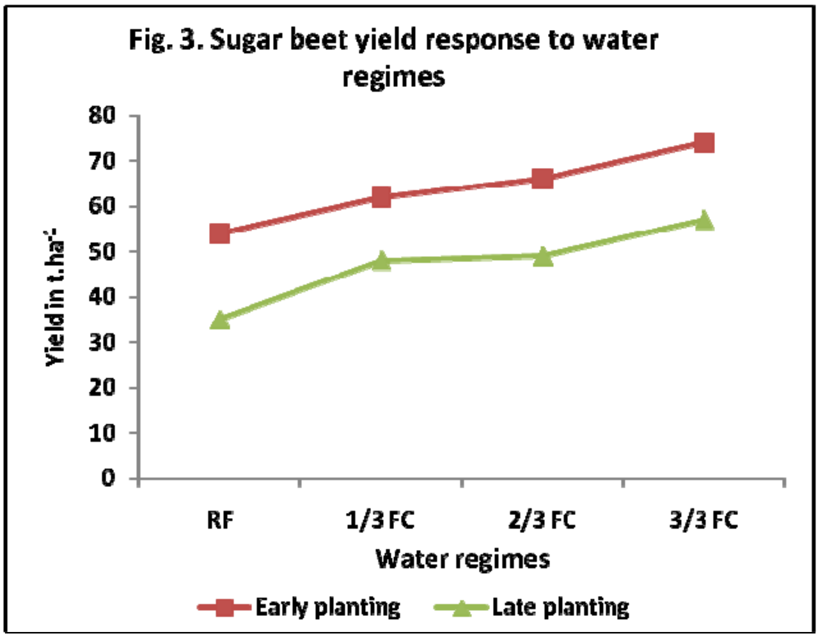
- Refilling soil profile up to 1/3 field capacity: 1/3 FC
- Refilling soil profile up to 2/3 field capacity: 2/3 FC
- Refilling soil profile up to full field capacity: 3/3 FC
- Rain-fed treatment in sugar beet. This treatment received only the two first irrigations.
- The fourth treatment in maize where irrigation is conducted as by a farmer.

The harvest of red pepper is still ongoing. Therefore, the results of this experiment are not included in this report.

Results/Achievements:

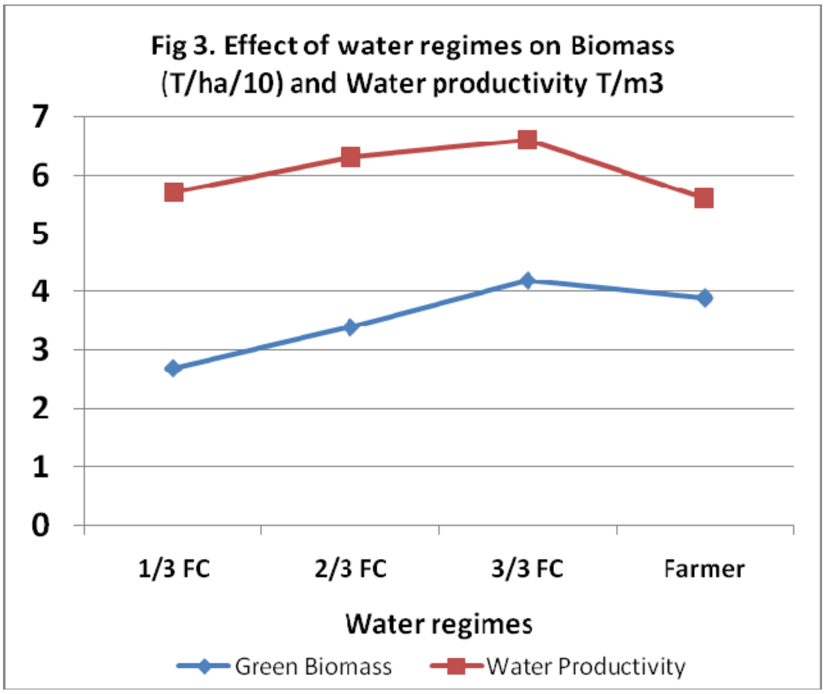
1. Case of sugar beet

Yields of sugar beet are presented in Figure 3 for both planting dates and four water regimes. The statistical analysis showed a significant effect of planting dates on yield and an interaction planting dates x water regimes. In average, sugar beet yields of early planting date were 30 % higher than those of the late planting date for all water regimes. Moreover, sugar beet yield increased with the increase of water availability from RF to 3/3 FC treatments.



2. Case of maize

The most important experimental results achieved are presented in Figure 4 and concern the total green biomass (expressed in 10^{th} of tons/ha or T/ha) and water productivity (tons/m^3 or T/m^3). Both variables showed a net increase with increasing irrigation water applied. However, a net decline in both components is noticed with the farmer's irrigation management.



Sub-activity 1.2: Response of wheat to water application and nitrogen

Objective:

Improve water productivity and nitrogen use efficiency, and protect the environment from water pollution by nitrates.

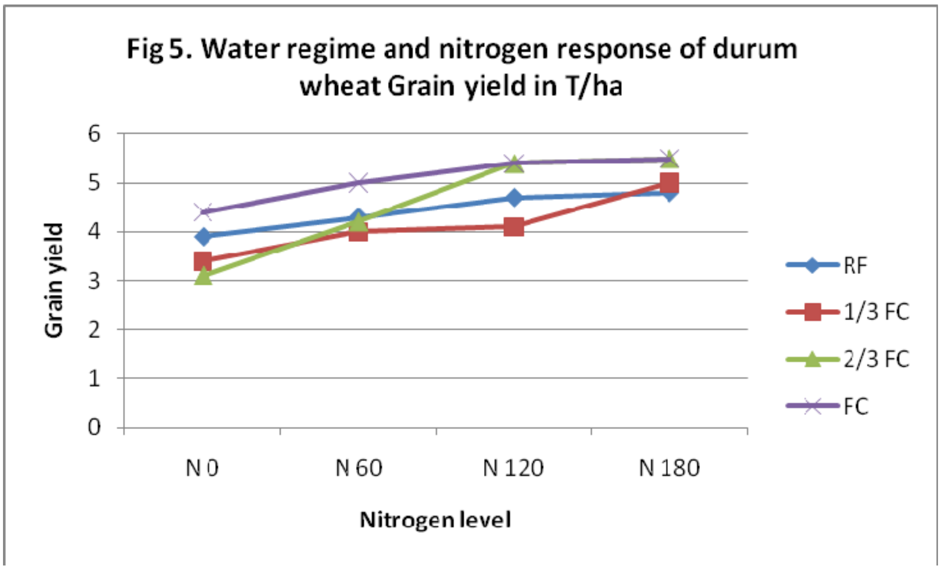
Methodology:

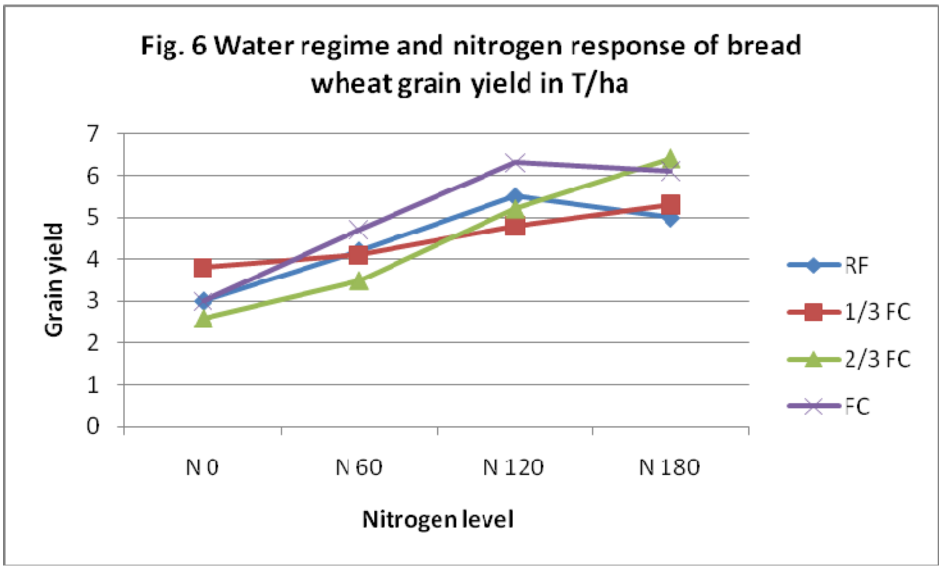
The experiment was carried out at INRA experiment station of Afourer. The studied factors are Nitrogen and water regimes based on the crop water requirements. Both bread wheat and durum wheat were tested. The sowing date was November 11, 2010 and the harvest date for yield and biomass estimation was June 9, 2011. The experiment design was a split-split-plot. The irrigation regimes and nitrogen levels were applied starting at the emergence of the seedlings. The treatments were:

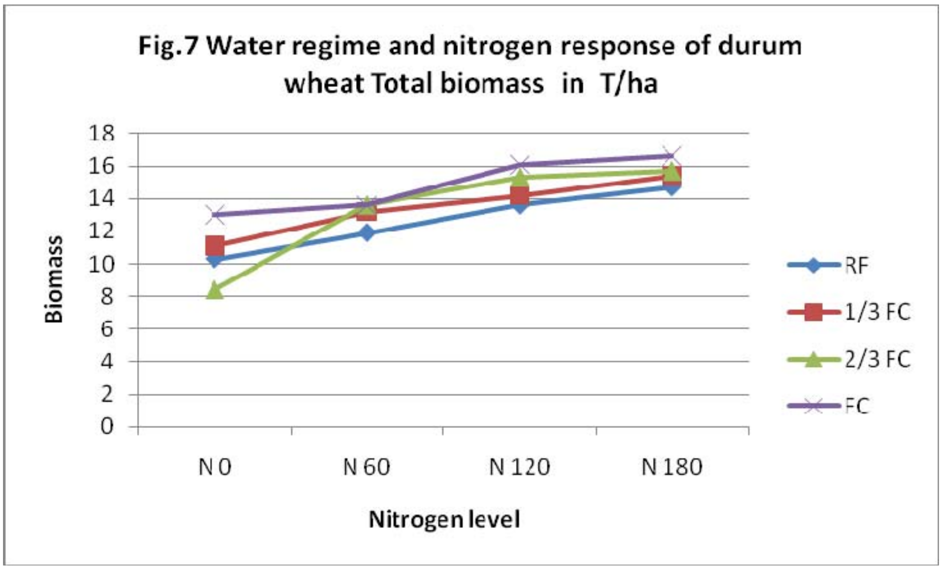
- Irrigation regimes: Rainfed, 1/3 FC: 33% of field capacity, 2/3 FC: 67% of field capacity, 3/3 FC: 100% field capacity. The irrigation was applied each time to refill the percent field capacity indicated by irrigation regime.
- Nitrogen rates: N0: 0 KgN/ha, N60: 60 KgN/ha, N120: 120 KgN/ha, N180: 180 KgN/ha

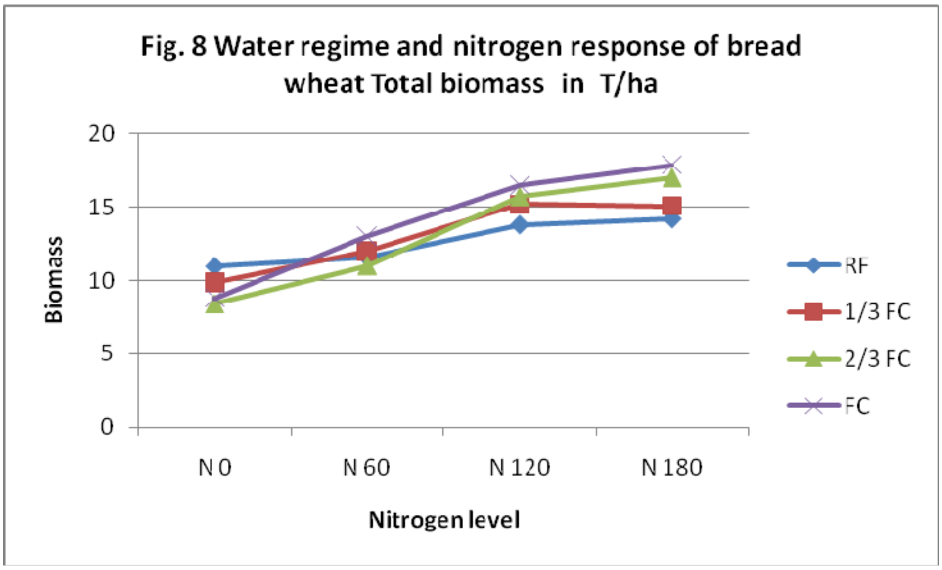
Results/Achievements:

Grain yield and biomass production are presented in Figures 5-8 for both durum and bread wheat. Nitrogen and water regimes had significant effects on both total biomass and grain yield. The response curves for nitrogen and water regimes are established for the first season. However, it is difficult to draw conclusions at this stage. There is a need to have more years to ajust and validate these curves.









Activity 2: Dissemination

Objective:

- Evaluate, package and apply through local communities in potential areas outside the rainfed benchmark sites best-bets packages of supplemental irrigation and associated practices and evaluate their impact on productivity, efficiency, farmers' income, resource base, and the environment.

Methodology:

Two sites were selected, one in Tadla perimeter and the other in Doukkala perimeter to conduct on-farm demonstration trials on wheat where improved package of supplemental irrigation was compared to the farmer management plot. The trial in Tadla was planted on November 4, 2010. The site of Doukkala was planted on November 22, 2010. The fertilizers applications were based on the soil analysis that was made before planting.

Results/Achievements:

The demonstration plots results are summarized in the table 1. The average grain yield was 67% higher in Tadla than Doukkala site. The rain received late in the season damaged the crop by causing lodging and grain shattering in Doukkala site. In both sites (Doukkala and Tadla), neither total biomass nor grain yield was significantly different between farmers' irrigation and deficit irrigation regimes.

In general farmer used more irrigation water than the quantities applied under deficit irrigation. Water productivity was slightly improved by deficit irrigation. However, it was still very low because more than 100 mm rain received during the end of the growth season was not productive and even had negative effect because it occurred during the grain maturation period of the crop in both sites.

Table 1: Yield, water use and water productivity in the demonstration sites

Sites	Water regimes	Total biomass T ha^{-1}	Grain yield T ha^{-1}	Water consumption in m^3 ha^{-1}	Water productivity in kg m^{-3}
Doukkala	Farmer	11	3.9	7390	0.5
	Deficit Irrigation	10	3.6	6436	0.6
Tadla	Farmer	12	6.5	8003	0.8
	Deficit Irrigation	13	6.1	6574	0.9

A number of visits were organized to the two sites to discuss with the farmers about the feasibility of the technical package application and adoption. Field days were also conducted on weed and diseases control where the demonstration of chemical application was performed. However, a field day where farmers from the region to be invited just before harvesting to evaluate the impact of the introduced technologies on yield, was cancelled due to heavy rain that occurred in the late of the season.

Constraints:

The most important constraint to be cited is the irrigation system. We did not have enough budgets to equip all the experiment plots with drip irrigation. So we did only equip the wheat experiment plot and we used surface irrigation in sugar beet, maize and red pepper.

Components II and III: Modeling water allocation and socio-economy

Activity1: Database for technologies dissemination and adoption studies

Objective:

Analysis of farmers' perception, awareness and adoption of supplementary irrigation and associated technologies in various types of farms;

Methodology and achievements:

The data base concerns a sample of 304 farmers that were randomly selected at Tadla sub-basin scale. Data are processed and ready for use. The sample represents approximately 3% of total households. Small-scale farmers represent 65% of total farmers in the region but have control over only 25% of the total area. Medium farm size group represents 32% of total households and have control over 42% of the total area. Large farms category controls 33% of the total area but represents only 3% of farmers in this region. This strata importance was accurately considered in the distribution of the cases among the sample. The spatial distribution of households was taken into consideration.

In fact, the project team members already started using the processed data. 80% of the data needed in activity 2 that concerns the policy analysis of supplementary irrigation and associated technologies were taken from this database and around 85% of data needed for payment of ecosystem services applied to drip irrigation activity are taken from the same data base. This last one will serve other activities especially the sub-basin modeling exercise. Some complementary data will be needed to answer very specific questions within technical, institutional and policy options (TIPO) activities.

Activity2: Institutional aspects of water management: the case of Water User Associations

Introduction:

Irrigation modernization has become the objective of the agricultural sector since the independence of Morocco. This objective was targeted in order, not only to intensify agricultural production, but also to contribute to food security. Since 1969 water policy became very important in the national agricultural policy. The main component of this policy is the construction of dams and equipment and management of large scale irrigation perimeters. Such choice has pushed the State to be the main operator and to intervene alone (design, fund, execute projects, and maintain equipment).

Today, and since the implementation of structural adjustment policy, the governments' intervention has reduced. The liberalization of crop patterns, the intervention of private sector, the implementation of contracts between the government and irrigation agency are the pilars of the new orientation of irrigation policy.

Moroccan policy has been changed during the 80's, especially in 1990 by the adoption of the concept of Participatory Management of Irrigation (PMI) and the involvement and empowerment of water users as the main actor in the system. So Water Users Associations (WUA) were created as institutions to be responsible of farmers' participation to water management.

The objective of the PMI is to make irrigated agriculture more productive, competitive and sustainable. WUA are considered as the framework for dialogue and effective participation of farmers in water management and equipment maintenance.

Objective:

The main objective of this activity is to identify the role of water users associations in promoting efficient water management practices and adoption of supplementary irrigation and associated technologies. To what extend this local organization can contribute to the improvement of current irrigation practices and how the project can rehabilitate its function as a key actor in managing water for irrigation? In the first phase of the Benchmak project we had largely described the legal assigned role of this organization and the main constraints that are blocking the achievement of its objectives. In this second phase we will emphasize the role of this actor and its collaboration with others (water basin, research institutions, farmers, development organizations such as ORMVAT and others).

Methodology:

The analysis in this activity involves a comparison of roles and interaction between stakeholders. As a social issue, this research component will be addressed using SAS² tools (Social Analysis Systems). Water Users Association organization must be investigated socially and in a multi-stakeholder mode and the insights that emerge fully integrated into processes of knowledge production, planning, and decision making. Different tools will be used:

1. Rainbow diagram: It contributes to stakeholder identification and helps to choose the method that we need to identify the key actors or stakeholders involved in a water management. This technique was used also to visualize the differences between stakeholders who may affect the adoption of new TIPOs alternatives and stakeholders who may be affected by this adoption.

WUA will be targeted in order to demonstrate its importance and improve its interaction with other actors.

2. Problem tree: It helps in identifying first and second-level causes and effects of a core problem. In our case, the core problem is water efficiency.

3. Stakeholder profile using the CLIP is a way to organize information about all actors concerned by water management and the use of improved water management technologies. Social Analysis CLIP helps to create profiles of the parties involved in the projects' actions. These profiles are based on four factors: (i) power, (ii) interests, (iii) legitimacy, and (iv) existing relations of collaboration and conflict. The technique allows us to describe the characteristics and relationships of key stakeholders in a concrete situation (such as a conflict of interests among powerful stakeholders) and to explore ways to resolve social problems (such as building trust or empowering marginalized groups). All stakeholders are ranked according to power, legitimacy and interaction. According to the actor's profile (dominant, vulnerable, marginal, respect), alternative scenarios to improve COLLABORATION between stakeholders will be discussed. The entry question for this analysis was: What are the mechanisms to be developed by actors to improve adoption of water management technologies at a large scale in Tadla?

Individual survey was conducted with selected associations and water users' federation. A stratified sample of 12 WUA distributed around Tadla perimeter was developed. The selection of WUA was based on the age of the association and its size (members). It was hard to identify WUA according to the main activity of the project or to the objective of being effective actor in water management. A list of 44 WUA was addressed in collaboration with WUA federation and the ORMVAT. To target questions, the output of benchmark database survey conducted in 2010 was used in order to avoid redundancy.

The main issues addressed are:

- WUA identity and creation history
- WUA activities and membership
- Water access and control by WUA
- Potential role of WUA in the adoption of improved technologies
- Possibility of privatizing water

The survey was conducted by a trained team of students from the faculty of social sciences and economics and a member of the ORMVAT. This activity was an opportunity to reiterate the project objectives and its holistic vision of the problem of improving water use efficiency. Water privatization issue has triggered an unexpected reaction of the members representing WUA involved in this research activity. The reason behind addressing this issue is to identify the reaction of WUA on one of the most important policy issue of the new strategy of Morocco Green Plan.

Results/Achievements:

1. The inefficient use of water in Tadla: the application of SAS² tools

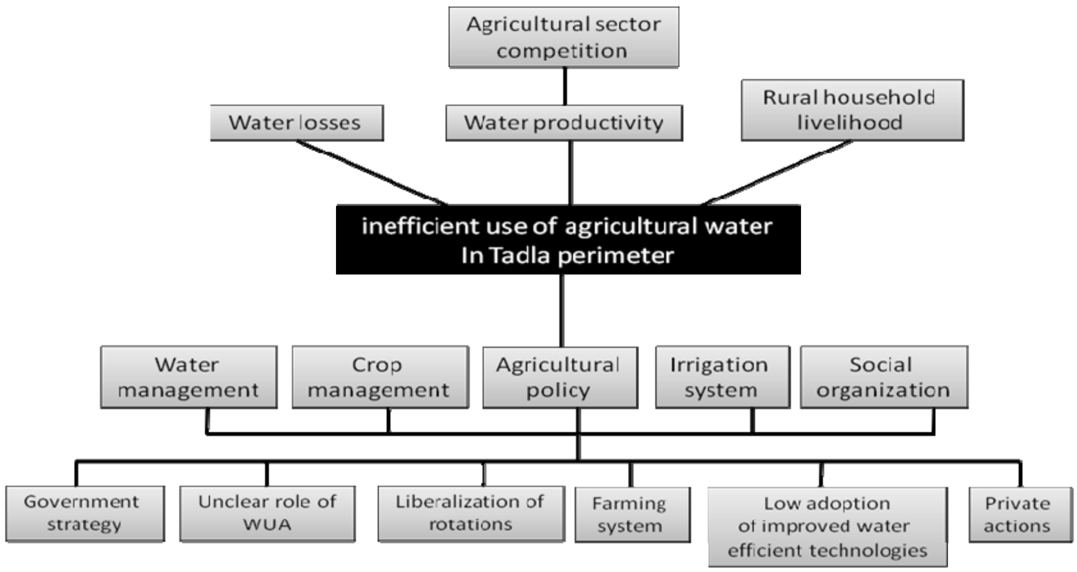
In order to identify the key questions related to the role of WUA in managing water or in the improvement of the efficient use of water in agriculture in Tadla, the benchmark scio-economy team, in collaboration with Master students from the university of Hassan 1st in Settat (Social

Science and Economics), has conducted a workshop with all stakeholders involved in water management. Most of the representatives were present except Water Basin Agency.

By applying SAS² tools, we have targeted different issues. The first one was the analysis of the first and second-level causes and effects of the core problem of the project and its relation with water management. The application of problem tree tool has contributed to understand how different stakeholders view the causes and effects of the inefficient use of agricultural water in Tadla. It was important to inform all participants about the interest of being neutral in identifying causes and effects.

As reported in Graph 1, different causes can contribute to the inefficient use of water and could have an impact on water productivity, households' income and agricultural sector competition.

Graph 1: Water use inefficiency causes and effects



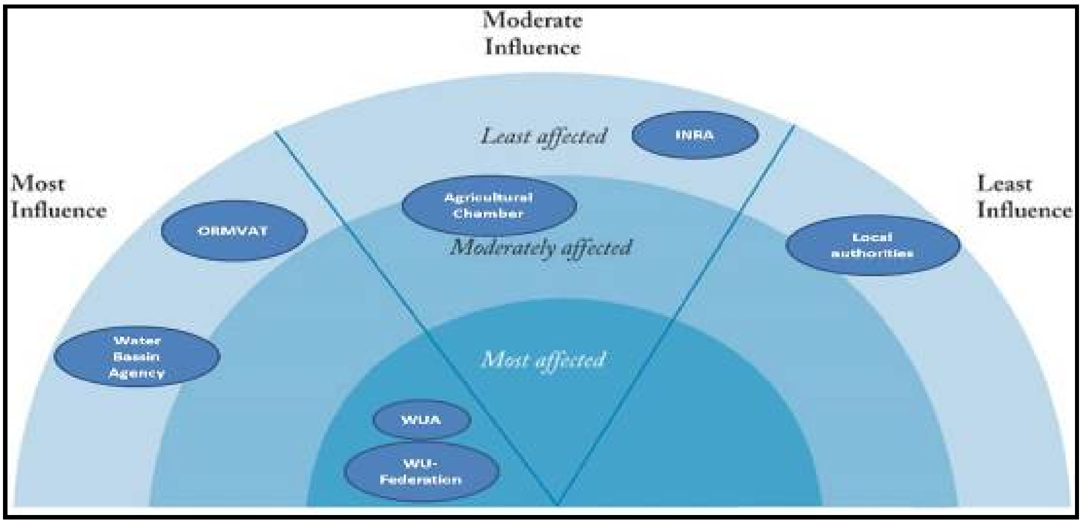
Most of the first and second-level problems are targeted by the benchmark project. Social and policy issues represent more than 80% of the problems reported by all stakeholders. According to the objective of this activity, WUAs seems to be an important cause affecting water management strategy and then the inefficient use of water.

2. Rainbow analysis

The main question is to link water management activity and adoption of improved water management technologies. It's clear that WUA is the most affected and affecting water management in the project site. So this actor and all related sector associations should be considered in the process of technology transfer. The WUA can play a key role in enhancing the adoption of TIPOs by all farmers at large scale in Tadla region. As a member of the board of Water Basin Agency, WUA can play a key role in water distribution within Oum Rabiaa basin which involves Doukkala and other irrigated perimeters. To identify the mechanism of collaboration between actors, we have conducted the CLIP analysis or actor profile.

Photo 1: Rainbow analysis

Diagram 1: The main affecting and affected actors



3. Stakeholder profile

The way that power, interests, legitimacy, and social relations are distributed in water management each situation determines the stakeholder structure and possible strategies to manage actions that concerns TIPOs. It appears that stakeholders have different profiles according to the criteria of classification cited.

Photo 3: CLIP of water basin agency   Photo 4: CLIP of water users federation

Photo 3 and 4 give the main outputs of CLIP analysis. Basin agency is characterized by high power, legitimacy and interest (LIP). It is a dominant actor and can affect all decision on water allocation and uses strategies. The same situation was found in the case of ORMVAT. For WUA or the Federation, the situation is different and they have legitimacy and interest but they don't have the resource or power to implement water management or use strategies. They are characterized as vulnerable which is in contradiction with the new strategy of participatory water management. This question was hard to discuss according to the existing relations between the WUA and ORMVAT and the administrative role of WUA at water basin agency. WUA is a board member of the water basin agency and represented by 4 members. How to correct the situation and how to reinforce the role of WUA by equal distribution of power among actors is a research question that will be addressed in the future.

4. Preliminary results of WUA survey

The survey was conducted with 12 WUA representing different users profile according to the objective of the association, activities and history. The sample is composed of 42% of surveyed associations with age over 20 years and localized in the north of Tadla perimeter, 17% of surveyed associations are just created in 2010 as part of the irrigation reconversion program and 41% are old associations but localized in the south part of the perimeter.

The questionnaire has targeted the following aspects:

- WUA identity
- WUA activities
- WUA main activities
- Institution management
- WUA and water management tools
- WUA and its role in the adoption of modern technologies
- The socioeconomic environment of WUA (new strategy of the ministry of agriculture, the involvement of WUA in water management, etc..)

The survey was conducted in collaboration with the faculty of economy and social sciences of Settat. Four students were trained and involved in the project.

The preliminary results of the survey show that:

- More than 75% of presidents of WUA are teachers and well informed about the rules and aware of the role of WUA in water management, but they are not directly involved in agricultural activities. All presidents were elected since the creation of the WUA and no annual meeting was organized so far.

- All WUA are informed about the role of ORMVAT in water management and have good relationship with technicians and water management teams.

- 82% of WUA members and managers agree that appropriate and improved technologies such as variety, irrigation and nitrogen can improve water use and productivity.

- 100% of surveyed WUA are against the privatization of water sector, particularly for irrigation in Tadla.

- The conversion from old irrigation techniques to drip is a new strategy and should be introduced progressively. It should be considered as a technique that contributes to water saving but should consider farmers practices.

- All WUA members are not informed about the new strategy of the ministry of agriculture: Green Plan of Morocco.

Activity 3: Policy analysis of supplementary irrigation and associated technologies

Objectives:

The objective of this activity is to develop policy and institutional options component of the integrated technical and institutional options for sustainable water use and management. As part of the socioeconomic studies, the main output of this investigation is the quantification of economic water productivity by developing production function models that explain its variability according to a set of variables such as fertilization, seed, prices and other socioeconomic variables.

Methodology:

The methodologies used to analyze the impact of specific policies on adoption of water management technologies are: (i) econometric tools to estimate production relationships and (ii) a household whole farm modeling. The selected tools are appropriate in answering the following questions:

- What are the main factors affecting economic water productivity?
- What are the social groups that can be affected by the adoption of improved water management technologies?
- How technical, institutional and policy options will affect households' main resources (capital and labor)? And how gendered activities related to water use will be affected?
- What are the appropriate technologies and policies that optimize the efficient use of water and improve agricultural income (by categories)?

Results/Achievements:

1. Econometric modeling activities

- Data collected in 2010 for more than 300 cases (households) in Tadla are processed using SPSS system. The first data analysis conducted is:
- Farm characterization using structural data
- Production activities description using first and second period statistical measures
- Farm typology using key discriminate variables (area and intensification)
- Econometric models developed for bread wheat, alfalfa and sugar beet.

Econometric analysis: Water economics production function development was initiated by involving a Master degree student from the University of Economics and Social Sciences of Settat. He developed a literature review on the topic of water economics productivity and econometric theory. A set of data was developed involving the benchmark team. Three main crops were selected for this work: Alfalfa, bread wheat and sugar beet. Improvement of water use by these crops will contribute significantly to water saving in the region.

A water production function model was developed for each crop using Cobb-Dougglas production function. Qualitative and quantitative variables are used as predictors of water economic productivity.

The elasticity of substitution between water productivity and other variables such us nitrogen, seed rate, weed control, farm size and a dummy variable (use of improved varieties and mechanization) was estimated directly by using Cobb-Dougglas form. We have limited the number of predictors to 5 variables after developing autocorrelation matrix between more than 13 variables. Adoption of improved technologies introduced by the benchmark project in the first phase will be considered in order to simulate its impact on water economic productivity. Each simulation will be conducted simultaneously. Results of some simulations will be used in the household production and consumption model combined with policy and institutional issues.

Preliminary results on modeling

Alfalfa model (148 case studies)

Ln(WEP) = 0.206CT-0.023LnAREA – 0.045LnSEED – 0.278LnNIT[a]
+0.174LnWCO(b)+0.802TECH[a]
$R^2 = 0.63$
F = 48.16[a]
(a): significant level 1%
(b): significant level 5%
Ln(WEP): natural log of economic water productivity in dh/m^3
CT: model constant
LnAREA: natural log of farm size in ha
LnSEED: natural seed rate in kg/ha
LnNIT: natural log of nitrogen quantity in kg/ha
LnWCO: natural log of weed control in unit/ha
TECH: dummy variable (0,1) for the use of improved technology (variety and mechanization)

Sugar beet model (70 case studies)

Ln(WEP) = -1.0106CT-0.116LnAREA[b] + 0.172LnNIT[a] -0.036LnWCO+0.811TECH[a]
$R^2 = 0.61$
F = 25.729[a]
(a): significant level 1%
(b): significant level 5%
Ln(WEP): natural log of economic water productivity in dh/m^3
CT: model constant
LnAREA: natural log of farm size in ha
LnNIT: natural log of nitrogen quantity in kg/ha
LnWCO: natural log of weed control in unit/ha
TECH: dummy variable (0,1) for the use of improved technology (variety and mechanization)

Bread wheat model (144 case studies)

Ln(WEP) = 1.292CT - 0.116LnAREA[c] - 0.393LnSEED[c] - 0.004LnNIT +
0.076LnWCO[c]+0.949TECH[a]
$R^2 = 0.51$
F = 29.194[a]
(a): significant level 1%
(b): significant level 5%
(c): significant level 10%
Ln(WEP): natural log of economic water productivity in dh/m^3
CT: model constant
LnAREA: natural log of farm size in ha
LnSEED: natural seed rate in kg/ha
LnNIT: natural log of nitrogen quantity in kg/ha
LnWCO: natural log of weed control in unit/ha
TECH: dummy variable (0,1) for the use of improved technology (variety and mechanization)

According to the output of the 3 regressions, all models are significant in explaining the variability of the distribution of economic water productivity among producers. The behavior of the 3 crops is different. All crops are sensitive to the use of improved technologies. This variable affects positively WEP, but the elasticity amount is different from one crop to another. In this case, the elasticity amount for bread wheat is around 0.95 indicating that an increase of the use of TECH by one unit will improve WEP by 0.95 units. In the case of bread wheat, seed rate and weed control are also affecting significantly WEP. Seed rate has a negative effect, indicating an increase of one unit of seed rate will reduce WEP. Also, an increase of one unit of WCO will affect positively WEP by 0.076 units. The important result is the farm size; small farms are using efficiently water. This result was largely discussed in the literature review and could be explained by the concept of economy of scale.

For the other crops (sugar beet and alfalfa), it seems that nitrogen has a significant effect on WEP. In the case of alfalfa, the effect is negative but it's positive in the case of sugar beet. That means that farmers should increase the amount of nitrogen for sugar beet but not for alfalfa.

To complete all scenarios simulations combining technical, policy and institutional aspects, a mathematical model will be developed. The household models developed in this activity will serve as the building block for the optimization and modeling activities.

The whole farm optimization model is developed and will be run using appropriate production, consumption and leisure coefficients. Up to now, only one model was developed for the whole region. Data collected in 2010 by the socioeconomic group will be used in the estimation of technical coefficients.

The modeling activity is conducted in collaboration with the department of Economics of the University of Economics and Social Sciences of Settat and the department of Social Sciences of IAV Hassan II, Rabat. It’s a PhD thesis on Applied Economics for an INRA candidate.

2. Household production and consumption model structure

The household is the basic economic organization in developing countries. It is a unit of consumption and production and a rational agent in relation to its decisions. Income generated by agricultural activities is distributed between operating and private spending. These expenses must be considered as competing investments and must be considered in the analysis of decision making process. Thus, the household model is used to maximize a function of utility and a profit function. This optimization generates demand functions for inputs, outputs supply functions and demand for consumer goods (including leisure) expressed in terms of market prices. The model is estimated on the basis of several mathematical assumptions, economic and econometric. The objective functions will therefore be assumed continuous, differentiable and satisfying the conditions of second order. The model was developed in 1965 by Gary Baker and used for rural household in 1967. The introduction of TIME as a variable in the model allowed the development of full income equation and affirms that the household is producing and consuming at the same time.

The first part of the model concerns maximizing profit function under technology constraint:

$$\Pi = \sum_{i=1}^{n} \sum_{j=1}^{n} \beta_{ij} p_i^{1/2} p_j^{1/2} + \sum_{i=1}^{n} \sum_{k=1}^{m} \beta_{ik} p_i z_k \quad (1)$$

P_i, P_j output and input prices,
Z_k level of fixed factors,
β_{ij} et β_{ik} parameters to be estimated.

The second part of the model concerns consumption function and the main constraint is the budget. The utility function is expressed as U= U(x,m) where x is the time allocated to leisure and m represents consumption units. The budget constraint is represented as follow:

$$\sum_{i=1}^{n} p_i x_i + p_l x_l \leq \Pi + w t$$

P_l and w are prices and wages at market level.

Since the maximization of the utility function implies expenses minimization for a given utility level, the consumption problem can be determined using an expenses function as follow:

$$C_{(p,\bar{u})} = \text{Min} \sum_{i=1}^{n} p_i x_i + p_l x_l ; U_{(x)} \succ \overline{U} \quad (2)$$

Household equilibrium is obtained when equation (1) is equal to (2).

In the first and second year of the project we have tried to develop model equations for production and consumption sides. Other activities such as income elasticity will be conducted in 2011 using local and national data. Technical coefficients are under process.

Activity 4: Can payment of ecosystem services secure irrigation water in Tadla region? The case of drip irrigation system

Introduction:

In Morocco, the agricultural sector is the main source of income, food, as well as employment for a large part of the population. The share of agricultural sector in both Moroccan GDP and total export is about 14% and 11%, respectively. Irrigated zones cover 13% of the total agricultural land and contribute 45% of the agricultural added value in a normal year.

Water resources in Morocco are limited. The amount of potentially divertible water using available technologies is about 20 billions m³. Agriculture remains the biggest user of these resources with 92 %. To sustain the increased demand for more and diverse agriculture products, it is inevitable to increase the area of irrigated crops or to increase the productivity per unit area over the years. Climate change is another major threat to the future of Morocco water resources. Morocco experiences, in addition to highly variable rainfall recurrent periods of drought. The country has experienced a drought in one year out of every three over the last century. Therefore, there is an urgent need for an efficient use of the resource through the development of appropriate irrigation technology for suitable crops. One of these technologies is drip irrigation system. In fact, the 2008 national agriculture strategy, called the Green Morocco Plan (Plan Maroc Vert, PMV), promote a number of practices to increase the stability and efficiency of water resources, including replacing existing irrigation systems with micro-irrigation. Under the PMV, drip irrigation will be expanded from 150,000 ha to 670,000 ha by 2020. This conversion from flood to drip irrigation systems needs adequate government interventions. This may include more incentives to adopt drip irrigation systems. Globally there has been a shift from traditional subsidy and trade policies to policies that provide farmers with incentives to increase the supply of ecosystem services from agriculture (in our case, water conservation). This is being referred to as Payments for Eco-system Services (PES; Lipper et al., 2009).

Objective:

The objective of this study is to identify the optimum level of payments for eco-system services (PES) that allows an acceptable adoption rate of drip irrigation systems and to assess whether it would be technically and economically feasible to pay farmers to reduce water consumption by changing from flow to drip irrigation in Tadla region.

Methodology:

In this study we are dealing with a very specific question: what is the effect of different level of PES on the adoption rate of drip irrigation systems in Tadla region?

The challenge of this study is to provide timely quantitative policy analysis using limited resources to support the policy decision process. A number of studies showed that the Minimum Data Modeling (MD) approach gave a good trade-off between timeliness, resource limitation and accuracy of information produced for policy decision making (Antle et al., 2006; Immerzeel et al., 2008; Claessens et al., 2009). Furthermore, unlike cost/benefit approach based on representative farmers, the MD approach takes into consideration the variability in agricultural systems that characterize our environments. For these reasons we choose to use the MD approach to estimate the rate of adoption of drip irrigation systems for various levels of PES in the Tadla region.

Figure1 shows how the supply of ecosystem services is derived from the spatial distribution of opportunity cost. The curve in the left side of the graph represents the opportunity cost distribution. The price per unit of e, P_e , is shown on the vertical axis and the density function $Ø(\omega/e)$ is shown in the horizontal axis. The area under this curve in the price range from $-\infty$ to 0 is the initial equilibrium supply for ecosystem services. The right side of the graph represents the supply curve. The horizontal axis shows the supply of ecosystem services as a function of price per unit e on the vertical axis. The supply curve crosses the horizontal axis at the initial equilibrium where $p_e = \omega/e = 0$. The supply of ecosystem services increases as the P_e increases. The rate of increase (slope of the supply curve) depends on the shape of the distribution of the opportunity costs. The supply curve approaches a vertical asymptote equal to the maximum amount of ecosystem services that can be produced when all farmers switch to practice drip irrigation.

Depending on the distribution of opportunity costs for switching from flood irrigation to drip irrigation, three cases are possible (Figure1):

- Case 1: Drip irrigation technology is profitable compared to flood, farmers adopt with no payment (incentives)
- Case 2: Flood irrigation practice is profitable, but drip irrigation technique is more profitable with payment of eco-system services for saved water. Farmers will adopt drip irrigation with incentives.
- Case 3: Flood irrigation is profitable even if a payment of eco-system services is offered.

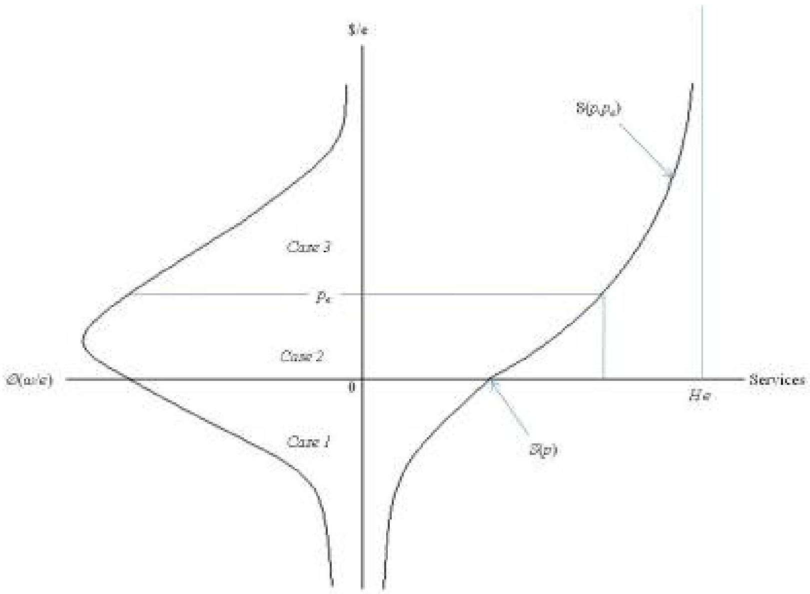


Figure 1: Derivation of the supply of ecosystem services from the spatial distribution of opportunity cost per unit of ecosystem services (Antle et al., 2006)

Primary data were extracted from the benchmark project database. These data concern especially the farm structure in the perimeter and all the data related to cropping systems under flood irrigation.

Some complementary data related to drip irrigation questions needed by the MD model were collected separately during June 2011. These data concern the costs of drip irrigation network establishment, the water use for drip irrigation technology at the farm level and the yields for different crops under drip irrigation. Altogether, fifty farmers were randomly selected but strata importance was considered in the distribution of the cases. The main criterion of selecting these farmers was the use of drip irrigation technology. The sampling framework was developed in collaboration with ORMVAT extension services.

Results/Achievements:

According to the household survey, the average age of farmers is 56 years. More than 74% of farmers are illiterate and only 6% of them have a high school level. The average family size is around 7 persons. More than 97% of farmers have agriculture as first activity, and it is their main source of income (73% surveyed farmers). Off-farm activities generate 17% of household income and concern different activities.

The average farm size for small-scale farmers is 4.2ha (table 1). This category of farmers represents 90.9% of total farmers in the region but have control over only 51% of total area. The average farm size for medium and large farms is, respectively, equal to 14.3 and 26.7 ha. Medium farm size category controls 15.5% of the area and represents only 5.6% of farmers in this region. Large farmers represent only 3.5% but have control over 33.5% of land.

Table 1: Farm structure for farmers using drip irrigation in Tadla perimeter

Farm category	**Number in %**	**Area in %**	**Average farm size (ha)**
Large (+20 ha)	3,5	33,5	26.7
Medium (10-20 ha)	5,6	15,5	14.3
Small (-10)	90,9	51	4.2

The data extracted from the database shows that for farmers using flood irrigation system, cereals represent the main crop in term of area for all categories of farmers (table 2). For small farmers, more than 50% of the area is cultivated with cereals. About 37% of big farmer's area is reserved to cereal production. Citrus is exclusively cultivated by medium and big farmers. The main raison for this is the high costs of the establishment and the three years period between tree planting and the first year of fruit production. The sugar beet area represents, respectively, 20% and 22% of total farm land for large and medium size farms. Alfalfa, olive trees and vegetables are cultivated by all farm categories. Small farmers have the largest share of land for these crops.

Small farmers have the highest rate of crop intensification and it is estimated at 144%. This rate is about 110 and 133%, respectively, for large and medium size farms. Because of their small farm size, small farmers tend to maximize their revenue from the same portion of land.

Table 2: Cropping pattern under flood irrigation system (in %) in Tadla perimeter

Crops	**Large (+20 ha)**	**Medium (10-20 ha)**	**Small (-10 ha)**
Citrus	**14,7**	20	0
Sugar beet	20	22	26
Cereals	**37**	**40**	**51,5**
Alfalfa	7	13,8	18,8
Maize F.,	6	3,2	2,1
Olive trees	12,2	12,3	11
Vegetables	13	21,6	34,5
Intensification R.	**109,9**	**132,9**	**143,9**

Table 3 shows that only part of the farm area is converted to drip irrigation. In average 70% of the area is converted to drip irrigation. After conversion, cereals, especially wheat, remain the main crop cultivated by all categories. However, this crop continues to be conducted under flood irrigated system. Farmers also maintained Alfalfa under flood irrigation system. Conversion to drip irrigation allowed farmers to give more importance to high added value crops (citrus, sugar beet and vegetables) in their production systems.

Drip irrigation has become the standard method of irrigation in Tadla for citrus. Most new planted citrus orchards are irrigated with drip systems. After conversion, all farmers tend to increase the area of high added value crops. The immediate consequence of this orientation is the reduction in area assigned to cereals and forage crops (mainly alfalfa).

Farmers do not introduce new crops after conversion but simply give more importance to such crops. They either choose vegetables like melon, red pepper or potato or install orchards (in most cases citrus). Usually, young citrus plantations are associated with vegetables during the first three years.)

Table 3: Cropping pattern after conversion to drip irrigation system (%) in Tadla perimeter

Crops	**Large**		**Medium**		**Small**	
	Drip irr.	**Flood irr.**	**Drip irr.**	**Flood irr.**	**Drip irr.**	**Flood irr.**
Citrus	17.3	0	22	0	0	0
Sugar beet	26	0	22	0	26	0
Cereals	0	31	0	38	0	51,5
Alfalfa	0	5	0	10,1	0	18,8
Maize F.,	6	0	3,2	0	2,1	0
Olive trees	12,2	0	12,3	0	11	0
Vegetables	16.5	0	25.3	0	34,5	0

When asked about crop yield effects of the conversion, all farmers indicate that an increase of crop yields was observed. This increase is very variable among and within categories of farmers.

For citrus trees the yield increased in average from 21 t ha^{-1} under flood irrigation to 38 t ha^{-1} under drip irrigation system. The continuous irrigation and application of nitrogen and other elements improves crop yields.

Investment in a drip irrigation system generates a fixed cost that must be paid each year, regardless of the volume of water delivered with the system. The annual fixed cost includes the repayment of a loan or the opportunity cost of capital used to purchase the equipment, to pay for the maintenance that must be performed regardless of use and depreciation. In general, the annual fixed costs of drip irrigation system are larger than surface systems due to the higher initial investment required to purchase and install drip irrigation systems. Conversion to drip irrigation system requires important investments; up to 60,000 DH ha^{-1}. The needed money is often provided through farmers' access to other sources of funding like emigration or other non agricultural activities. The average fixed cost for our sample was estimated to about 45,000 DH ha^{-1}.

Table 4 shows the ecosystem services after the conversion to drip irrigation system. The largest quantity of saved water is observed in citrus. Medium size farms save about 4876 m^3 ha^{-1} and the quantity of water saved by big farmers is estimated at 4420 m^3 ha^{-1}. This represents a decrease of 56% of citrus needed water under flood irrigation.

In terms of weighted average, medium size farms save about 3831 m^3 ha^{-1} $year^{-1}$, big and small farmers save, respectively, 3412 and 2776 m^3 ha^{-1} $year^{-1}$.

Table 4: Ecosystem service after conversion to drip irrigation (saved water in m^3 per ha) in Tadla perimeter

Crops	**Large (+20 ha)**	**Medium (10-20 ha)**	**Small (-10 ha)**
Citrus	4420	4876	0
Sugar beet	3888	4424	2944
Maize F.,	2214	2414	2295
Olive trees	1512	1374	1123
Vegetables	3656	3884	3205
Weighted average	3412	3831	2776

Table 5 shows the adoption rates for different levels of payments of ecosystem service. The basic rate of adoption is 4.2%. This means that 4.2% of farmers adopt drip irrigation without any incentives. In average, a payment of 1.4 dirham per saved m^3 to farmers improves the adoption rate of drip irrigation system by 22.9%. If we assume that the depreciation period of drip irrigation equipments is five years and the average saved water in the perimeter is 3340 m^3 ha^{-1} $year^{-1}$, the total payment for saved water, during five years, will be 23,380 DH ha^{-1} which represent around 52% of the initial investment. A payment of 2 dirham per saved m^3 to farmers increases the adoption rate to about 80% and the total payment will represent around 74%. In the case of collective conversion to drip irrigation project financed by the Green Morocco Plan and in order to reach 80% of adoption (farmers' engagement or agreement of acceptance) the government gives farmers a subsidy of about 80% of total investment, this represents around 2.2 dirham per saved m^3. This means, first, that the price offered by the government is very close to the price estimated by the model, second, the higher price offered by the government reflects the importance given by the policy makers to water conservation in Morocco.

Table 5: Average Payment of Eco-system Services (PES) levels in Tadla perimeter

PES (dh m^{-3})	Adoption rate (%)	Total PES (dh ha^{-1})	% of investment
0	4.2	0	0
1,4	22.9	23380	52
1,6	55.3	26720	59
1,8	74.7	30060	67
2	**80.5**	**33400**	**74**
2,2	**89.5**	**36740**	**82**

Conclusion

Drip irrigation provides opportunities to improve both the farm-level net returns and the public net benefits generated with limited water resources. Potential farm-level benefits include reductions in water deliveries and labor costs, higher crop yields, and a broader set of production opportunities in regions where water supplies are particularly limited.

Potential public benefits include higher farm-level net returns and the net values generated in agriculture and in other uses with water made available when farmers replace alternate irrigation methods with drip irrigation. Public benefits also are enhanced when drip irrigation reduces or eliminates negative impacts and opportunity costs, such as water use inefficiency, nutrient leaching, and the rapid depletion of nonrenewable groundwater resources.
Model results show that the price offered by the government (subsidies) is very close to the price estimated by the model and the higher price offered by the government reflects the importance given by policy makers to water conservation in Morocco. Results of this model confirm and support the recent subsidy levels set by the government (80 to 100%) for the adoption of drip irrigation system.

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II. PLAN OF WORK

Component I: Fine-tuning, out-scaling and dissemination

Activity 1: Planting date x irrigation scheduling for maize, sugar beet and red pepper

Objective:

- To improve land and water productivity and reduce the effect of climate variability and change

Methodology:

Site: Experiment station of Afourer, Tadla

Treatments

- Planting date :
  - ✓ D1: early November, D2: early December for sugar beet
  - ✓ D1: Late March, D2: early May for Maize
  - ✓ D1: Early March, D2: late April for red pepper
  - Irrigation regimes: 1/3FR: 33% of full requirement, 2/3FR: 67% of full requirement, FR: full requirement

Experimental design

- Split plot with 4 replications

Activity 2: Response of wheat to different water and nitrogen applications

Objective:

- Improve water productivity and nitrogen use efficiency, and protect the environment from water pollution by nitrates

Methodology:

Field experiments will be conducted in the experimental station of Afourar in Tadla

Treatments

- Species: BW: Bread wheat, DW: Durum wheat
- Irrigation regimes: Rainfed, 1/3FR: 33% of full requirement, 2/3FR: 67% of full requirement, FR: full requirement
- Nitrogen rates: N0: 0 KgN/ha, N50: 50 KgN/ha, N100: 100 KgN/ha, N150: 150 KgN/ha

Experimental design

- Split plot with 4 replications

Activity 3: Dissemination

Objective:

Evaluate, package and apply through local communities in potential areas outside the rainfed benchmark sites best-bets packages of supplemental irrigation and associated practices and evaluate their impact on productivity, efficiency, farmers' income, resource base, and the environment.

Component II: Modeling water allocation

Activity 1: Policies analyses

Objective:

- Describe and quantify the policies instruments that influence directly or indirectly the resources allocation in the studied area

Methodology:

- Review the available information
- Surveys at the farmers, institutions and decision makers

Activity 2: Elaboration and calibration of a disintegrated model of economic management at the basin level of comparative static type

Objectives:

- Establish the global structure of the model;
- Disintegrate the model by type of use of water resource, homogeneous units of water use and demand and by production systems and farms;
- Calibrate the model by positive mathematic programming;
- Validate the model and conduct the simulation to test the sensitivity of the model.

Methodology:

- Develop the equations
- Run the model with different sets of data for calibration and validation.

Component III: Socio-economy

Activity 1: Institutional aspects of water management: the case of Water User Associations

- Continue the social analysis of water management stakeholders in order to develop appropriate mechanisms that can be implemented to improve WUA position and power;
- Organize a workshop involving WAU members and ORMVAT and validate survey outputs and continue CLIP tool in order to identify the appropriate factors that can improve the collaboration between all actors.
- Involve two master students in two studies related to activity 3.

Activity 2: Policy analysis of supplementary irrigation and associated technologies

- Fine tuning the 3 econometric models for Tadla perimeter and simulate the impact of appropriate factors (Nitrogen and price)
- Elaborate the final report for the econometric modeling activity
- Technical coefficients estimation and development of water use equations by crop and period
- Household production and consumption model running and development of appropriate simulations for policy and institutional analysis

Activity 3: Non-monetary benefits of conversion from flood irrigation to drip irrigation

B. RAINFED SATELLITE SITE OF TUNISIA

I. PROGRESS

Introduction:

The field is the elementary unit of production and therefore is the first target for improving water use efficiency. Generally, farmers seek optimum strategies that best meet their personal needs for a given combination of climate soil and economic conditions. They have to make long term decisions about crops to produce, rotational sequences, machinery, equipment, labor and marketing arrangements. Farmers can also introduce occasionally tactical adjustments to their overall strategy to take advantage of favorable weather, or reduce inputs, even skipping component crops entirely, when unfavorable weather conditions means that the marginal benefits of individual activities will not meet the costs incurred.

In Tunisia, major difficulties to strategic planning and tactical adjustments relate to the well-known high variability of the Mediterranean climate. Moreover recently observed climate changes, conflicting signals on the use of biocides because of environmental concerns, growing competition for water resources due to population increase and higher prices for energy and fertilizers are exacerbating the already serious threats to farming in the rainfed areas. This is particularly true for northern Tunisia where the rural activity depends very much on how rainfall water is used for the benefit of crop production.

Within the context of unpredictability, we are attempting to help improve the ability of farmers and supporting services to respond to the various abiotic constraints. Our experimental results have shown the potential for improving crop production (wheat) through the manipulation of the cropping system: choice of cultivars, land preparation, planting date, fertilization, irrigation scheduling, timely application of pest and disease controls, and crop rotation. The question is how to upscale solutions for individual field to an entire community, in terms of technical, managerial and institutional actions for improving agricultural productivity.

Because the environments we are working with are highly variable, farming strategies can only be established by analysis of crop performances over a substantial number of seasons. This cannot be done by experimental work alone. Simulation models that portray the response of crops to weather, soil and management variables are required to serve as analysis tools.

For our work, it is hypothesized that efficient farming is achieved when the best use of the rainfall water is made, i.e. when practices are designed to accommodate rainfall variability.

Improvement opportunities are considered for the region of north-eastern Tunisia. Our task consists in developing and applying an out-scaling methodology that uses results of the INAT-experimental station in Mornag and the cereal-based farming area of Capbon, north-eastern Tunisia.

Objective:

Considering that optimal patterns of water use by crops under variable environmental conditions are best investigated by simulation models, the main objective of our work is to use simulation models "Aquacrop" to identify options for improving the cereal based cropping systems in Capbon.

Outputs (project):

Actions are planned to produce knowledge and quantitative information for farmers, extension services, and decision makers on four major issues:

- Actual patterns of the evapotranspiration (ETa) of wheat and associated crops in the cereal growing areas of Tunis-Capbon.
- Variations in ETa owing to rainfall distribution.
- Variations in ETa that relate to the soil.
- Yield gap and constraints to improve water productivity.

Activities:

During the last period (2009-Present) we have been conducting field work on the wheat and faba bean crops that are commonly used in the Tunis-Capbon region. Wheat is considered as the reference crop for cereals such as barley triticale and oats, whereas faba bean is considered as representative of legumes. Two main activities are considered here: i) the work done at the experimental station and ii) the investigation carried out in farmers fields.

Both activities were conducted with the same objective of developing a data base on seasonal ETa, total biomass production and economic yield for model validation in both Tunis and Cap-bon area. Productivity measurements were carried out according to the same methodology in the research station as well as the production fields. However, soil water content monitoring was systematic in the experimental plots but targeted only critical crop growth stages such as emergence, anthesis and maturity in the production fields.

Activity1. Measuring ETa, crop growth, crop cover and yield for the wheat and faba bean crops in the INAT-Mornag experimental station

Objective:

Development of an appropriate data set on wheat and faba beans to be used as a common ground for AquaCrop validation and for interpreting crop performance in production fields.

Methodology:

At the INAT- Mornag research station, the experimental field was divided equally between the two reference crops wheat and faba beans. Treatments consisted for each crop in changing varieties and/or planting patterns in order to capture variations in the commonly used practices for model parameterization. A total of 4 plots having each an area of 2000 m^2 (40mx50m) was used for wheat as well as for faba bean.

Crop growth and actual evapotranspiration monitoring are obtained through estimation of the crop cover fraction (CCF), leaf area index (LAI), above ground total dry matter (DM) and soil water content (SW).

CCF measurements consisted in taking orthogonal photos of the crop following an X pattern in the field. A total of 12 photos were taken at each sampling date and for each one of the indicated treatments in order to make precise estimation of the parcel CCF. Image processing was carried out in the lab using special techniques based on the enhancement of the vegetation/soil contrast.

Sampling consisted in cutting plants for lab measurements, from a square of 50cmX50cm, in each one of the parcel. LAI is first measured using a leaf area meter, before the determination of DM content of the sample. SW is measured right on the spots that served for plant sampling, using the auger method for every 10 cm soil layer on a total depth of 100 cm.

During the cropping year 2009-10 monitoring started at plant emergence and ended when the crop reached maturity. A total of 10 sets of measurements were performed over the cropping cycle, for each one of the experimental plot from January to May 2010 (Table 1).

Table 1: measurements carried out on each one of the experimental plots (4 for wheat and 4 for faba beans), INAT-Mornag 2010

	Jan 29	**Feb 5**	**Feb 15**	**Feb 23**	**Mar 13**	**Mar 24**	**Apr 6**	**Apr 22**	**May 11**	**May 27**
CCF	X	x	x	x	x	x	x	x	-	-
DM	-	x	x	x	x	x	x	x	X	x
SW	-	x	-	-	x	x	x	x	X	x
LAI	-	x	x	x	x	x	x	x	-	-

Case of wheat

In wheat, the plots comprised the widely used durum varieties Karim and Razzeg in addition to a recently released Maali that has larger canopy development (Table 2). All plots were under supplemental irrigation and received the commonly applied cultural care of fertilization and weed control.

Table 2: Wheat plots used in the monitoring experiment

Wheat Variety	**inter-row spacing (cm)**
Maali	17.5
Razzeg	17.5
Karim	17.5
Karim	35

Case of faba bean

The faba bean crop is commonly planted with very variable densities, so it was important to produce data for this crop on plots with increasing spacing. Obtained results concern the plantings densities shown in table (3).

Table 3: Faba bean plots used in the monitoring experiment

Faba Plots	**inter-row spacing (cm)**
FB1	17.5
FB2	35.0
FB3	52.5
FB4	70.0

Results/Achievements:

Climatic conditions

Precipitation and temperature are measured daily in the meteorological station of INAT-Mornag which is adjacent to the experimental field. Weather records were also obtained from the weather stations of INAT and Tunis-Carthage, located at about 20 km from the experimental fields. Monthly rainfall for the cropping seasons, 2009-2010, are given in table (4).

Table 4: Monthly rainfall (rounded to mm) for the experimentation conducted at INAT-Mornag over the cropping year 2009-2010

Station	sep	oct	nov	dec	jan	feb	mar	apr	May	total
Mornag-INAT	36	47	43	15	34	37	70	51	80	413
Tunis-Carthage	51	51	39	30	41	55	73	44	48	432

Biomass production

Total dry matter increases were measured in all plots during active growth and CCF rapid changes. Biomass accumulation for both crops was important during the march-april period and stabilized around 1200 g/m^2 for wheat and about half of that amount for faba bean.

Soil Water content variations

Soil moisture was measured at critical stages of growth and during the period of rapid increases of CCF for the purpose of modeling evapotranspiration for wheat as the reference crop for cereals and faba bean as the reference for legumes.

Since the used crops have different rooting systems, soil water use patterns were expected to have quietly contrasting aspects. As a matter of fact, humidity profiles obtained for the wheat crop (Figure 1) show important differences with those obtained for faba bean (Figure 2).

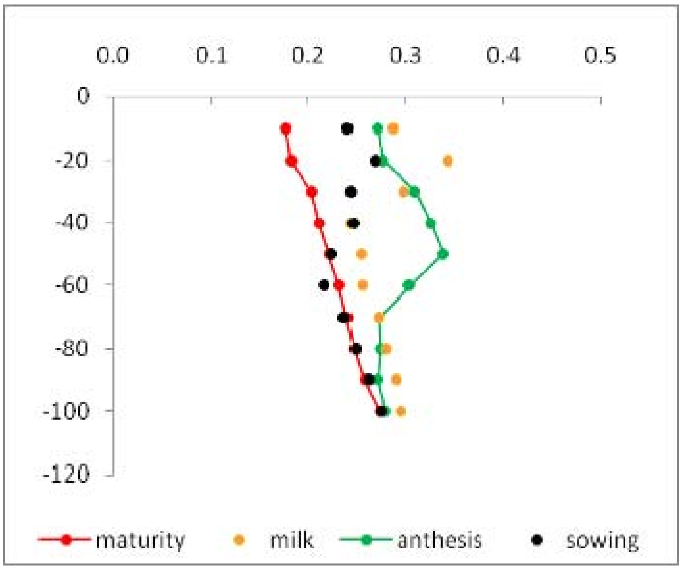


Figure 1: Soil moisture of the root zone for wheat, INAT-Mornag, 2009-2010.

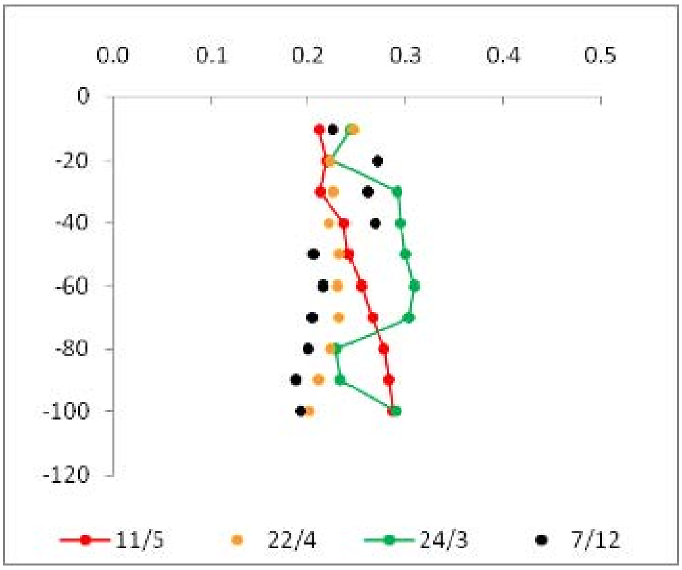


Figure 2: Soil moisture of the root zone for Faba bean, INAT-Mornag, 2009-2010.

Yield

Yield and yield components were measured in order to have the standard data sets needed for modeling purposes. Tables (5) and (6) show the range of yield variations obtained in relation to row spacing for the wheat and faba bean crops, respectively.

Table 5: Range of variation in yield and harvest index for wheat in the Inat-Mornag experiment, 2009-2010

Component	**range of variation**
Distance between rows (cm)	17.5 – 35.0
Above ground biomass (g/m²)	514 - 853
Tillers (/m^2)	233 - 462
Grain yield (g/m²)	279 - 429

Table 6: Range of variation in yield and harvest index for faba bean in the Inat-Mornag experiment, 2009-2010

Component	**range of variation**
Distance between rows (cm)	17.5 - 35.0
Above ground biomass (g/m²)	351 - 448
Grain yield (g/m²)	141 -166
1000kernel weight (g)	227 - 368

Activity 2: Assessment of crop productivity and seasonal evapotranspiration in farmers' fields of the Capbon region

This activity was launched in 2009-2010 cropping season and is continuing for the second year 2010-2011. Eight farms were selected in order to carry out the productivity investigation on wheat and associated crops. Assessment targeted specifically the wheat crop during 2009-2010 but was extended to the other crops used in rotation by farmers during the present year.

Objective:

Obtain real data on crop water productivity under the full intensity of farming conditions in the region of Capbon.

Methodology:

Since we are seeking to obtain quantitative data that could be used for AquaCrop parameterization and validation, it is important to estimate crop cover and biomass production in selected production farms in Capbon. Sampling sites correspond to production fields located in the hilly areas upstream of the Lebna basin (6 sites) and in the downstream areas (4 sites). Fields selection took into consideration the ongoing work on soil survey in Capbon (Digisol), since it is essential that good soil data should be easily made available for simulation.

Farms were visited individually for appraisal of the cropping conditions, and for biomass and yield estimation, through sampling.

Results/Achievements:

Field work during the year 2009-2010 targeted wheat which is actually the most common field crop in northern Tunisia. During the present year, although wheat remains the dominant crop, investigation was extended to species that are commonly used in crops succession by small farmers. Table (7) gives the sites that served for productivity assessments.

Table 7: number of sites concerned by the field work in the upstream and down stream areas of Capbon over the two successive years 2009-2011

Year of investigation /area	**Durum wheat**	**bread wheat**	**barley/ triticale**	**faba beans**	**chick peas**	**vetch**	**total**
2009-2010							
Upstream (hilly)	4	1	1				6
Downstream (plain)	4						4
2010-2011							
Upstream (hilly)	2		1	2	1		6
Downstream (plain)	1				1	1	3
Total	11	1	2	2	2	1	19

During the current year, while keeping wheat as the reference crop, we decided to include in the biomass and soil water measurements protocol of work crops that were introduced in the previously investigated fields. The purpose is to gain insight in how rainfall water is used by the cropping systems of Capbon compared to our research station in Mornag. Therefore, estimations of productivity and seasonal water consumptions were carried out on 7 of the fields that were used last year. However in two cases we had to move to nearby locations and on one site the crop was judged not relevant to our work (condiment).

Precipitation during the cropping season 2009-10:

Acquisition of daily precipitation and temperature records were obtained from the weather station of Kamech located in the hilly agricultural areas and Kelibia which represents the southern coastal plain of Capbon. Table (8) gives the precipitation amounts obtained for these two stations, over the cropping year 2009-2010.

Table 8: Monthly rainfall records (rounded to mm) in weather stations of Capbon during the cropping year 2009-2010

Station	**sep**	**oct**	**nov**	**dec**	**jan**	**feb**	**mar**	**apr**	**May**	**total**
Kelibia	89	92	44	35	92	46	84	34	41	561
Kamech	78	151	64	50	68	57	74	57		

Crop performance in the production farms:

As mentioned earlier, a total of 10 production fields were investigated for the appraisal of farmers' performance. Sampling was carried out according to the same methodology used in the experimental plots for the estimation of crop production and yield components. The range of variation concerning wheat over the cropping year 2009-2010 are summarized in table (9)

Table 9: Results concerning the investigation on wheat productivity in Capbon, 2009-2010

component	**range of variation**
dates of emergence	November-December
Plants	100- 288
height at anthesis(cm)	51-90
dates of maximum LAI	16 Feb -12 April
maximum LAI	0.9-6.6
biomass (g/m^2)	259-981
HI	0.25-0.51

Conclusion:

Potential yields that could be achieved with the prevailing climate and soil resources is an important information for developing cereal based cropping systems in Tunisia. Our work is concerned by estimating actual productions through direct measurements and attainable yields through simulation, in relation to different water use patterns.

As presently parameterized, the Aqua Crop model allows for wheat growth simulation in the experimental station. Its use as a tool for out-scaling purposes requires appropriate validation in the area of interest. Concurrent monitoring carried out on crop growth in the research station (INAT-Mornag) and production farms (Capbon) will be used for this purpose during the coming period.

II. PLAN OF WORK

The same activities will be conducted in 2011-12 to collect more data to be used in the modeling.

C. RAINFED SATELLITE SITE OF ALGERIA

I. PROGRESS

Activity 1: The role of nitrogen supply and soil moisture-based supplemental irrigation regimes on durum wheat grain yield, water and nitrogen use efficiency and dry matter accumulation and distribution

1. Introduction

Wheat is the major cereal cultivated in the Mediterranean region and represents a strategic crop for food security across the whole area; where there is increasing evidence for water resources scarcity. Despite this scarcity, farmers allocate high amounts of water for irrigation exceeding crop requirements by 30–49%. Besides plants and environmental factors, the large range of water use efficiency (WUE) values observed for the same species in Mediterranean climate can be ascribed mainly to fertilizers and water management. The understanding of the interactive effect of water and N availability, associated with the ability of crops to efficiently use these resources is a subject of many studies in the Mediterranean region where wheat crop generally suffers from both mid-season drought that reduces grain number per spike and terminal stress (water and heat stresses) that reduces grain weight. Therefore, planning suitable irrigation and nitrogen fertilization strategies at appropriate crop phenology stages can ensure optimum grain yields. The present study aims at evaluating the effect of the interaction of nitrogen supply regimes with soil moisture deficit-based supplemental irrigation levels on grain yield, water use efficiency, and dry matter distribution and accumulation of CHEN'S durum wheat cultivar. Since the analyses of some parameters have not been completed yet, only the analyzed data will be presented in this report.

2. Objectives:

- The aim of this study is to develop water and nitrogen management guidelines that allow optimal grain yields of durum wheat and water saving in the northern part of Algeria.

3. Methodology:

A field trial was carried out in 2011 at Baraki research station (Algiers, 36° 41' N, 3° 5' E, Altitude: 18m) belonging to the National Institute of Agronomic Research of Algeria (INRAA.).

The climate is typically Mediterranean with 20-year average annual rainfall of 584 mm. The physical and chemical characteristics at the beginning of the experiments were as follows (Table 1).

Table 1: Soil physical and chemical characteristics

Depth (cm)	Ph (1:2.5 soil/water extract)	Ec 1:2 soil/water extract, (mmhos/cm)	N%	P2O5 (ppm)	K2O (ppm)	Carbon (%)	Clay %	Silt%	Sand %
0-10	8.06	0.19	0.15	55	559	1.64	53.75	30.99	15.28
10-20	7.98	0.19	0.2	45	614	1.78	52.75	29.97	15.75
20-30	8.04	0.17	0.2	45	559	1.64	54.50	28.3	17.45

3.1. Treatments and crop management

Durum wheat seeds of CHEN'S cultivar were sown under field condition with row spacing of 15 cm and seeding rate of approximately 300 kg/ha. Sowing date was December 30, 2010. The state of the experiment at early and late growth stages is presented by photo 1. Wheat was exposed to 4 water supply regimes, rainfed, and 1/3SI, 2/3SI, 3/3SI, corresponding respectively to the applications of 1/3, 2/3, 3/3 of full supplemental irrigation (SI) and to 4 nitrogen fertilizer rates N_0, N_{50}, N_{100}, N_{150} (0 Kg N/ha, 50kg N/ha, 100kg N/ha, 150kg N/ha, respectively). The Nitrogen fertilizer in the form of urea was applied at tillering (Zaddock 25) and at stem elongation (Z35) growth stages. In addition to the differentiated nitrogen treatments, 50 kg of N /ha (150 Kg/ of NPK-15%) were supplied as a basal dressed fertilization before sowing. During stem elongation foliar phosphorus (43%), in the form of P_2O_5, was applied.

A split plot experimental design was used in the study. The irrigation regime was assigned to the main plot and nitrogen rate to the sub-plot. Four irrigation water levels and four nitrogen rates were randomly distributed in three replicates. The 48 sub-plots of 1,5x10 m were separated by a border of 2m and the main plots by 3m border. Soil water content was monitored using a Neutron probe (DR 503). Water was applied to all treatments at the same time when the readily available water content of the soil in 50 cm root zone reached 50% in the full supplemental irrigation (SI) treatment. The amount of irrigation water given to the full SI treatment corresponds to field capacity in the root zone.

Photo 1: Mehdi Boualem field trial on February, 15 and End-May 2011

The irrigation was managed through a regular monitoring of soil moisture using a neutron probe. The Neutron probe calibration (Photo 2) was done through correlating, at different soil depths, actual soil moisture values determined with gravimetric method, with the device readings (Table 2). Different moisture conditions were created; 50, 150, 200 mm in 3 x $1m^2$ plot as well as 100% moisture condition using small water tank. The same work of calibration was done within each full supplemental irrigation treatment which has ultimately provided a model for soil moisture monitoring.

Photo 1: Neutron probe calibration and field capacity test

Knowing the field capacity of the soil and monitoring soil moisture at different soil depth and periods helped to determine the amount of water to apply and at which time we should trigger supplemental irrigation/deficit irrigation. The soil moisture at both field capacity and permanent wilting point was 30.8% and 15.4%, respectively. The first parameter was measured in laboratory while the second was fixed –as recommended in the literature for clayey soil- at the soil moisture corresponding to half field capacity

Table 2: Sample of Data set from full SI treatments produced for neutron probe calibration

Counts (average)	**Soil water content (%)**	**Depth(cm)**
7289	15.8	20
7233	15.9	20
7733	16.3	40
6651	16.4	20
7605	16.7	40
7458	18.2	40
6964	19.0	20
7399	19.2	20
7521	19.5	20
7639	19.5	40
7428	19.8	20
7962	19.9	40
8738	19.9	80
8738	19.9	

The soil moisture was monitored down to 110 cm. The targeted soil horizons were: 10-30cm. 30-50cm. 50-70cm. 70-90cm. 90-110cm. The horizon 0-10cm was considered half value of 10-30cm. The planed irrigation method was basin irrigation; however it turned out to be not an easy task given the nature of the soil (clayey) that cracks (Photo 3) and does not allow good irrigation uniformity. Consequently, the plots were irrigated by hand (Photo 4).

Photo 3: Basin irrigation planed and finally dismissed due to the appearence of cracks

Photo 4: Irrigation method used in the experiment

3.2. Dry matter accumulation and distribution between anthesis and maturity stages

The level of soil moisture after anthesis has an effect on photosynthetic rate in the flag leaf and on the partitioning of dry matter among various organs of the plant and hence on grain yield. To study the effect of varying soil moisture regime and nitrogen level on the accumulation and distribution of dry matter of CHEN'S wheat cultivar; plant samples were collected at anthesis and maturity stages and separated into leaves, stems + sheaths, spike axis + glumes and grains (Photo 5). Moreover, 15 spikes per plot were sampled from flowering to maturity stage at regular periods (between 7 and 10 days). The spikes dry weight was measured after drying the spike samples at 80°C.

Figure 5: Plant sampling and processing for dry matter accumulation and distribution analysis

The parameters calculated include:

- dry matter translocation amount after anthesis = dry weight at anthesis − dry weight at maturity;
- dry matter translocation ratio after anthesis (%) = (dry weight at anthesis − dry weight at maturity) / dry weight at anthesis × 100;
- dry matter translocation to grain after anthesis = grain dry weight at maturity − dry matter translocation amount after anthesis;
- contribution of dry matter translocation to grain after anthesis (%) = dry matter translocation amount after anthesis /dry weight of grain at maturity × 100.

3.3. Yield analyses, nitrogen use efficiency and water productivity

The harvest time ranged from mid to late June 2011 at grain humidity of 13%. Yield was determined in 3 x 1 m^2 sampling areas in each sub-plot. The grain yield per square meter was determined by weighting grains from all spikes in the harvested area. Harvest index (HI) is determined as the ratio of grain weight to total aboveground dry matter (straw + grain).

In general, nitrogen use efficiency (NUE) is defined as the amount of harvestable yield (grain or/and total dry matter) per unit of nitrogen supplied (soil N + Fertilizer) to the plant. Nitrogen Agronomic efficiency (NAE) is the amount of harvestable grain yield. per kg of applied fertilizer N defined by the following equation:

$NAE = [(Yfi - Y_0)/Ni]$

NAE: Agronomic N efficiency ($kgha^{-1}$/ KgN). Yf: yield per plot with N application, Y_0: yield per plot without N application (kg ha^{-1}). N_i : N application Kg N ha^{-1}

Water productivity (WP) is used here to define the relationship between crop production and the amount of irrigation water. Crop output is expressed in terms of total dry-matter yield.
IWP_1 = *Grain yield / irrigation water applied* ($kgha^{-1}$ *mm*)
IWP_2 = *Total dry matter / irrigation water applied* ($kgha^{-1}$ *mm*)
IWP_3 = *Dry matter (straw) / irrigation water applied* ($kgha^{-1}$ *mm*)

Irrigation benefit is used to define the relationship between irrigated and non irrigated yield per plot and the amount of irrigation applied:
$IB = (Y_i - Y_c)/i$

3.4. IB: irrigation benefit ($kgha^{-1}\ mm$); (Y_i-Y_c) difference in yield induced by irrigation comparatively to plot control. i: irrigation amount in mm

Other measurements were made including: straw yield. 1000 kernel weight (KW), chlorophyll content (Photo 6), before and after the application of each treatment, and grain protein content.

Photo 6: Chlorophyll 3-points measurement before and after treatments

4. Results/Achievements:

4.1. Statistical analysis

Data processing and statistical analysis were performed using Windows Excel and Genstat statistical package.

4.2. Climate conditions

Rainfall distribution is presented in Figure 1 and Table 3. Except the month of November where the rainfall slightly exceeded the long term average, we have noticed that for the other months the rainfall was significantly different whether by surplus or deficit. In 2010-2011 cropping season, the precipitation amount totaled 700 mm which represents 19.4 % more than the long term average of 586.3 mm (1990-2010).

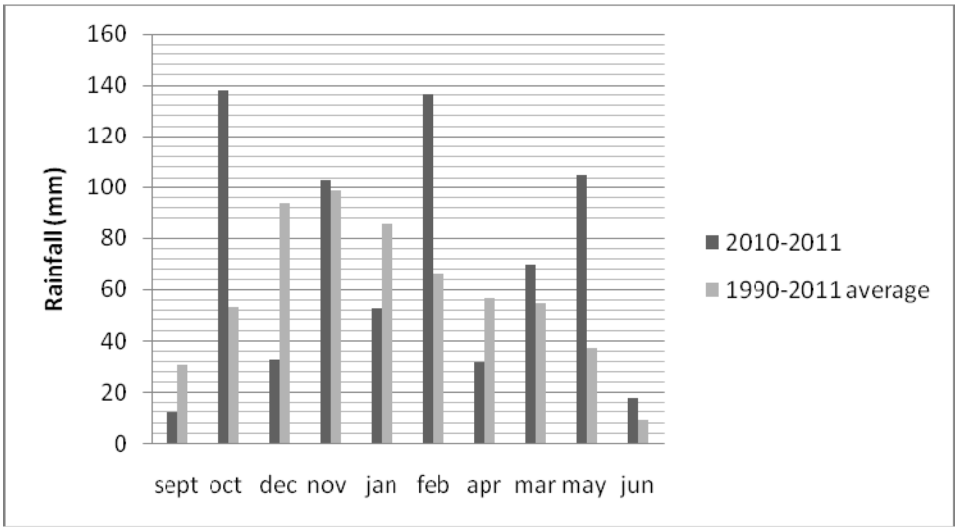


Figure 1: Comparison of long term average rainfall and that of 2010-2011

October, February and May had, respectively, rainfall amounts of 159%, 106% and 180% higher than the long term average. Drought was also recorded before sowing in September (- 61%), November (- 65%) and after sowing in January (-39%) and March (-43.9%). The sowing was under good moisture conditions in December when the rainfall slightly exceeded the monthly long term average.

Table 3: Climatic conditions in 2010-2011 cropping season

	Sept	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Apr**	**Mar**	**May**	**Jun**
Rainfall (mm)	12	138	33	103	53	136	32	70	105	18
T° mean (°C)	23.5	20.0	15.5	13.4	12.3	12.0	15.1	17.7	20.3	22.1
T Min (°C)	19.2	15.0	11.7	8.3	7.8	7.2	10.3	13.0	15.8	17.6
T Max (°C)	27.7	25.0	19.4	18.6	16.8	16.8	19.9	22.4	24.8	26.6

4.3. Response of wheat yield to the variation of supplemental irrigation (SI) level and nitrogen (N) rate.

Overall, the data shows that the levels of grain yield, as compared to the ones recorded in the region, were high despite the late sowing date. It was noticed that grain yield was more affected by Nitrogen than by irrigation. Moreover, Nitrogen x Irrigation interaction effect on grain yield was not significant (Table 4). The non-response of yield to supplemental irrigation can be explained by the particular high rainfall conditions that prevailed during 2010-2011cropping season.

Table 4: N and SI effect on yield and its components

Source of variation	d.f.	Grain Yield	Straw yield	Above ground Biomass	Harvest Index	1000 KW	Spikes/ m^2
Nitrogen(N)	3	0.011*	(0.012) *	0.006**	(0.369)	<0.001***	0.351
Water regime(WR)	3	0.295 ns	(0.001) ***	0.056*	(0.002) **	<0.001***	
WR x NR	9	0.854 ns	0.740 ns	0.902 ns	0.721 ns	0.033 ns	

**Significant at P < 0.05.   **Significant at P< 0.01. ***Significant at P< 0.001.. ns: no significance*

4.4. Effect of Nitrogen on yield and its components

Nitrogen factor had an effect on grain yield *(F pr =0.011)* and on other variables such as straw yield. Total above ground biomass and 1000 Kernel weight (Table 5); but there was no significant effect of the interaction SI x N, except for 1000 grain weight.

Table 5: Effect of supplemental irrigation and nitrogen rate on grain yield, above ground dry matter, straw yield, harvest index of CHEN'S wheat cultivar during 2010-2011 cropping year

Nitrogen regimes	N0	N50	N100	N150	F pr	LSD	NxSI	CV%
Grain Yield	4072	4300	4549	5051	<0.001	504.1	0.781	11.4-14.1
Spike/ m^2	226.4	214.1	221.4	234.2	0.351	22.93	0.909	12.3-16
1000KW(g)	51.12	52.81	53.57	53.23	<0.001	1.009	0.033	2.3-3.9
HI	0.6318	0.6526	0.6553	0.6536	0.051	0.01876	0.867	8.9- 15.4
NUE grain		86.01	45.49	32.86	<0.001	6.329	0.689	13.7 16.9
Straw yield	2362	2302	2390	2679	0.009	225.2	0.740	11.1-13.9
Above ground biomass	6418	6660	6929	7608	0.005	652.5	0.902	11.4-12
NUE adm		123.2	67.0	50.7	<0.001	11.92	0.218	3.3-31.7

The response of grain yield and biomass production to nitrogen rate increase is presented by figure 2 and 3. The average grain yield increased with the increase of nitrogen rate with the lowest yields observed for the unfertilized plot (N_0 = 4072 kg ha^{-1}) and 50 kg N ha^{-1} (N_{50}=4300 kg ha^{-1}) rate. The 150 kg N ha^{-1} treatment gave. Relatively, the highest yield (5050 kg ha^{-1}) that is to say increases of 978 kg ha^{-1}, 750 kg ha $^{-1}$ and 381 kg ha^{-1}, comparatively to $N_{0,}$ N_{50} and N_{100} fertilization rates, respectively. However, the difference of yield was more significant in the case of N_{150}-N_0 and N_{150} -N_{50} differences and at less extent for the difference N_{150}-N_{100}. The N_{50} treatment was not statistically different (<504.1 kg ha-1) than the control treatment (N_0).

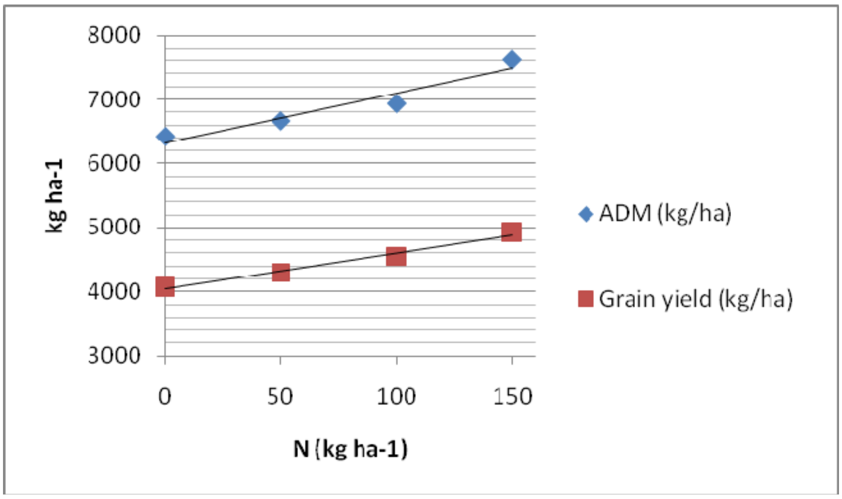


Figure 2: Above ground dry matter and grain yield as affected by N rates

The response of the above ground biomass (ADM) to nitrogen fertilization showed the following order of production N0<N50<N100<N150, with respectively, 6418, 6660, 6960 and 7608 kg ha^{-1}. The highest increase was recorded with N_{150}, while the magnitude of differences with respect to N_0 was observed to be of less extent for N50.

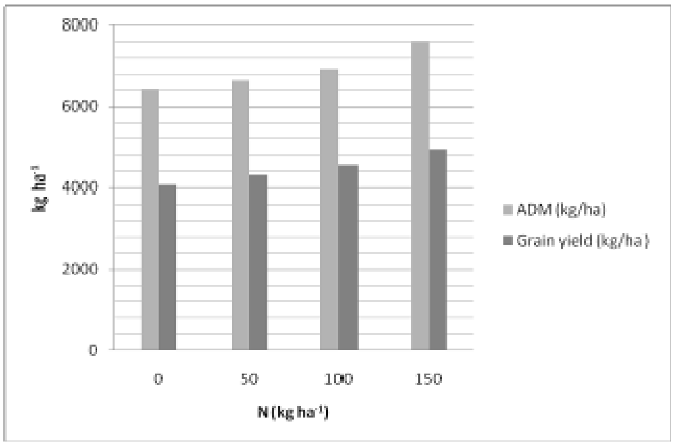


Figure 3: Grain and above ground dry production as a function of N rates

The effects of nitrogen on the other parameters measured can be summarized as follows:

- Nitrogen treatments had no statistical significant effect on harvest index (pr =0.369); although the ranking of the values of HI were N1>N0>N100>N150.

- Nitrogen fertilization had no effect (*pr= 0.351*) on spikes number per m^2; but the highest values were obtained with N_{150} (234 spikes) followed by N_0 (226). N_{100} (221) and N_{50} (214).

- Nitrogen fertilization had a highly significant effect (*P<0.001*) on 1000-grain weight. Indeed, N applications involved an increase of 3% for N_{50}. 5% for N_{100} and 4% for N_{150}, as compared to the unfertilized treatment. Above N_{100}, the additional N fertilization didn't involve any increase in 1000-grain weight

- The response of grain nitrogen use efficiency (NUE_{grain}) and above ground biomass nitrogen use efficiency (NUE_{adm}) is presented in Figure 4. NUE_{grain} was calculated as the ratio of grain production to nitrogen applied. The effect of nitrogen rate on NUE_{grain} was highly significant (pr < 0.001). NUE_{grain} ranged from 32.86 to 86.01 kg grain/kg N with the highest value observed for N_{50} rate (86.01 kg/kg N) followed by N_{100} (45.49 kg/kg N) and N_{150} (32.86 kg/kg N). In the case of NUE_{adm}, N_{50} rate was more efficient than N_{100} and N_{150} with, respectively, 123.2, 67.0 and 50.7 kg ha-1/kg N. The highest differences were recorded between N50 - N100 and N50-N150 with, respectively, 72.5 and 56.2 kg/kg N while there is less gain in above dry matter per kg of N fertilizer added after N_{100}.

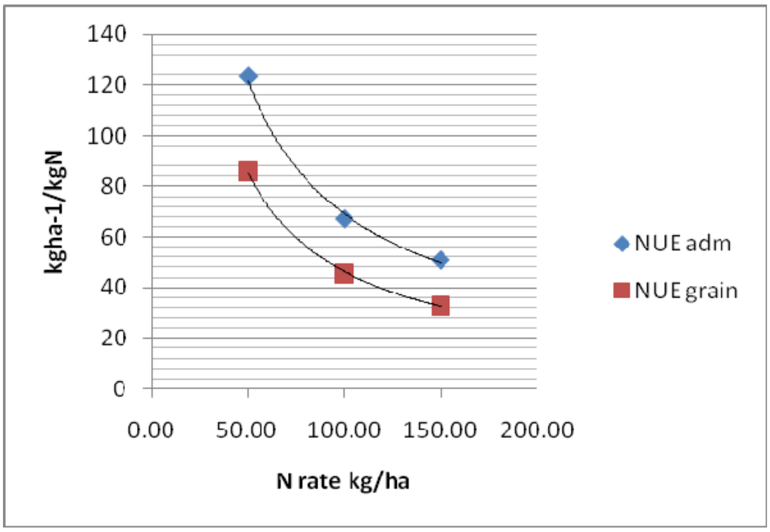


Figure 4: Average grain and above ground dry matter Nitrogen use efficiency as affected by nitrogen fertilization of Durum wheat

The differences in yield (Table 6) due to supplemental irrigation and the interaction Nitrogen x supplemental irrigation were not significant (*pr= 0.854*).

Table 6: Grain yield as a function of SI and Nitrogen interaction in durum wheat

SI*Nitrogen	N0	N50	N100	N150
Rainfed	4202	4407	4848	5435
(1/3)SI	3977	3994	4804	5063
(2/3)SI	4082	4211	4211	4621
SI	4027	4589	4334	5086

4.5. Effect of SI on yield and its components

The effect of SI on yield and its components is presented in table 7. Irrigation water application affected more 1000 grains weight (pr <0.001), straw yield (pr <0.001), spike number (pr <0.001) and harvest index (pr=0.011). Regarding 1000 grains weight, the 3 irrigations regimes gave significantly higher kernel weight than the rainfed treatment with values of 51.01, 52.46, 53.34 and 53.93g for Rainfed, full SI, 1/3SI and 2/3SI, respectively. The irrigated treatments were not statistically different.

Rainfed treatment also produced the highest number of spikes per m^2 followed by SI, 1/3SI then by 2/3SI, and this obviously affected positively the grain yield with rainfed treatment= 4723 $kgha^{-1}$, SI = 4509 $kgha^{-1}$, 1/3SI = 4460 $kgha^{-1}$ and 2/3SI = 4281 $kgha^{-1}$
In the case of straw production, except for SI treatment, we noticed that the ranking was the same as for 1000 grains weight and number of spikes per $m^{2.}$
The harvest index was in favor of SI treatment followed by 1/3SI, 2/3SI and rainfed, with values of 0.6666, 0.6467, 0.6466 and 0.6334, respectively.

Table7: Effect of supplemental irrigation treatment on yield and its components

SI regimes	R	1/3SI	2/3SI	SI	F-pr	LSD	NxSI	CV%
Grain Yield $kgha^{-1}$	4723	4460	4281	4509	0.228	424.7 $kgha^{-1}$	0.781	11.4
Spike number / m^2	261.5	216.2	196.6	221.7	<0.001	22.93	0.909	12.3
1000 grain Weight (g)	51.01	52.46	53.34	53.93	<0.001	1.009 g	0.033	2.3
HI	0.6334	0.6467	0.6466	0.6666	0.011	0.01876	0.867	3.6
NUE grain $kgha^{-1}$ /KgNa	57.85	52.65	52.18	56.47	0.199	12.658 kgha-1/kgna	0.689	13.7-16.5
Straw yield $kgha^{-1}$	2717	2445	2320	2252	<0.001	450.4	0.740	11.1
Above ground dry matter $kgha^{-1}$	7457	6813	6587	6759	0.054	652.5kg/ha	0.902	11.4

Water productivity (grain) $Kgha^{-1}$ /mm	6.747	6.087	5.900	6.105	0.096	0.7026		0.848	13.6

4.6. Supplemental irrigation effects on water productivity (WP) and irrigation benefit (IB)

The ratio of grain yield to the amount of water received by the crop (irrigation + rainfall) was in favor of rainfed regime that produced more grain weight per mm of water (6.747 kgha-1/mm). Supplemental irrigation did not improve water productivity. An independent analysis of variance of water productivity (grain and above dry matter) for rainfed regime showed that the gain weight produced per mm of water was affected positively by nitrogen rate increase and the ranking was as follows: N0<N50<N100<N150 with values of 6.0. 6.3. 6.9. 7.8 $kgha^{-1}$ /mm, respectively. The same ranking was observed for above ground dry matter (pr= 0.025). The corresponding values were 13.3, 13.6, 14.9, 16.4 $kgha^{-1}$ /mm (Table 8).

Table 8: Durum wheat grain and above ground grain yield and production per mm of rain as affected by nitrogen rates

	N0	**N50**	**N100**	**N150**	**Least significant difference $kgha^{-1}$ /mm**	**Cv%**
Grain yield kg/ha	4202	4407	4848	5435	791.3	8.9
NUE		88.1	48.5	36.2	8.83	7.7
Water productivity (grain) $kgha^{-1}$ /mm	6.0	6.3	6.9	7.8	1.13	8.9
Water productivity(adm) $kgha^{-1}$ /mm	13.3	13.6	14.9	16.4	1.98	7.2

II. PLAN OF WORK

Activity 1: Fine tuning the intervention response of wheat to water application and nitrogen in the Algeria rainfed satellite site

Objective:

- Improve water productivity and nitrogen use efficiency. and protect the environment from nitrate induced water pollution

Methodology:

An experiment will be undertaken in Baraki area on the effect of water regime and nitrogen fertilization rates on durum wheat. Supplemental irrigation amounts will be determined from the status of soil water content through constant monitoring. The experiment is described as follows:

- Species: Durum wheat
- Irrigation regimes: Rainfed, 33% of full water requirement, 67% of full water requirement, 100% of full water requirement
- Nitrogen rates: 0 KgN/ha. 50 KgN/ha. 100 KgN/ha. 150 KgN/ha
- Experimental design: Split plot with 3 replications

Observations and measurements:

- Dates of emergence. Beginning of tillering (3-4 leaves). Beginning of stem elongation (First node at 1 cm from the soil). Heading. Anthesis and Physiological maturity;
- Components of yield:
- Number of seedlings at full emergence (plants/m^2). Number of Tillers/m^2. Number of spikes/m^2. Number of kernels per spike.
- Number of kernels/ m^2. 1000-seed weight Total dry matter/m^2 at heading/Anthesis. Grain yield/ha at harvest. Total dry matter/ha at harvest
- Soil moisture made at: 0-10; 10-30; 30-50; 50-70. 70-90 and 90-110 cm depth:
    - ✓ Before and 48 h after each irrigation
    - ✓ At planting
    - ✓ At 3-4 leaf-stage

- ✓ At beginning of stem elongation (first node of the main stem at 1 cm from the soil)
- ✓ At heading
- ✓ At grain milk stage
- ✓ At maturity at depths.

- Nutrients in the soil at planting at 0-20 cm and 20-40 cm depth (before the application of nitrogen fertilizer):
  - ✓ Total N content
  - ✓ Nitrate content and
  - ✓ Organic matter content
  - ✓ P2O5 content
  - ✓ K2O content

Starting date: October 2011 **Completion date**: June 2013

Activity 2: Dissemination of Benchmarck I and II outputs outside rainfed Algeria Satellite Site

Objective:

- Test, with selected farmers in Belabès semi arid area outside the rainfed satellite site, best-bets packages of supplemental irrigation and associated practices and evaluate their impacts on land productivity, water productivity, farmers' income and environment.

Methodology:

- selection of sites for on-farm demonstrations
- identification of existing programs or incentives regarding irrigation and set MOU with local technical and administrative services
- Selection of pilot farms and farmers

- Conduction of on-farm demonstration trails where improved package of supplemental irrigation is compared to the farmer management plot
- Organization of field days

Starting and completion date: September 2011- Sept. 2013

BADIA BENCHMARK AND SETELITE SITES

A. BADIA BENCHARK SITE OF JORDAN

I. PROGRESS

Introduction

The steppe represents the drier environments of WANA, excluding desert areas. These marginal areas are home to a substantial proportion of the region's rural and poorest populations. Water is the over-riding constraint. The low and highly variable rainfall is often inadequate for economic crop production. The distribution of precipitation in these areas is highly erratic both within and between years. Most of the limited rainfall comes in sporadic, intense and unpredictable storms, usually on crusting soils with low infiltration rates, resulting in surface runoff and uncontrolled rill and gully water flow. Thus, much of the limited rainfall is lost either directly by evaporation from the soil surface or to run-off, which, if not intercepted, collects in wadis or pans where most of the water eventually evaporates. The end result is that the greater part of the precipitation is lost back to the atmosphere as evaporation, land is degraded by erosion, and vegetation, except in those areas where rainwater collects, is limited and subject to severe water stress. Sheep is an integral part of Bedouins life. Sheep represented a source of food and clothing, and a symbol of wealth and pride. The steppe encompasses a wide and a significant part of Jordan covering approximately 1,200,000 hectares, which constitutes 15% of the total area. Steppe extends in WANA and covers the vast majority of the rangelands area.

The project developed, in the 1st phase, innovative methods in Jordan using a combination of new tools and conventional methods to select water-harvesting sites in the steppe. GIS analysis was then used to integrate biophysical and socioeconomic factors into a comprehensive site characterization. The database that was developed, the results obtained, coupled with the water harvesting technology 'menu' developed by ICARDA provide an accessible tool for planners, researchers and project managers to identify potential sites and techniques and assess potentially feasible techniques for a specific location based on topography, soils, land tenure, etc.

The Benchmarks Project has helped introduce a new concept – mechanized micro-catchment water harvesting – that is now being widely scaled out in Jordan's and Syrian's steppe areas.

Although a set of technologies has been developed, evaluated and disseminated through the project first phase, fine-tuning of the interventions and a wider dissemination and out scaling is still needed through linkage with other development projects. For up scaling the improved packages, a detailed policy analysis, including financial and legal instruments and options for the development of local and regional institutions – oriented specifically towards water harvesting and reversing land degradation, are also needed. Moreover, less progress has been made on integration of the project results in policy guidelines dealing specifically with the challenges of the Steppe. Also, needed is the strengthening of the integration of livestock within the system and the development and implementation of a grazing management system.

Most of the Steppes in the CWANA region are similar to that of Jordan. So, all approaches and technologies developed by the project during the first phase can be used in other places with similar bio-physical and socio-economic characteristics. The project will develop out scaling strategies to effectively disseminate generated technologies. The outputs of the first phase will be out-scaled to other regions within Jordan and to satellite sites in Libya and Syria.

Component I: Interventions fine tuning, out scaling and dissemination

Water Harvesting and Mechanization activities

Activity 1: Introducing mechanized establishment of forage shrubs from seeds inside the WH micro-catchments

Objectives:

- Optimize the soil hydro-physical conditions that are suitable for germination and emergence of forage shrubs' seeds in the nursery, and enhance further growth of seedlings in the field
- Test new potential seedbed preparation and seed placement techniques that can create favorable soil and water conditions in the seedbed zone and that provide easy operation of the seeder.
- Mechanize the direct seeding of forage shrubs inside the WH structures by developing or modifying special seeder to do this job.

Methodology:

The aim of using these techniques is to create a soil micro-medium environment in the seed zone that is suitable for the germination and emergence, and that is able to hold water for longer time than the rest of the field soil can. This requires that the following conditions are met:

- Encourage fast germination and emergence of the seed after rainfall and before the soil in the seedbed dries up. This can be achieved by using pretreated seeds (by scarification and soaking). This will remove the bracts covering the seeds as a physical inhibitor and wash out them from any existing salts as chemical inhibitor.
- Create favorable soil physico-hydraulic conditions (low emergence resistance and better water holding capacity) in the very close zone of the seedbed that surrounds the seed. This can be achieved by drilling the seeds together with the suitable medium in the seedbed.
- A seeder that is capable to drill the medium-seed mixture at proper depth and proper seeding rate inside the WH micro-catchment.

Depending on the above-mentioned conditions the activities will be conducted in the following stages:

Stage 1: Nursery
Stage 2: field experiment
Stage 3: Seeder development

Stage 1: nursery experiment (2011-2012)

Objective:

- Study and investigate the growth behavior of shrubs under different seeding soil mediums and different watering regimes.

Results/Achievements:

During this year the nursery experiment was carried out (April – Aug. 2011) to study and investigate the growth behavior of selected specie of fodder shrubs (Atriplex) under open nursery conditions to a specified age under different seeding soil mediums and different watering regimes (Figure 1). The soil mediums and analysis are shown in table 1.

Table 1: soil mixture analysis

	Soil type	**Soil characterization**	**value**
1.	Natural*: Clay: Manure	pH	7.9
		EC ds/m	12.41
		P-ppm	24.8
		K-ppm	680
		O.M%	6.64
		Nitrogen	0.45
		Clay%	27
		Silt%	41.3
		Sand%	31.7
2.	Natural: Clay: Sand	pH	8.1
		EC ds/m	0.4
		P-ppm	23.9
		K-ppm	424
		O.M%	1.39
		Nitrogen	0.08
		Clay%	18
		Silt%	29.8
		Sand%	52.2
3.	Natural: Manure: Sand	pH	8.3
		EC ds/m	9.84
		P-ppm	20.3
		K-ppm	476.4
		O.M%	4
		Nitrogen	0.25
		Clay%	8.5
		Silt%	24.2
		Sand%	67.3
4.	Clay: Manure: Sand	pH	8.2
		EC ds/m	7.49

		P-ppm	202.2
		K-ppm	513.6
		O.M%	5.06
		Nitrogen	0.27
		Clay%	14.8
		Silt%	12.1
		Sand%	73.1
5.	Natural: Clay: Manure: Sand	pH	8.1
		EC ds/m	7.85
		P-ppm	196.3
		K-ppm	420.6
		O.M%	4.7
		Nitrogen	0.23
		Clay%	14.9
		Silt%	28.8
		Sand%	56.3
6.	Natural	pH	8.2
		EC ds/m	0.37
		P-ppm	49.8
		K-ppm	740.2
		O.M%	1.58
		Nitrogen	0.09
		Clay%	18.2
		Silt%	57.2
		Sand%	24.6

*Natural: soil collected from Al-Majediah site

Three watering intervals used during the experiment were:

- Irrigation of plants once a week.
- Irrigation of plants twice a week
- Irrigation of plants three times a week.

Data such as date of emergence, plant height, above ground dry weight, and root length were collected. Also, seed germination was tested in the laboratory. All data for the first year (2011) were collected and will be statistically analyzed at the end of August 2012 when the data for the first and second year are available.

Note: the root system for each sample was collected, cleaned and scanned for the evaluation of each soil medium. The results are in the process of analyses.

Figure 1: Atriplex seedling at nursery, with different soil medium for seed germination

Activity 2: Cisterns improvement and maintenance

Objectives:

- To assess the impact of traditional and project assisted flood diversion practices for crop production in the semi-arid (agro-pastoral) area of the Badia where the benchmark project activities are conducted.
- To suggest alternatives and economically viable methods of surface water harvesting for domestic uses and livestock.
- Improve the performance efficiency of the cisterns in terms of storage capacity, and water quality
- Develop an integrated a plan of maintenance to ensure the sustainability

Results/Achievements:

Different field visit were conducted in the Al Majidyya area to evaluate, with the community, each cistern and map the location of all cisterns (Figure 2). Example of cisterns that need maintenance is shown in Figure 3.

The list of the existing cisterns and the requirements for their improvement, as well as the new proposed cisterns are presented in annex 1.

Figure 2: Location of the cisterns at Al Majdyya site


Figure 3: Example of cisterns that need maintenance.

Activity 3: Fine tuning of field layout and arrangement of intermittent and continuous contour ridges developed in phase 1 (2 sites).

Objectives:

- To test barley cultivation under 2 water harvesting techniques as compared to conventional cultivation.
- Test different layout arrangements for contour earth ridges (intermittent and continuous).
- Evaluate water harvesting techniques in terms of barley production per unit area.

Methodology:

One experiment was conducted at Al Majideyya with 13 treatments:

- T1: (NV) - Native vegetation, land resting with protection.
- T2: (NVCR) - Native vegetation under contour ridges.
- T3: (BT50) - Traditional cultivation of Barley, 40 kg/ha.
- T4: (BT100) - Traditional cultivation of Barley, 80 kg/ha.
- T5: (BCR50) - Barley in modified contour ridges, 40 kg/ha.
- T6: (BCR100) - Barley in modified contour ridges, 80 kg/ha.
- T7: (BCS50) – Barley (seeding rate of 40kg/ha) in contour strips of 2:1 catchment to cultivated area ratio.
- T8: (BCS100) - Barley (seeding rate of 80kg/ha) in contour strips of 2:1 catchment to cultivated area ratio.
- T9: (D2L1FS) – Fodder shrubs planted in Vallerani pits size 2 with 5 lines of pits followed by a continuous contour ridge.
- T10: (D2L2FS) – Fodder shrubs planted in Vallerani pits size 2 with 10 lines of pits followed by a continuous contour ridge.
- T11: (D4L1FS) – Fodder shrubs planted in Vallerani pits size 4 with 5 lines followed by a continuous contour ridge.
- T12: (D4L2FS) – Fodder shrubs planted in Vallerani pits size 4 with 10 lines followed by a continuous contour ridge.
- T13: (FS800) - Fodder shrubs under continuous contour ridges.

The spacing between contour lines will be 6 meters for all treatments and the plant density of the fodder shrubs will be the same for all related treatments. Each treatment will be implemented on a plot of 120 m x 35 m. The plot configuration will be set so that the 120 m length will be with the direction of the slope. The treatments will be arranged to fit RCBD design with 3 replicates.

Di-amonium phosphate (DAP) fertilizer will be applied at a rate of 40 kg per hectare only to half the area of Barley plots.

Barley plots will be statistically analyzed as a separate experiment implemented over 2 sites.

The area needed is around 17 ha.

The Mhareb experiment will be as follows:

- T1: (BT50) - Traditional cultivation of Barley, 40 kg/ha.
- T2: (BT100) - Traditional cultivation of Barley, 80 kg/ha.
- T3: (BCR50) - Barley in modified contour ridges, 40 kg/ha.
- T4: (BCR100) - Barley in modified contour ridges, 80 kg/ha.
- T5: (BCS50) – Barley (seeding rate of 40kg/ha) in contour strips of 2:1 catchment to cultivated area ratio.

- T6: (BCS100) - Barley (seeding rate of 80kg/ha) in contour strips of 2:1 catchment to cultivated area ratio.

The spacing between contour lines will be 6 meters for the modified contour ridge treatment. Each treatment will be implemented on a plot of 120 m by 35 m. The plot configuration will be set so that the 120 m length will be with the direction of the slope. The treatments will be arranged to fit RCBD design with 3 replicates.

Di-amonium phosphate (DAP) fertilizer will be applied at a rate of 40 kg per hectare only to half the area of Barley plots.

The area needed is around 8 ha.

Results/Achievements:

Sites are selected, designed, and planted during the season 2010/20111.
No data collected because of drought.

Activity 4: Check dams: Earth check dams in 2 locations

Objectives:

- To demonstrate the use of earth check dams together with a suitable land use in participation with the local community.
- To rehabilitate some of the existing check dams and make them functional again.

Methodology:

The area for this study in Mhareb and o Al Majideyyawith is around 15 ha each site. The tasks implemented are:

- Preparation of the topography map for each site.
- Determination of the locations and dimensions of existing check dams within the site.
- Planning of the site with earth check dams designed to suit the planned land use
- Implementation of the check dams and use of the land.

Results/Achievements:

The check dams were evaluated and rehabilitated according to the needs and their locations are mapped (Figure 4).

The details of the evaluation of the check dams and the maintenance requirement for each structure are presented in Annex 2. .

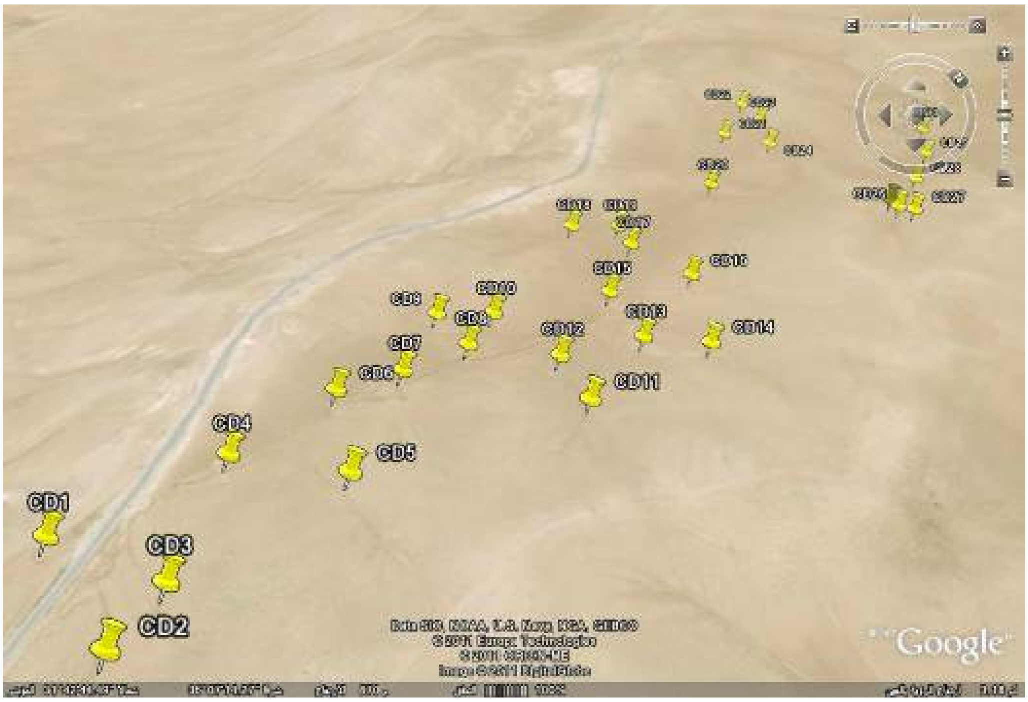


Figure 4: Location of each check dams at the site.

Activity 5: Design of Marabs and water spreading in 2 locations)

Objectives:

- To demonstrate the use of Marabs for Barley production using properly designed water spreading structures.

Results/Achievements:

Two Marabs are selected, the topography map (Figure 5) was developed and water harvesting (spreading) techniques are designed.

One Marab at Al Majddyya was designed, constructed and planted with barley during the season 2010/2011. The Marab was maintained and prepared for planting barley in 2011/2012 season.

The data was collected and analyzed.

One Marab at Muhareb was designed, constructed and planted with barley during 2011/2012 season.

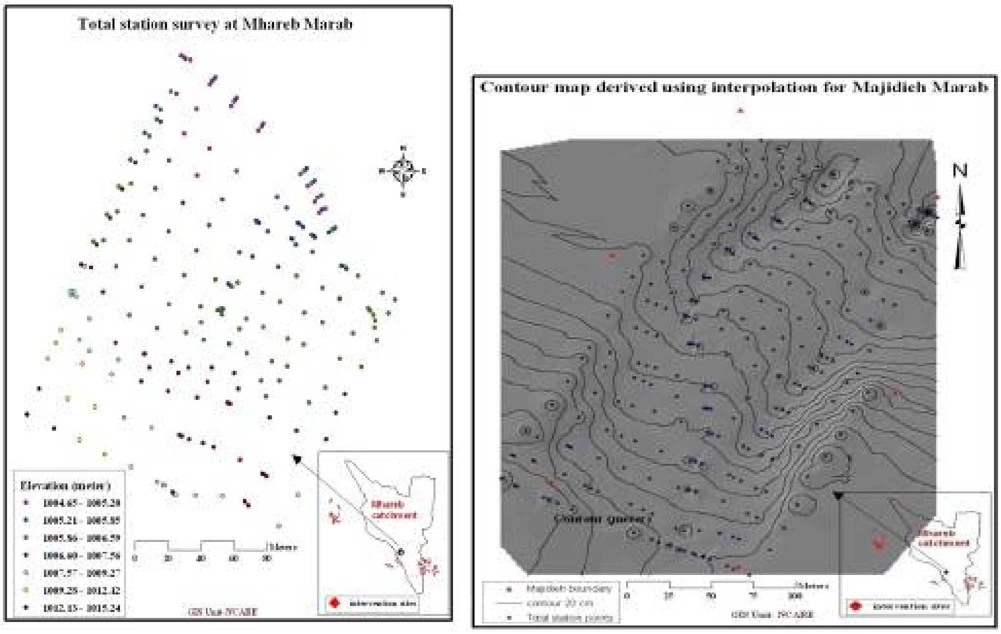


Figure 5: Total station survey and converting to (X, Y, Z) at Marab to contour map

Activity 6: Test of adapted promising barley genotypes

Objectives:

- Improvement of barley production under Marab conditions through the selection of adapted genotypes.

Methodology:

Different combinations of crops were compared: 1) Barley Rum + Vetch, 2) Barley Rum, 3) Local barley +Vetch, 4) Local barley, 5) Barley Acsad, 6) Barley Acsad +Vetch

Results/Achievements:

Data are presented in Table 2. The treatment Barley Acsad gave the highest yield. It was followed respectively by Barley Acsad + Vetch and Local barley + Vetch. Pictures of the plants ate different growth stages are presented in Figure 6.

Figure 6: Different stages of plant at Marrab site.

Table 2: Marrab Production kg/ha

Number	Treatment	Green weigh	dry weight	Seed weight	barley height (cm)	Vetch height (cm)	Tillering num	fertilizer DAP/kg/ha
1	Barley Rum+ vetch	7650	1550	1500	92	37	11	50
2	Barley Rum	15100	4000	1570	93 ، 95 ، 100		10	50
3	Barley Local + vetch	9100	2500	2500	75	35	9	50
4	Barley Local	7800	2750	1800	80		9	50
5	Barley ACSAD	3600	1000	3800	62		8	
6	Barley Rum	3300	950	3430	75		6	

Activity 7: Rehabilitation of the water harvesting structures at the Jordan University of Science and Technology (JUST)

Objective:

- Improvement of soil water collection and conservation

Methodology:

- Rehabilitate the site that was managed during the first phase of the project.
- Maintain and replace the TDR tubes
- Map the site
- Establish experiments on the effect of water harvesting on pistachio tree'.

Site Description

The Benchmark site is located in the north east side of JUST campus. This site is located at N32º 33' latitude, E 35º 51' longitude and 520 m above the sea level. The area is dominated by a Mediterranean-type climate characterized by cool and rainy winters and hot dry summers. In general, this area is characterized by low rainfall amounts 200 - 300 mm with an erratic distribution over the rainy season which starts around the end of October and lasts through April (Figure 7). The Micro-catchments techniques existing in the site are (Figure 8).

- Semi-circular: Different sizes depending on the radius.
- Small runoff basins: Diamond Shape with different sizes (6*6, 8*8,10*10, 13*13).

- Contour Ridges
- Bits or semicircles were constructed using the Vallerani Implement.

The plant species are: almond, pistachio, olive, salsola and atriplex.

Figure 7. Location of the experiment site

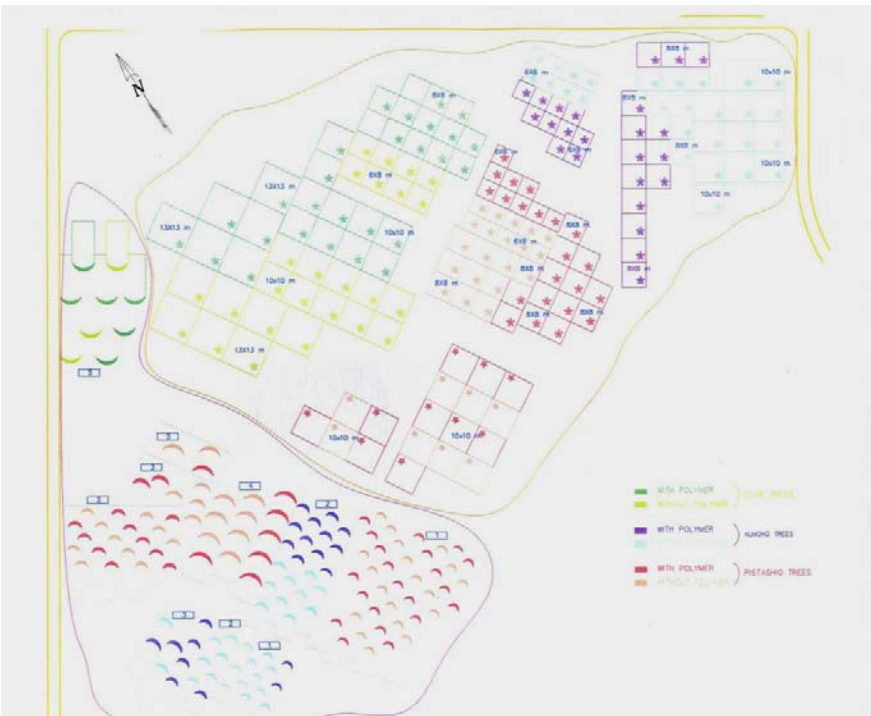


Figure 8: Description of micro catchments

Water measurements:

- Soil water storage: using the TDR device (The time domain reflectometry).
- Pan evaporation measurements

Plant Measurements

- Trees and Seedling growth
- Canopy cover
- Plant Height
- Vegetation Biomass
- Physiological Responses of the plants to water availability.

Results/Achievements:

- The project activities in the site where suspended since 2006. The re-activation of the activities started in October of 2010 by:
- Weeding the micro- catchments areas is the main priority since October till now.
- Rolling the soil to compress the catchment areas
- Recovering the diamond shape and semi-circlar micro-catchment systems
- Several micro-catchment areas need to be replanted with trees.
- Three tree species are now available for experimentation: Pistachio, Almond and Olive trees.

Activity 8: Water harvesting and conservation effects on Pistachio and Almond in the JUST site

Objective:

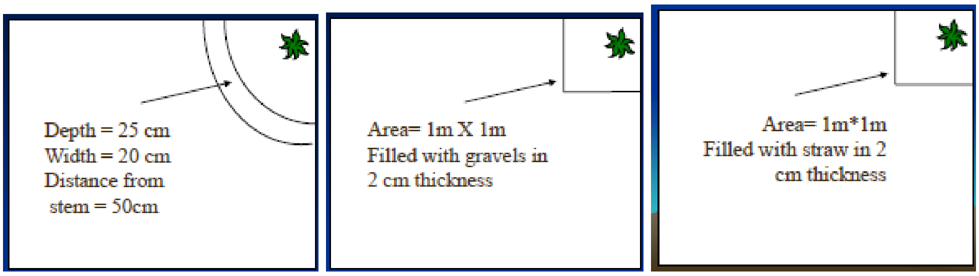
- Implement new research activities aiming to increase the efficiency of water availability to the plants and reducing evaporation.

Methodology:

An experiment will be conducted with the following treatments:

- Treatment 1: Use of local gravels to be spread over the area around the tree species. (Horizontal and Vertical)
- Treatment 2: Use of the plants straw to cover the soil in order to reduce the evaporation around the plant species
- Control Treatment.

Soil moisture and plant growth and development will be monitored.



A1: VERTICLE GRAVEL COVERAGE

Depth = 25 cm

Width = 20 cm

Distance from stem = 50cm

A2: HORIZANTAL GRAVEL COVERAGE

Area= 1m X 1m

Filled with gravels in

2 cm thickness

A3: HORIZINTAL STRAW COVERAGE

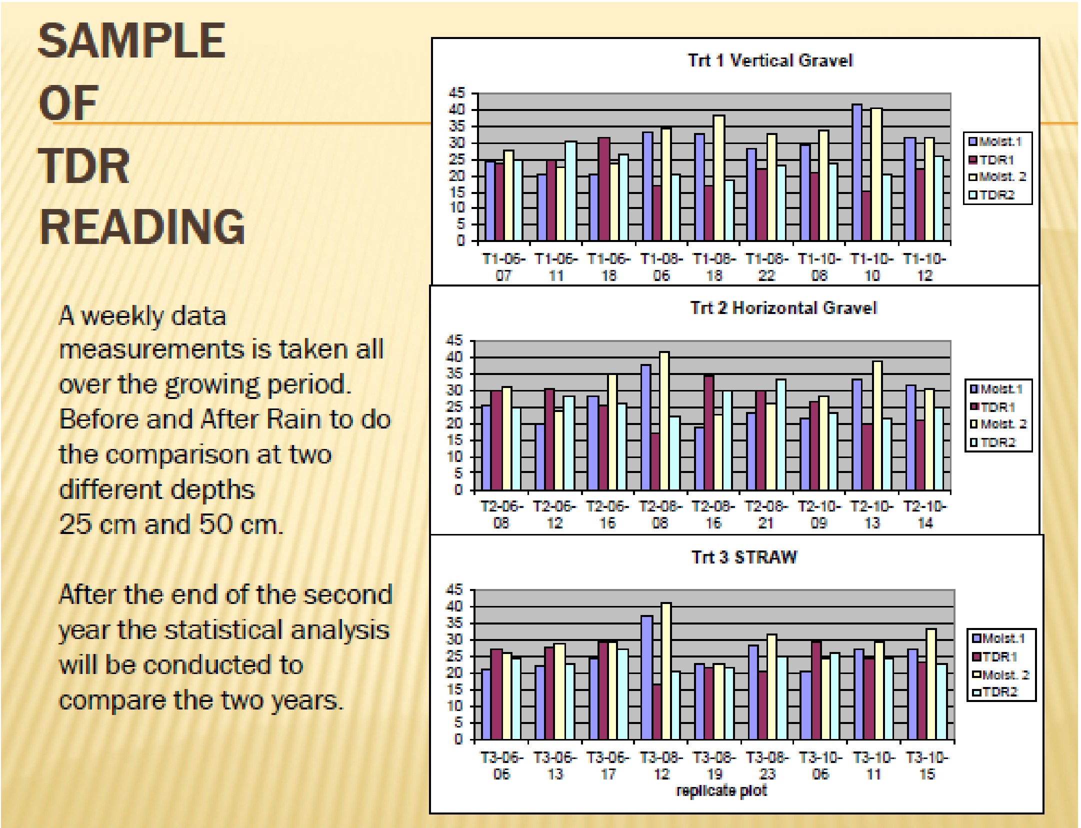
Area= 1m*1m

Filled with straw in 2 cm thickness

A4: CONTROL – NO TREATEMENTS.

Results/Achievements:

Soil moisture was monitored weekly. Data are reported below.



Activity 9: Seed increase of two-row barley released varieties under (farmer's fields).

Objectives:

- Barley seed multiplication at the farm level

Methodology:

Four farmers were selected and about 10 ha were planted by barley.

Results/Achievements:

No seeds were collected because the crop failed due to severe drought

Activity 10: Diversification of cropping systems through planting barley and vetch mixtures.

Objective:

- Identify the best combination of intercropping systems

Methodology:

Different rates of barley and vetch 1:1, 1:2, 1:3 were planted in 2010-11.

Results/Achievements:

No data because of drought

Rangeland Rehabilitation and Management activities

Activity 1: Introducing New Fodder Shrubs

Objectives:

- To demonstrate to the community the benefits of water harvesting for improving forage resources in the Badia.
- To implement the awareness-extension activities especially for local community.
- To improve livestock production and associated grazing practices in the Badia.
- To evaluate the effect of WHT on the native vegetation regeneration and improvement.
- To multiply and reintroduce the shrubs species collected from the rangelands.

Methodology:

Seed collection (shrubs)

- Seeds will be collected from the available fodder shrubs at the site or from other sources (NCARE, ICARDA, especially new species to be introduced in this phase of the project).
- Seeds will be reintroduced within the WHT.

Shrubs plantation

Seedlings of Atriplex, Haloxylon, etc. will be planted in December 2010-January 2011 in the micro-catchments. Shrubs will be spaced at 2m within the different types of WHT.

Data to be collected (new and old sites)

- Survival: will be recorded on three sampling dates (one month after plantation, at the end of growing season usually in June, and in October).
- Biomass: The reference unit technique will be used for biomass estimation

Results/Achievements:

- Seeds of different species were collected during 2011 to be planted in 2011/2012
- 3000 seedlings of Atriplex and Salsola were planted to replace the absent plants. The survival rate was 30%. The survival rate was low because of low and drought.

Activity 2: Native vegetation study (location and species)

Objectives:

- Conduct vegetation classification and taxa study in the sites (plant species).
- Monitor the changes of biodiversity during project period in the protected site.

The main objectives for vegetation assessment were to characterize and provide a clear understanding of the current state of the ecosystems on the basis of the composition of the vegetation and to monitor the vegetation changes at Al-Majedyya due to human activities and natural and environmental factors. The description of plant species was done by a number of characteristics including frequency, abundance, cover, density and species diversity (Shannon Diversity Index H´). These measurements enable vegetation condition to be accounted for development of action plan.

Methodology:

- Preliminary surveys in May-June 2010 and in October-December 2010 for the documentation of natural vegetation cover in the area.
- Transect – quadrate method will be used.
- Botanical composition of each quadrate will be studied during the project period, considering the following data;
  - ✓ Cover percentage (visual estimation as percent of ground covered by plant canopy of the species), stone cover and root cover percentage will be estimated.
  - ✓ Total number of each species will be counted in each quadrate every season.
  - ✓ Plant Taxa will be identified fully to the species level according to the available flora references.
  - ✓ Plant height.
  - ✓ Diversity.
- Species frequency, abundance, density and relative density will be calculated.

Results/Achievements:

- Survey was conducted in April-June 2011 for documentation of natural vegetation cover in the area.
- Botanical composition of each quadrate was studied
  - ✓ Cover percentage.
  - ✓ Total number of each species.
  - ✓ Plant Taxa was identified to the species level.
  - ✓ Diversity.

- Species frequency, abundance, density and relative density will be calculated.

Two areas were selected within the site to serve as the vegetation sampling locations. Within each area permanent transects were delineated. Along each transect, samples were taken systematically every 15 m, resulting in 15 samples per transect (totalizing 90 samples per area). Each vegetation sample consisted of a complete list of the vascular plants present, number of individuals of each species, and an estimate of species cover within an area of $1m^2$ located perpendicular to the transect. Transect-quadrate method was used in sampling the species.

The total number of plant species recorded in the two areas was 26 plant species (Table 1). The average vegetation cover over all studied quadrates was low. Despite the low vegetation cover percentage recorded at the demonstration site, the site still has good potential to provide grazeable plants.

The continual and intensive grazing of Al-Majedeh rangelands damage the plant community structure and increase bare-ground coverage. This degradation results in undesirable plant species composition, sharp declines in plant biomass production and a loss of species diversity. A reduction in plant community structure and composition subsequently reduced the carrying capacity of the range site, a condition that negatively affects the economic and social status of the region.

1	*Adonis dentata*
2	*allium sp.*
3	*Anabasis syriaca*
4	*Androsace maxima*
5	*Anthemis palestina*
6	*Astragalus guttatus*
7	*Bromus sp.*
8	*Carduus getatus*
9	*Eremopyrum bonaepartis*
10	*Erodium deserti*
11	*Fumaria densiflora*
12	*gagea reticulata*
13	*Gymnarrhena micrantha*
14	*Haloxylon persicum*
15	*Herniaria hirsuta*
16	*Hypecoum pendulum*
17	*Malcolmia afericana*
18	*malva sylvestris*
19	*Roemeria hybrida*
20	*Salsola sp*
21	*Schismus barbatus*
22	*Silene arabica*
23	*Sinapis alba*
24	*Sisymbrium runcinatum*
25	*spergularia diandra*
26	*Vicia peregrina*

Different vegetation covers at the Majidyya site

Activity 3: Estimation of forage production and link with satellite images (cover).

Objectives:

- Determination of grazing capacity / sustainable stocking rate.

Methodology:

The data collected and evaluated are, shrub height, biomass production, and grazing capacity.

Results/Achievements:

The data are not presented because they are still preliminary still it's a draft data, the satellite image and the camera not yet purchased. We will get it during November 2011.

Improved the vegetation cover at the Al Majidyya site

Activity 4: Collection and Reseeding of native plants

Objectives:

- To multiply and reintroduce the annual native species collected from the rangelands.
- Local community training and increasing awareness in seed collection and multiplying through awareness-extension activities

Results/Achievements:

Different seed of native plant are collected
Experiment was designed and prepared for plantation.
All the seeds will be planted at the site on this season 2011/2012.

Activity 5: grazing management (direct grazing and/or cut & carry)

Objectives:

- To investigate the rangeland (native vegetation) biodiversity.
- To promote equitable use of the rangelands.
- To investigate the plant preference among native vegetation of small ruminants as will as their behavior under the selected rangeland.

Methodology:

The tasks assigned to this activity are:

- To complete the range vegetation characterization: Definition of vegetation types and toponyms polygons; identify species with special use for animal or medicinal plants with specific conservation need and estimate carrying capacity for several rainfall events.
- To assess the stocking rates.
- To discuss, with the community, possible management options with and without improvement: rotational grazing,
- To discuss, with the community, alternatives of site grazing: mobility to cultivated zones (residual grazing) and other rangeland sites; parking and hand feeding; destocking; regulating (and not stopping) access of external flocks,
- To choose a grazing management plan and identify related regulations with community members and transhumance.
- To monitor the state of the resource, animal productivity and herder's income.
- To investigate the animal behavior and plant preference.

Results/Achievements:

During 2011, the entire field, at Majidyya, was evaluated for different uses. Table 3 shows that there two ways to use the shrubs; first by direct grazing or cut and curry, both methods depend on the quantity of dry meter.
It is clear from the evaluation that the sustainability of the pasture is more ensured in the protected and managed field as compare to overgrazed fields.

Table 3: Stocking rate program resulted at Al Majediah region 2011

Location	**Plant**	**Dry Yield (kg/site)**	**Days**	**Animals No.**	**Recommendations**
MJ12CRS	*Atriplex*	231	15	10	Grazing
MJ9CRSa		41		2	Cut & replanting of missing shrubs
MJ9CRSb		14		1	
MJ8CRS		56		2	
MJ19VS		720		32	Grazing
MJ18VS	*Salsola*	845		38	
MJ5CRSa		273		12	
MJ5CRSb	*Atriplex*	2046		91	
MJ3CRSa	Those locations subjected to heavy grazing.				
MJ3CRSb					
MJ3CRSc					
MJ7VS					

Activity 6: Livestock integrated package

Objective:

- Integrate rangeland-livestock production by the sustainable management practices transfer.

Methodology:

- Flushing: supplying animal growers with barley, wheat bran, soybean, vitamins and alfalfa to be provided before mating.
- Synchronization using sponges with PMSG.
- Salt and mineral cubes.
- Vitamin AD3E
- Health program (vaccination, internal and external parasites).

Achievements:

Several visits were conducted for stockowners in the selected sites, for the purpose of signing contracts and three stock owners were selected.

Flocks were surveyed by Specialists for inspection for their performance and health status. Some of animals had some infections and they were already treated.

About 1000 straw blocks were distributed to the farmers.

Vaginal sponges, as well as, their PMSG hormones were purchased and 200 sponges were used by different farmers

Animal production and health monitoring were conducted in two villages (Al Majidyya and Mhareb):

Pregnancy diagnosis was performed in one farm in order to make synchronization for estrus. Seven animals were checked for pregnancy using Trans-abdominal ultra-sonography and the results are presented in table 4. Sheep with pseudo-pregnancy were treated with prostaglandin F2 alpha to end the pregnancy and return back to estrus.

Table 4: Results of pregnancy diagnosis

Owner name: Ali Shoshani		**Date:19-5-2011**	
Reproductive status	pregnant	Not-pregnant	Pseudo-pregnancy
Number of animals	2	4	1

For parasite control, fecal samples were collected from 4 farms for examination of internal parasite. Flotation test for those samples was performed and results are presented in table 5 Farms suffering from internal parasite were treated by anthilmintic (Ivermectin and Albendasole).

Table 5: internal parasite versus farms, -ve negative and +ve positive

Owner name	**Internal parasite**
Ali shoshani	- ve
Salameh naser	+ ve
Salameh al ateebi	+ve
Salameh Ghanem Al 3abieen	+ve

Sick animals were examined from 1-5-2011 till 1-8-2011 and the diagnosis and treatment are summarized in table 6.

Table 6: Sick animal Diagnosis and Treatment

Diagnosis	Number of Cases	Treatment
Pneumonia	6	Antibiotic+ Anti-inflammatory
Emaciated	10	Antibiotic (Oxytetracycline)
Sub-mandibular edema	3	Anthilmintic+ Antibiotic
Carbohydrate Engorgement	2	Laxavet+ Antibiotic(Pencillin)

In the case of the control of abortion disease, blood samples were collected randomly from farms suffering from this disease. Serum was harvested and stored at -20C until analysis for chlammydia abortus using ELISA kit. Three farms out of five (60%) were positive for chlammydiosis. The farm owner of these three farms was asked to control this disease. Placental tissue will be collected from farms suffering from abortion and examined by PCR for chlammadiosis, Toxoplasmosis and Brucellosis.

Synchronization of estrus using intra-vaginal sponge and PMSG treatment was performed for 5 farms (82 animals). Pregnancy diagnosis was performed after 1 month from insemination. Furthermore, Flushing with high protein diet was performed for those five farms to increase the percentage of twinning.

Health monitoring and treatment of animal in two villages (Al Majidyya Mhareb)

Below is the list of farmer (Table 7) who cooperated with the project and the activities implemented in order to improve the herd management and increase the benefit for the farmers.

Table 7: List of cooperating farmers

Fodder (kg)	Objective	Farmer name
300	Improve nutrition	Hamad msardeh
500	Improve nutrition	Ibraheem Masardeh
750	Improve nutrition	Mohamad Mhareb
150	Improve nutrition	Mesleh Mhareb
500	Improve nutrition	Hamed Mhareb
500	Improve nutrition	Smeran Mhareb
500	Improve nutrition	Qudity Mhareb
750	Improve nutrition	Smreen Mhareb
500	Improve nutrition	Mbarak Msardeh
1000	Improve nutrition	Khalaf Msardeh
500	Improve nutrition	Mohamad Msardeh
500	Improve nutrition	Awad Msardeh
200	Improve nutrition	Abdallah Msardeh
500	Improve nutrition and pregnancy	Hamadah mhareb
1000	Improve nutrition and pregnancy	Swealem Mhareb
500	Improve nutrition and pregnancy	Salameh Mhareb
600	Improve nutrition and pregnancy	Ali Shoshan
750	Improve nutrition and pregnancy	Ahmed Elghabeen

Annex 1: List of existing cisterns and the improvement requirements in addition to new proposed cisterns

Number	Improvement requirement
C1	Removal of deposited sediments from inside the cistern, construction of sediment trap and filter, and improvement of water entrance area with a layer of cement surrounding the sediment trap as a basin.
C2	Removal of deposited sediments from inside the cistern, construction of sediment trap and filter, and improvement of water entrance area with a layer of cement surrounding the sediment trap as a basin.
C3	Removal of deposited sediments from inside the cistern, improving the sediment trap and providing filtering gravel, and improvement of water entrance area with a layer of cement surrounding the sediment trap as a basin.
C4	Removal of deposited sediments from inside the cistern, improving the sediment trap and providing filtering gravel, and improvement of water entrance area with a layer of cement surrounding the sediment trap as a basin.
C5	Removal of deposited sediments from inside the cistern, construction of sediment trap and filter, and improvement of water entrance area with a layer of cement surrounding the sediment trap as a basin.

C6	Cleaning and removing both sediments and garbage and manure from inside the cistern. Check the inner part for seepage, particularly above the middle, and treat the seepage. Construct a sediment trap and filter, and divert all water inlets toward it. Construct a cover to prevent birds from affecting the water quality.
C7	Removal of deposited sediments from inside the cistern, construction of sediment trap and filter, and improvement of water entrance area with a layer of cement surrounding the sediment trap as a basin.
C8	Removal of deposited sediments from inside the cistern, construction of sediment trap and filter, and improvement of water entrance area with a layer of cement surrounding the sediment trap as a basin. Construct a cistern neck with a cover.
C9	Removal of deposited sediments from inside the cistern, construction of sediment trap and filter, and improvement of water entrance area with a layer of cement surrounding the sediment trap as a basin.
C10	Removal of deposited sediments from inside the cistern, construction of sediment trap and filter, and improvement of water entrance area with a layer of cement surrounding the sediment trap as a basin. Construct a cistern neck with a cover.
C11	Removal of deposited sediments from inside the cistern, construction of sediment trap and filter, and improvement of water entrance area with a layer of cement surrounding the sediment trap as a basin.
C12	Removal of deposited sediments from inside the cistern, construction of sediment trap and filter, and improvement of water entrance area with a layer of cement surrounding the sediment trap as a basin.
C13	Removal of deposited sediments from inside the cistern, construction of sediment trap and filter, and improvement of water entrance area with a layer of cement surrounding the sediment trap as a basin.
C14	Removal of deposited sediments from inside the cistern, construction of sediment trap and filter, and improvement of water entrance area with a layer of cement surrounding the sediment trap as a basin.
C15	Removal of deposited sediments from inside the cistern, construction of sediment trap and filter, and improvement of water entrance area with a layer of cement surrounding the sediment trap as a basin.
C16	Removal of deposited sediments from inside the cistern, construction of sediment trap and filter, and improvement of water entrance area with a layer of cement surrounding the sediment trap as a basin.
C17	Removal of deposited sediments from inside the cistern, construction of sediment trap and filter, and improvement of water

	entrance area with a layer of cement surrounding the sediment trap as a basin.
C18	Removal of deposited sediments from inside the cistern, construction of sediment trap and filter, and improvement of water entrance area with a layer of cement surrounding the sediment trap as a basin.
C19	Removal of deposited sediments from inside the cistern, construction of sediment trap and filter, and improvement of water entrance area with a layer of cement surrounding the sediment trap as a basin.
C20	Removal of deposited sediments from inside the cistern, construction of sediment trap and filter, and improvement of water entrance area with a layer of cement surrounding the sediment trap as a basin.
C21	Removal of deposited sediments from inside the cistern, construction of sediment trap and filter, and improvement of water entrance area with a layer of cement surrounding the sediment trap as a basin.
C22	Removal of deposited sediments from inside the cistern, construction of sediment trap and filter, and improvement of water entrance area with a layer of cement surrounding the sediment trap as a basin. Also to provide the cistern with a cover at the top of the neck.
C23	Removal of deposited sediments from inside the cistern, construction of sediment trap and filter, and improvement of water entrance area with a layer of cement surrounding the sediment trap as a basin.
C24	Removal of deposited sediments from inside the cistern, construction of sediment trap and filter, and improvement of water entrance area with a layer of cement surrounding the sediment trap as a basin.
C25	Removal of deposited sediments from inside the cistern, construction of sediment trap and filter, and improvement of water entrance area with a layer of cement surrounding the sediment trap as a basin.
C26	Removal of deposited sediments from inside the cistern, construction of sediment trap and filter, and improvement of water entrance area with a layer of cement surrounding the sediment trap as a basin.
C27	Removal of deposited sediments from inside the cistern, construction of sediment trap and filter, and improvement of water entrance area with a layer of cement surrounding the sediment trap as a basin.
C28	Removal of deposited sediments from inside the cistern, construction of sediment trap and filter, and improvement of water entrance area with a layer of cement surrounding the sediment trap as a basin. Also to reconstruct the cistern neck and install a cover.

C29	Removal of deposited sediments from inside the cistern, construction of sediment trap and filter, and improvement of water entrance area with a layer of cement surrounding the sediment trap as a basin.
C30	Removal of deposited sediments from inside the cistern, construction of sediment trap and filter, and improvement of water entrance area with a layer of cement surrounding the sediment trap as a basin.
C31	Removal of deposited sediments from inside the cistern, construction of sediment trap and filter, and improvement of water entrance area with a layer of cement surrounding the sediment trap as a basin.
C32	Removal of deposited sediments from inside the cistern, construction of sediment trap and filter, and improvement of water entrance area with a layer of cement surrounding the sediment trap as a basin.
C33	Removal of deposited sediments from inside the cistern, construction of sediment trap and filter, and improvement of water entrance area with a layer of cement surrounding the sediment trap as a basin.
C34	Removal of deposited sediments from inside the cistern, construction of sediment trap and filter, and improvement of water entrance area with a layer of cement surrounding the sediment trap as a basin.
New Cistern 1	Proposed cistern to benefit from the roof top of the close-by house in addition to a catchment area of around 350 square meters in front of the house. The cistern should be supplied with the proper PE. tubes to direct the roof top water to the cistern.
New Cistern 2	Proposed cistern to collect runoff water from an open area around 300 square meters.
New Cistern 3	Proposed cistern to collect runoff water from an open area around 450 square meters.

Annex 2: List of check dams and the maintenance requirement for each structure.

Number	Maintenance requirement
1	Putting back few stones, closing few water paths adjacent to the upstream side of the wall, and covering one third of the wall height with 5- 10cm of soil.
2	Repair the top side of the wall, and closing water paths from both upstream and downstream side.
3	Repair the top side of the wall, and closing water paths from both upstream and downstream side.
4	Rebuild damaged over the gully after excavating a foundation 0.2 meter deep and extending the excavation 0.5 meter in both banks so that the structure is anchored at both sides of the gully while keeping the same top level of the structure. One end of

the wall require some repair, and the other end with the spillway needs a 30 cm high and 50 cm wide edge from one side only to guide the water safely out and to level the spillway. Also important is the placing of soil on the upstream side only to form a triangle with the check dam wall.

5 Maintenance is required regarding the top of the structure and in the location of the gully. The structure requires the filling of soil along the upstream side to form a triangle with the check dam.

6 Maintenance is required regarding the top of the structure. The structure requires also the filling of soil along the upstream side to form a triangle with the check dam.

7 This earth check dam requires filling one hole in the dam wall with compacted soil. The spillway needs reconstruction with stones and concrete and then a 5 cm cover with stones is required over the whole spillway.

8 Maintenance is required regarding the top of the structure. The structure requires also the filling of soil along the upstream side to form a triangle with the check dam after closing all gaps and water paths firmly.

9 Rebuild the affected part only.

10 The structure requires closing all water paths at the upstream side and also the filling of soil along the upstream side to form a triangle with the check dam.

11 Rebuild the affected part only while keeping the same top level along the whole length of the structure.

12 Close the spillway while maintaining the same top level of the structure. The gaps at both sides of the gully from the downstream side should be closed firmly with soil and covered with some stones. A wing like extension should be constructed at each end of the structure forming an angle of 120 degrees with the dam wall, and each extension should be 2 meters long.

13 Rebuild the damaged part over the gully in addition to general maintenance of the top part of the structure. The structure requires also the filling of soil along the upstream side to form a triangle with the check dam after closing all gaps and water paths firmly.

14 Rebuild the damaged part over the gully in addition to general maintenance of the top part of the structure.

15 This earth check dam requires filling an excavated hole in the dam wall with compacted soil. The spillway needs reconstruction with stones and concrete and then a 5 cm cover with stones is required over the whole spillway.

16 General maintenance of the top part of the structure is required. The structure requires also the filling of soil along the upstream side to form a triangle with the check dam after closing all gaps and water paths firmly.

17 Fill the excavated parts below the gabion dam at the sides of the gully with stones, then increasing the height of the spillway with stones and concrete by 40 cm at the downstream side and 10 cm at the upstream side. Finally, the gabions on the two sides of the gully are to be covered with soil to a height of 15 cm above the level of the gabions (except only 50 cm at each side of the spillway). The structure requires also the filling of soil along the upstream side to form a triangle with the check dam and at the upstream side and in the gully bed some stones are required before adding the layer of soil.

18 Repair the part constructed over the gully and increasing the width of that part from the upstream and where the back slope is very high. Also to close gaps and water

paths at the upstream and downstream sides near the gully before putting a soil layer to cover part of the upstream side.

19 Repair the part constructed over the gully and increasing the width of that part from the upstream and where the back slope is very high. Also to close gaps and water paths at the upstream and downstream sides near the gully before putting a soil layer to cover part of the upstream side.

20 Fill the excavated parts below the gabion dam at the sides of the gully with stones, then increasing the height of the spillway with stones and concrete by 30 cm at the downstream side and 10 cm at the upstream side. Finally, the gabions on the two sides of the gully are to be covered with soil to a height of 15 cm above the level of the gabion (except only 50 cm at each side of the spillway). The structure requires also the filling of soil along the upstream side to form a triangle with the check dam and at the upstream side and in the gully bed some stones are required before adding the layer of soil.

21 General maintenance of the top part of the structure is required. The structure requires also the filling of soil along the upstream side to form a triangle with the check dam after closing all gaps and water paths firmly.

22 General maintenance of the top part of the structure is required particularly in relation to the top level of the wall. The part constructed over the gully requires to be reinforced with additional stones increasing the width of the wall from the upstream side only. The structure requires also the filling of soil along the upstream side to form a triangle with the check dam after closing all gaps and water paths firmly.

23 General maintenance of the top part of the structure is required particularly in relation to the top level of the wall. The part constructed over the gully (at least 4 meters length) requires to be reinforced with additional stones increasing the width of the wall from the upstream side only. The structure requires also the filling of soil along the upstream side to form a triangle with the check dam after closing all gaps and water paths firmly.

24 The height of the stone wall at the edge of the earth dam should be decreased by 0.5 meter and the stones are to be used to construct a small wall (4 meters long, 0.5 meter wide, and 0.4 meter high) to form a 110 degrees with the other wall, so that the spilled water is guided safely without causing damage to the earth dam. Also, to check the dam wall for holes and to close firmly any hole with soil.

25 no work needed.

26 Close a gap at the upstream side of the wall at the location of the gully. The structure requires also the filling of soil along the upstream side to form a triangle with the check dam.

27 Repair only the part constructed over the gully and increasing the width of that part from the upstream side, then adding a fill of soil to form a triangle for that part only and at the upstream side.

28 Repair only the part constructed over the gully and increasing the width of that part from the upstream side (so that the overall width of that part reach 3 meters), then adding a fill of soil to form a triangle for that part only and at the upstream side.

29 Clear the stones at the damaged parts, then prepare a foundation and excavate in each bank 1 meter and putting the soil at the upstream side. Reconstruct the damaged part including the extensions in both sides of the gully. Increase the height of the structure by an additional 25 cm and make sure that the part constructed in the gully bed is

	covered with concrete. A stone and soil layer is added to form a triangle at the upstream part only while only an apron of compacted stones should be placed at the downstream side to a length of 2 meters.
30	General maintenance and check of the top level of the wall (the same level along the wall length), and repair some parts (parts over the gullies) in addition to increasing their width from the upstream part by 40 cm.

Component II: Watershed modeling, monitoring and management Component

Activity 1: Sub-watersheds Selection

Objectives:

- Define the criteria for site selection, review and analyze the available data and select the site in cooperation with other groups

Methodology:

According to the discussion held in Amman workshop, the sites should meet some general criteria:

- Two pairs of relatively identical small (< 1 sq. km) sub-watersheds are required.
- The sites should be within Mharib or Al Majidyya watersheds.
- Project interventions should be implemented in one of the sub-watershed pair.

Therefore the methodology will be as follows:

- Using GIS, define the whole watershed of Mharib and Majidyya which measures about 70 km^2.
- Locate the sites of previous interventions.
- Review available data related to the project proposed site.
- Display the available DEM.
- Derive slope map.
- Derive contour map
- Derive streams using 3D analyst to cover the whole area.
- Draw the sub-watersheds using contour and stream lines
- Calculate areas of the sub-watersheds
- Discuss with the other groups to select the suitable sites for the project.
- Select the two pairs of sub-watersheds: within each pair, one sub-watershed contains water harvesting intervention and the other is without (four different land uses were

represented: continuous contour ridges, intermittent Valerrani, barley field with annual tillage and natural range). .

Define the criteria for the site:

The important criterion for selecting the sub-watershed is the level of data availability on the potential watersheds needed for modeling process. In case of limiting or missing data, extrapolation of data from other intervention sites will be used to compensate the gaps of existing data. In addition, the similarity regarding soil, slope and land use are another criteria that should be applied on the potential watershed and the control watershed. Table 1 shows the coordination and size of each sub watersheds.

Table 1: coordination and size of each sub watershed

Target Area	N	E	Area (m^2)
1	3513744	0227636	840
2	3508987	0237698	863
3	3507758	0238492	880
4	3508975	0236610	865

Results/Achievements:

- The area where the sites were selected is presented in Figure 1.
- Four sub-watersheds within the large watersheds (Majidyya) were selected, two with project interventions and the other without any interventions.
- Four plots of Geo textile were installed, two on a plot with project intervention and two on an area without project intervention, to collect the silt and take soil samples for moisture contents, soil texture, and soil fertility (NPK and organic matter) measurements.
- Four runoff plots were installed at two different sub-watersheds, two with project intervention and two without project intervention, to measure the runoff and sediment accumulation.
- Two weirs were constructed, one on a plot with project intervention, and one on a plot without intervention. Two sensors are installed for each weir, one for runoff measurement, and one for water level measurement.

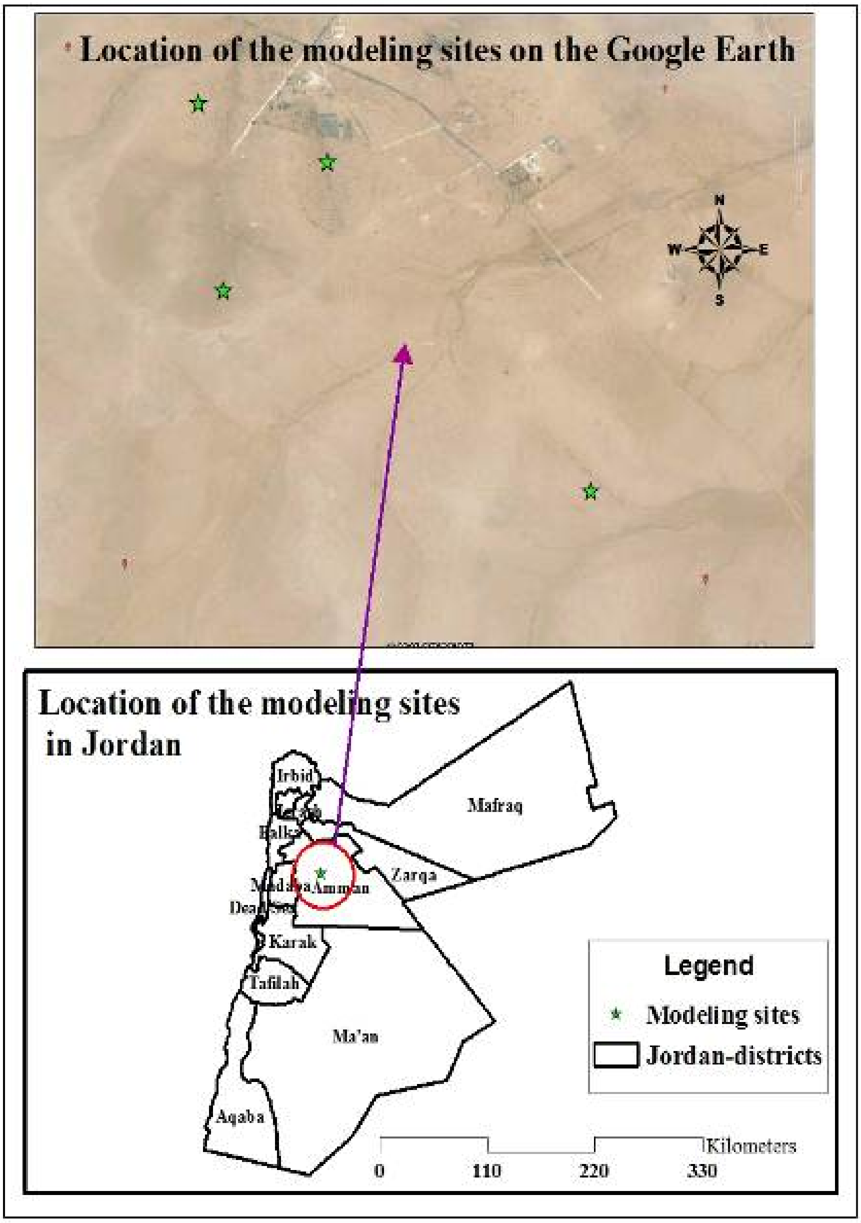


Figure 1: location of selected site for modeling, including Geotextile and weir

Activity 2: Define indicators and Model(s)

Objective:

- Define suitable indicators to enable the evaluation of biophysical and socio-economic impacts of rainwater harvesting interventions.

Results/Achievements:

The ICARDA and NCARE team discussed this activity during meeting and reviewed many models that could be used, and decided to use SWAT model because it is the most fit to research need, and can be compatible with GIS software. Among the biophysical indicators defined are: runoff, soil organic matter, soil fertility (NPK and organic matter), erosion, biodiversity, flood reduction and productivity. In collaboration with the socio-economic component, these indicators will be transformed into economic values of benefits and/or losses.

Activity 3: Data Collection

Objective:

- Collect existing bio-physical an socio-economic data required by SWAT model and the biophysical indicators.

Methodology:

Data on climate (rainfall, temperature), soil characteristics, runoff and sediments are monitored continuously during the whole season. Tables below show the list of the variables measured/analyzed and of the monitoring indicators collected from the sites and from the sub-site where the project water harvesting plots are installed. .

Field data

<table>
<tr><td>Site serial No</td><td colspan="3">Grid No or relative location:
Easting = Northing = Elevation=</td></tr>
<tr><td>Samples for analyses[1]</td><td>0-25 taken
Yes No</td><td>25-60 taken
Yes No</td><td>60-100 taken
Yes No</td></tr>
<tr><td colspan="2">Soil depth (cm)[1]=</td><td colspan="2">Slope (%)[1]=</td></tr>
<tr><td colspan="2">Sample for bulk density (0-25cm)[1] core</td><td colspan="2">Taken Untaken</td></tr>
<tr><td>Sample (0-5cm)[2]</td><td>OM Taken Untaken</td><td colspan="2">Aggregate stability Taken Untaken</td></tr>
<tr><td>Soil structure[1]</td><td colspan="3">Shape= platy, prismatic, columnar, blocky
Size = very fine, fine, medium, coarse, very coarse
Grade= weak, moderate, strong</td></tr>
<tr><td>Land use[1]</td><td colspan="3">WH-intervention and crop type :</td></tr>
<tr><td>Vegetation cover[1]</td><td>Type=</td><td>Percent=</td><td>Tilled
Not tilled</td></tr>
</table>

Stone and Rock[1]	Stone% =		Rock% =	
Erosion type[1]	Sheet	Rill	Gully	undifferentiated
Erosion status[1]	sever	moderate	low	
Site photo[2]	Photo serial number=			
Comments				

Laboratory analyses

Sample (0-5cm)[2]	OM=	Aggregate stability (MWD)=, BD	
First layer (0-25)[1]	OM =	Aggregate stability (MWD)=	
First layer (0-25)[1]	Soil bulk density=	EC=	
First layer (0-25)[1]	Total N=	Exch. P=	pH=
Texture 0-25[1]	Sand=	Silt=	Clay=
Texture 25-60[1]	Sand=	Silt=	Clay=
Texture 60-100[1]	Sand=	Silt=	Clay=
Stone content[1]	0-25=	25-60=	60-100=
Moisture content[3]	0-25=	25-60=	60-100=

Monitoring and Modeling indicators

Yield biomass (productivity) and / or stem diameter for all interventions and control	
Runoff after each significant rainfall event	
Sediment concentration after each significant rainfall event	
Texture of sediment collected after each significant rainfall event	
Biodiversity for all sites and for control at selected time (spring)	
Organic carbon in runoff water and sediments after selected significant rainfall events	
Moisture content (storage) after each	

significant rainfall event	
OM for the surface layer (0-5cm) at the beginning and end of the season	
Aggregate stability (MWD) for the surface layer (0-5cm) at the beginning and end of the season	
NPK in runoff water and sediment after selected significant rainfall events	

Results/Achievements:

Review and analyze the available data:
Data and maps available from the 1st phase of the project were reviewed and analyzed. Using GIS, all available layers and grids were displayed, while other required layers and maps were derived using spatial analyst tools. The available maps include; location of the intervention sites, soil, topographic map, and land use.

Using available DEM and the hydrological tools, topographic information maps were derived: stream lines, sub-watersheds, and slope. All the maps are printed and available at the GIS unit. Climatic data from queen alia airport for 25 years and Muaqqar station for 10 years are revised to meet the model requirements. The data include precipitation, temperature and wind.

New data collection**:**

A database on climatic parameters (collected from the data logger of sensors), sediments quantity and quality (Figure 2) and runoff (Figure 3) (from runoff plots), and soil characteristics (from all the sites) in the location has been developed. Soil samples from four different sub watersheds have been analyzed at NCARE laboratories. All collected information will be used to calibrate and validate the model.

Figure 2: Geotextile construction for sediment data collection

Figure 3: Weir construction and data collection

Activity.4: Run the simulation model

Objective:

- Calibrate and validate the model and run it for different scenarios of watershed management

Methodology:

Different sets of data will be collected to be used in the model calibration and validation

Results/Achievements:

Specialized Training Course on SWAT model (Soil and Water Assessment Tool) was organized by ICARDA on 09-14 July, 2011, Amman, Jordan (Figure 4). The participants were, 4 from ICARDA, Aleppo, 6 from NCARE Jordan, one from Lebanon, one from Ethiopia, and one from Morocco. The training course started with two days class-room work followed by on-the-job training where real data were used to run the model.

Secondary and monitoring data of the watershed (runoff, sediments, production) have been collected; but, we need at least 2 year data to reach the objectives of modeling.


Figure 4: photo of SWAT training group

Component III: Socio-economic Component

Introduction

One of the main objectives of the project "Options for Coping with Increased Water Scarcity in Agriculture in West Asia and North Africa" at the second phase is develop integrated technical, policy and institutional options (TIPOs) for sustainable water management to facilitate the rural communities' role in conserving water and improving their livelihood. The socio-economic component is also aiming at developing a policy and institutional framework for the implementation of appropriate water saving strategies that promoting the conservation of natural resources.

One objective of the project first phase is to increase the understanding by policy-makers of the effects of policies and institutional changes on water productivity and resource management. Contacts with policy makers started at the inception of the project, as they participated in the project initiation workshops, which were held in the three benchmark countries. They also participated in field days and management meetings of the project. A review of the water policy was conducted in each benchmark site. In the second phase, alternative policy options will be developed after consultation with the community and other stakeholders, in particular, key policy makers. The developed option will be evaluated and tested in pilot areas, and the most appropriate options that will improve the utilization and management of water resource, achieve equitable water distribution and delivery and conserve the natural resource will be recommended to the governments for their adoption at the national level.

At the 1st phase, socioeconomic surveys that characterize the communities involved in the project activities were conducted in order to identify the main technical, social, economic and environmental constraints of the communities' livelihood improvement. Also, it focused on the water resources available at the community level and on how this resource has been managed. The surveys' results established baseline information for the project target areas and communities and a community action plan was developed and implemented by the project with full participation of the community.

Activity 1: Assessment of the potential constraints for adoption of water harvesting technology in the Badia.

Objectives:

- To identify constraints for widespread adoption of project technical interventions in the Badia agro-pastoral system
- Assessthe impacts of property rights on the adoption of water harvesting technology in the Badia. This activity includes the following sub activities:

Activity 2: Policy options of land tenure and land property right in rangeland management

Objectives:

- To assess the extent to which current land tenure system, land property rights and their policy options for community-used rangeland are affecting adoption of technological options (water harvesting technologies, and rangeland management) and to improve the utilization and management of rangeland resource and conserve the natural resources.

Methodology:

- A literature review for current land property rights and arrangements for the community-used rangelands was used to assess the impacts of property rights on the adoption of water harvesting technology in the Badia. Secondary data on inventory policies and recent policy changes was collected from the Ministry of Agriculture, the Department of Statistics, the relevant projects and studies and any other available references;
- For studying the current land tenure system ,land property rights and their policy options for community-used rangeland and rangeland management and for the purpose of studying the potential constraints for adoption of water harvesting technology in the Badia . A socio economic questionnaire was used to collect the information needed .The questionnaire was prepared by the socioeconomic team members of the project to satisfy

the objectives of this component and was modified and discussed with all team members of the Project .A socioeconomics team was trained to collect the required data from the field; several meetings were held for the team and the questionnaire was discussed with them in detail. Pre-testing is done in the targeting communities to test the questionnaire validity to farmer's situation, slight modifications were done through feedback from farmers' interview.

Data collected through the household survey to achieve the objectives of the two activities included**:**

- The questionnaire was designed to capture information about the following aspects:
- Farmers' socioeconomic characteristics such as family size, age, sex composition and educational status.
- Type and amount of resources owned and used by the families, resources included: labour, land, and capital resources.
- Livestock herd characteristics and management options of pastoral and feed resources
- Agricultural activities and other off-farm activities, wages and earnings.
- Community characteristics including land and pasture resources, demography, livestock holdings, livelihood options, and land institutions.
- Community access to grazing land and terms, who manage the rangeland, management procedures and arrangements.
- Rangeland management including sources (village lands, tribal lands, reserves, rented lands, etc) within the community.
- Land property rights including holding system, how the holder got the land, who manage the land, and utilization from the land.
- Type of water harvesting technology used, and other factors related to water harvesting technology adoption: know how, cost of implementation and maintenance, financing the technology adoption. Information about the technical, institutional and policy factors relevant to technology adoption.

Methods of sample selection**:**

Given the fact that each community represents a single agro-ecology and high degree of homogeneity among community members as was evident from field visits, a simple random sampling approach was used to select a representative sample. A sample of 48 household were selected and personally interviewed from the targeted communities.

The data were collected from all households represented from the Muhareb and Al Majidyia communities (28 households). The rationale for using a comprehensive survey method in the these community areas is as follows: (a) All the households are located in one area and the researchers were able to reach all of them; (b) It is always recommended to collect data from the whole community, wherever possible, rather than a sample in order to collect sufficient information to be used in the analysis.

Methods of data analysis

The questionnaire data was coded and have been entered to SPSS Program, it was cleaned for un-reliable information's. Descriptive analysis was used in this study. It was used to describe to describe community characteristics that include production systems, livestock production, socio-economic aspects, natural resources, constraints related to water harvesting, and rangeland use and property rights.

A. Literature review

Review and analysis of current land property rights and current arrangements for the community-used rangelands in Jordan aim to assess the impacts of property rights on the adoption of water harvesting technology in the Badia. Secondary data on inventory policies and recent policy changes collected from Ministry of Agriculture, the Department of Statistics, the relevant projects and studies and any other available references;

However, the assessment of the impacts of property rights on the adoption of water harvesting technology in the Badia aims to assess the extent to which current land tenure system, land property rights and their policy options for community-used rangeland are affecting adoption of technological options (water harvesting technologies, and rangeland management) and to improve the utilization and management of rangeland resource and conserve the natural resources.

1. The Agricultural Policy Charter:

The Agricultural Policy Charter prepared in August 1995 and constituted an integral part of overall policy for the development of the Jordanian society and economy, recognizing the interdependence and yet polarity of rural and urban development. The Policy Charter aims to achieve efficiency, sustainability and equity.

The agricultural policy aimed at achieving balanced rural development, a prerequisite to achieve that is a diversified agrarian structure with a variety of viable land and flock ownership modes, farm types and farm sizes, taking the interrelationships into consideration, which acknowledge that agricultural and rural development, as well as economic stability and growth are inseparable. In respect to property rights, the Government of Jordan seeks to achieve an agricultural sector with a varied structure of ownership of land and water resources as well as plant and animal stocks, and an agricultural sector that constitutes the basis for integrated socio-economic development of the rural areas.

1.1. Agricultural Land Tenure and Urban Expansion:

Although acknowledging the principles of private ownership and private management of resources, private ownership cannot ignore the most important obligations in meeting actual interests of the entire society.

- Thus, land use for agricultural purposes should be environmentally sound and sustainable.
- Land fragmentation in rainfed agriculture zones must be halted and reversed by land consolidation.
- Land leasing and tenancy systems in the irrigated zones will have to be adjusted to better respond to actual social and technological requirements.
- Land tenure legislation for the Badia will have to address the problems of laying claim on ostensibly unoccupied land to stop overgrazing.
- As similar problems apply to forestry areas, a well defined legislation will be needed to ensure that forestry policies are adequately implemented in future.
- Address the problems associated with the conversion of agricultural land for housing, industry and road development optimize benefits to the society and minimize the loss of productive agricultural land.

1.2 Regulatory Framework, Services and Information:

The Government is committed to support the development of the agricultural sector through its institutions and activities by providing the policy framework and regulations as well as the needed information and services. The importance of these institutions and activities lies in their direct impact on the environment within which the farmers enterprises and agribusinesses operate, e.g. information and advisory services, production technology, regulatory marketing environment, availability of capital resources and inputs.

1.3. Optimal Utilization of the Water Resources:

In order to achieve the objective of efficient and sustainable utilization of the available production resources, the Government will adopt the following policies and strategies.

- Policies aiming at maximizing the efficiency of water storage, conveyance, distribution and on-farm application
    - ✓ Developing suitable water storage structures both on- and off-farm in order to minimize evaporation and seepage losses; and
    - ✓ Converting from the open canal conveyance and distribution systems to closed pipe systems in the Jordan Valley and the Highlands;
    - ✓ Replacing existing surface basin or furrow irrigation by drip systems;
    - ✓ designing and implementing approved irrigation schemes, jointly between public and private sector;
    - ✓ The price of the publicly developed and managed water to reflect its importance and scarcity.

To achieve the above policy, the Government will adopt the following measures and strategies:

- Streamlining all overlapping issues and responsibilities between the ministries and other public sector institutions concerned, regarding the management of the water resources.
- Strengthening the national capacity for the generation and dissemination of information on crop - water requirements, irrigation scheduling and management in each of the country's agro-climatic regions.
- Also, strengthening the national capacity for generating and disseminating technical information on water saving technologies.
- Upgrading the management capacity of the manpower involved in the water distribution involved.
- Furthering public awareness on the efficient use of water, water quality, and conservation of watersheds.
- Exempting materials required for the local manufacturing of water saving technologies from import customs duties, in order to minimize production costs for such equipment.

1.4 Land Consolidation

Land fragmentation is a serious obstacle for both, increasing agricultural productivity and natural resource management. It is a very difficult problem to be dealt with, politically and socially. However, consolidation of fragmented holdings will be encouraged and further land fragmentation must be averted. This will require comprehensive and prudent legislation in this respect. Such legislation will also stipulate minimum plot sizes, which would vary according to the production potential of the land. Also, land envisaged for development, with more than 75% of its surface covered with bedrock, could be subdivided for urban or industrial use.

1.5 Encouraging Soil and Water Conservation

Soil and water conservation will be targeted on land with slopes which are greater than eight percent. Although a great deal has been achieved through government supported programmes in certain areas, the remaining task is urgent and large in scope. Public sector involvement will be expanded, and increasing the pivotal role of the private sector will be encouraged, especially through investing in the establishment and maintenance of fruit farming - with the aim of increasing the productivity of the land and at the same time protecting water and soil resources.

1.6 Policies and strategies for the sustained exploitation of the low rainfall zones

Jordan's rangelands comprise approximately 90 percent of the nation's entire land area, and contribute to about 30 to 40 percent of the total livestock feed of plant protein. Although extensive in area, these lands have a low productivity ratio per surface unit. To a large degree these lands have been degraded as a result of misuse practices such as arable cultivation of wide areas in this zone - ostensibly for barley production, but probably in fact as a means of laying claim to the land - have led to widespread erosion and has accelerated the desertification process and degradation of this land resource. Broad agricultural policy objectives in this field which will be pursued by the government in this subsector will be:

- Prevent rangeland degradation and reverse the desertification process;
- Restore rangeland productivity and stabilize range forage and livestock production;
- Enhance environmental quality, and
- Improve the economic and social welfare of the people inhabiting and drawing their livelihood from these lands.

In order to achieve these objectives the Government will:

- Develop and implement policies to address the existing problems of land use, economic and social development, management and administration.
- Modify the roles of government agencies and institutions involved and their current responsibilities. It will also be essential to create a special agency supported by professional qualified staff and required to implement the policies related to rangeland development
- Although the government has a major responsibility for taking action to stop and reverse the desertification process; this can only be achieved and sustained with the active participation of the local population concerned.

1.6.1. Land Tenure

Rules and regulations governing land tenure in Jordan are contained in Agricultural Law 20/1973; however, enforcement of those sections dealing with rangelands is minimal. These sections of the Agricultural Law must be enforced in order to save the rangelands from uprooting of shrubs and trees, ploughing and overgrazing. Furthermore, this law must be reviewed and amended to include new concepts of rangeland utilization through a cooperative approach rather than individual exploitation, in order to restore sustained rangeland productivity, prevent cultivation of sub-marginal lands and provide for optimal range management compatible with the preservation of the environment.

The new rangeland tenure policy will also provide for the Government to reinstate jurisdiction over unregistered sub-marginal lands, especially lands that have been cultivated for barley production. These lands will then be properly managed to ensure sustained productivity and halt erosion.

1.6.2. Improving Rangeland Fodder Production

Rangeland forage production is seasonal and an adequate feed supply for the livestock must be secured the year around. To meet this forage requirements production and forage from range and crop lands must be integrated in a complementary system. Applicable rangeland management and animal husbandry practices will mainly comprise: 1) Demonstration of improved forage production on selected rangeland sites; 2) Establishment of range management plans for organization of livestock grazing, type and numbers of permitted livestock, degree of utilization of forage plants, the implementation of such plans would be monitored and controlled; 3) Control and development of livestock water supply; 4) Improvement of herd management, through selection, breeding, culling and marketing practices; 5) Improvement of forage conversion efficiency; 6) Programmes for the effective division of tasks in livestock development between rehabilitated rangelands and integrated crop-livestock systems on cultivated arable land.

1.6.3. Regulation of Border Crossings for Livestock and Herders

Cooperation and agreement with neighboring countries will be sought concerning grazing rights and quarantine measures in border adjacent areas, and cross-border movements of livestock and herders.

Although the Government prepared the policy charter in 1996, the local and rural community who are the productive society for agriculture not involved neither in preparation nor in implementation. However, a competitive agricultural system, catering for local as well as export markets, requires a reliable and efficient legal and regulatory framework. The Government formulates regulations concerning the production and market environment, while phyto-sanitary as well as seed and plant certification not considered. The infrastructure for implementing such policies and for monitoring and enforcing these regulations was not established.

Policies relevant to optimal utilization of the water resources may result in substantial savings and reduce the presently experienced shortages of irrigation water. This will require joint efforts and investments of both, Government and the farmers involved; particularly. Raising public awareness on the efficient use of water, water quality, and conservation of watersheds is highly needed.

2. Agricultural development strategies

Agricultural development strategies were included in the economic and social planning since the 1950s, where the 10-year program was drafted. The Council of Construction by cooperation with relevant ministries and governmental offices prepared the first development plan for the period (1963-1967), adjusted and reorganized in a new seven-year plan for (1964-1970). In 1971, the National Council for Planning created and implemented three development plans for the periods (1972-1975), (1975-1980), and (1981-1985). These plans drew up a set of overall strategies for maintaining high economic growth rates, for increasing the GDP contribution of commodity-producing sectors and for balanced social and economic policies at both national and regional levels. Agricultural development strategies are a key element of the Plans. These strategies aim to increase agricultural production in both irrigated and rainfed areas, and to stem population migration from rural to urban areas by providing opportunities for small farmers and farm workers to raise their incomes to local levels.

Four consequent economic and social development plans prepared and implemented by the Ministry of Planning by cooperation with relevant ministries and covering the periods (1986-

1990), (1993-1997), (1999-2003), and (2004-2006). These plans were drafted as a tool for a new developmental strategy, and designated a major role for the private sector, and confined the role of the government mostly to infrastructure-related projects that are essential for stimulating private investment (Ministry of Planning and International Cooperation, 1986-2004).

Furthermore, agricultural policies and strategies were developed for desertification control, rangeland rehabilitation, agricultural sector development and bio-diversity conservation. A special law for the protection of the environment was enacted (Law No.12 for 1995).

3. Social and Economic Development Plan

The Social and Economic Development Plan for agricultural sector was prepared in 1998. Major objectives of the Development Plan in the Agricultural Sector can be summarized as follows:

- Increase agricultural production to enhance self-dependency at a growth rate of 6% per year.
- Adopt a market-oriented production policy and expand production of commodities that Jordan enjoys competitive advantage and competent prices in their production at the regional and international levels.
- Improve national capacity in forest management and livestock development, afforest 150 thousand dunums of lands registered as forests in the various governorates, and conserve the major water catchments.
- Expand plantation of barley in lieu of wheat in suitable areas, and transfer from the existing production system thereat to a system that combines barley plantation and livestock breeding.
- Control natural rangeland degradation, define their uses and reinstate their productivity; and consequently increase their contribution in fodder production.

<u>Agricultural Development Constraints and Obstacles</u>

Agricultural Development Constraints pertaining to scarce natural resources (arable lands and water); institutional, financial and technical constraints; and economical and social factors that have directly and indirectly affected - and are still affecting- the agricultural development. Most important constraints and obstacles relevant to property rights are:

- In-efficient legislation as regards the agricultural sector and their inability to be in harmony with the economic and social changes and with the agricultural development needs and requirements. In addition, some of these legislations are not being enforced.
- Weak farmer organizations and lack of suitable conditions for participation by the farmers and workers of the agricultural economical activities in decision and policy making.
- Limited arable lands, fragmented and small-sized holdings, and high dependency of production on rainfall
- Limited water resources that are available for agricultural purposes and their low quality

Means and Procedures in the Field of Policies, Legislations and Structural Reform

- Re-consider the duties of the various ministries and government institutions and define their responsibilities to ensure avoidance of overlapping and interaction and guarantee complementarily among them.
- Review the laws, regulations and instructions, and re-consider them to be in harmony with the local, regional and international social and economic changes and developments and with the adopted agricultural policy requirements. These include Agricultural Law No. 20 for 1973, Agricultural Council's Law No. 24 for 1989, Agricultural Marketing Organization Law No. 15 for 1987, and National Center for Agricultural Research and Technology Transfer Law No. 42 for 1993 … etc.
- Attain optimum use of lands by issuing the necessary legislations to control urbanization encroachment onto arable lands, and representation of the Ministry of Agriculture in the Planning Council.
- Abstain from expanding the municipal and village council borders except after a thorough study approved by all concerned parties, including the Ministry of Agriculture, to serve optimum land uses.
- Set up suitable legislations and incentives to encourage integration of holdings and small plots.
- Establish the Plant and Animal Production Support and Enhancement Fund, pursuant to Article 197 of Agricultural Law No. 20 for 1973. Resources of the fund to consist of fines, confiscation and fees as stipulated in the law, in addition to prices of selling forest lands located within the municipal and village council planned borders and the percentage of fees collected by municipalities for marketing agricultural products within their boundaries.

Previous government agricultural development plans characterized by:

- Not comprehensive, lacked integration and the continuity needed to ensure stability and sustainability.
- Lack of a strategic approach for natural resource use to formulate a plan for resource management, including protection from misuse, and deterioration.
- Previous agricultural policies did not cover all aspects of development
- Weak participation of the private sector in agricultural development planning, which is attributed to Government reluctance concerning private sector participation, and shortage of professional and agribusiness organizations in the private sector.
- Inadequate cooperation and coordination among government organizations involved in agricultural development, due to weak administrative and technical capacity and the absence of joint programs.
- Shortage in financial resources that prevent implementing some of the adopted policies and giving them the required strength.

- Inadequate organization and structure of the national agricultural information system, data provided by the Department of Statistics (DOS) differ from that of the Ministry of Agriculture, in addition to inaccuracy of data provided in different areas. This affects the ability of planners and decision makers to plan and make sound decisions.
- Ineffective agricultural research programs, methods of technology transfer, and agricultural extension and their impact on increasing production, improving produce quality and lowering costs of production.

4. National Strategy for Agricultural Development (NSAD)

In 2003 The National Strategy for Agricultural Development (NSAD) was drafted, including five sub-sector strategies. The NSAD aims to attain economic, social, and environmental objectives. The economic objectives emphasized the importance of providing a suitable environment for the private sector to effectively participate in agricultural development, increase investment in the agricultural sector, increase incomes of farmers and workers in the supporting agricultural activities, and improve the competitiveness of produce in quality and price in local and export markets. Social objectives include: limit migration from rural areas into urban areas, increase women participation in agricultural development, enhance the capabilities of farmers and agricultural workers, and develop living standards for rural people. Environmental objectives include: conserve land, water and natural vegetation and utilize them within their production capacity to ensure sustainable and long-term agricultural production, conserve Jordan’s biodiversity and utilize it in supporting agricultural development

Historically, agricultural policies in Jordan have emphasized import substitution for key food commodities, and have adopted a range of input and output subsidy, tariff protection, price control, credit, and other incentive measures to stimulate domestic food production. The government also intervened massively to control purchase, marketing, and processing of strategic commodities and farm inputs, as well as supporting consumers through pricing policies.

Consequently, the agricultural sector started to witness declining growth rates during the late 1990s. This decline was attributed to the policy of trade liberalization adopted by the Government in 1994, and to the structural adjustment program of the agricultural sector (ASAL) in 2000. This trend increased with the implementation of measures related to Jordan’s accession to the WTO, where measures undertaken for the protection of local production from external competition where abolished, except for a small percentage of custom duties on the import of certain commodities.

5. National Rangeland Strategy

The National Rangeland Strategy for Jordan was prepared by the National Rangeland Strategy Committee in the Ministry of Agriculture in 2000. The strategy articulated that Jordan ranges suffered continuous deterioration due to elimination of its vegetative cover as a result to overgrazing and early grazing of range plants, plowing of rangelands to prove property rights, uprooting of bushes for use as fuel wood, and arbitrary movement of vehicles. Consequences of such activities were loss of productivity and accelerated desertification.

The Rangeland Strategy aims to control deterioration of the rangelands and invert the desertification process; Increase livestock production by restoring the rangelands productivity and increasing range fodder production; Improve and conserve the environment; Improve the socio-economic conditions of the rangelands inhabitants; Support range institutions with the financial and human resources, particularly the Range Department; and Amend and develop range pertinent legislations.

The document described the status of rangeland tenure and underlined that Jordan rangelands were characterized by effective land tenure systems and grazing rights that were associated with tribal institutions. This arrangement protected the resources within those lands and organized their utilization in a way that assisted in rangeland conservation and continued productivity under the prevailing environmental and social conditions. Upon elimination of these systems and rights and declaration of rangelands as state owned areas that are open for everybody, new land uses encroached at rangelands. Many of these areas were over-used without consideration to their resource requirements or their productivity. According to the Agriculture Law number (20) for the year 1973, all natural rangelands are owned by the State; but in practice and reality, the case is the opposite. The area of these lands is about 80 million dunums, or 90% of the Kingdom's total area of 89.3 million dunums.

Natural rangelands can be classified into three ecological zones:

- Badia Ranges with approximate area 70 million dunums, which are concentrated in the area that receives less than 100mm/year rainfall. Most of these lands are owned by the state.
- Steppe Ranges with an area of about 10 million dunums. They receive an average annual rainfall of 100- 200mm. Ownership in these areas includes private ownership, which constitutes 90% of the total area of the zone. The average area of the holding is 236 dunums in the northern Badia, 198 dunums in the middle Badia and 91 dunums in the southern Badia. The remaining portion of this area (10%) is state-owned.
- Mountainous Ranges with an area of about 450,000 dunums. They receive an annual rainfall in excess of 200mm. They are composed of small plots that are scattered around villages.

There are many laws and regulations that govern ownership/holding of rangelands although it has been acknowledged that the non-utilized lands surrounding cities and villages are State lands. The main laws concerned with rangelands are as follows:

Law No. 409 for the year 1952 (Land and Water Settlement Law)

This law provides for settling lands and water to all persons, commissions and societies who have the right to deal with, own or benefit from lands or water, whether this right is acknowledged or in dispute. Lands that are not settled in the name of the Budget in the form of State land as follows:

- Forest lands,
- Range lands,
- Urban use lands, and
- Disregarded lands.

This applies also to lands which the claimant cannot prove his ownership of them.

Law No. 14 for the year 1961 (Government Lands Protection Law)

This law describes the Special Law Courts that handle cases of encroachment on lands and the pertinent punishments. The law does not give the offender a priority in land ownership.

Law No. 20 for the year 1973 (The Agriculture Law)

This law defines range lands as "all state-owned lands that are registered as such, and any other state-owned lands that receive less than 200 mm annual rainfall". (Article118). Article 119 defines the lands that are exempted from the above definition, which are as follows:

- Lands cultivated under permanent irrigation.
- Lands used for public benefit.
- Municipalities, village councils and organized areas.
- Agricultural and housing project sites, if those projects were adopted at the time of enforcement of the law.
- Lands that are allocated for State benefits and institutions.
- Lands exempted from time to time by the Council of Ministers from provisions of this law.

Article (120) of the law specified the Minister's authority to issue decisions to regulate grazing, develop range lands, specify kinds and numbers of animals allowed to graze, utilize surface water, manage small dam projects, drill and equip artisan wells with pumps, and to conserve ranges' environment and natural components.

Articles (121, 122,123, 124, 128, 129, 130, 131 and 132) defined range plants and fodder plants. They also gave the Minister varied authorities in range land rental and punishments for encroachment on ranges and their lands, plants or constructions. Meanwhile, Articles (125, 126 and 127) of the law specified conditions for range land rental.\

Law No. 17 for the year 1974 (State Property Management Law)

This law provided for priorities when renting state-owned lands. Priority is to be given to farmers, cooperatives and graduates from agricultural colleges. Five years after the lands rental, they can be sold to the renting party. The law and the regulations issued pursuant to it (Regulation No. 53/1977) specified land rental fees at 8% of the land value, at 500 dunums in the eastern regions, 100 dunums in highlands and regions adjacent to the Jordan Rift Valley, and 50 dunums in irrigated lands. Also, the subject law provided for possibility of dividing the lands rented in this manner after 10 years from the new ownership registration or vestment.

6. Other Program and Policies

6.1 Economic Adjustment Programs

During 1988-1989 Jordan has experienced rigorous economic crisis, where deterioration of real GDP growth (-13.4%), double-digit inflation rate (25.7%), mounting budget deficit 20.8%, and sharp devaluation of the Jordanian Dinar. Both external shocks (sharp fall in grants and remarkable reduction in workers' remittances) and internal factors (expansion of public sector, intensive government subsidies, and inefficient tax system and trade regime) were caused such crisis.

The government adopted six International Monetary Fund (IMF)-supported programs during the period 1989-2004. The comprehensive economic adjustment programs emphasized both public and private sector involvement and partnership, and the growth of international and inter-regional trade, strategically managed within a framework of sustainable development. The first phase of the economic reform program resulted in an improvements achieved in a number of important areas have been satisfying. Real gross domestic product (GDP) grew from – 13.4 in 1989 to 7% in 2004. Foreign exchange reserves increased from $ million 130 in 1989 to about $ million 4824 in 2004. Moreover, inflation was reduced from 25.6 percent in 1989 to an average of 3.4 percent in 2004 (Jordan's Economic Reforms, 2005). In the second phase, a five-year economic and social development plan for (1993-1997) was drafted as a tool for a new developmental strategy.

The plan designated a major role for the private sector, and confined the role of the government mostly to infrastructure-related projects that are essential for stimulating private investment. The third phase builds upon past accomplishments to further consolidate and expand the reform programs. These programs, underscored in Jordan's National Economic and Development Strategy, and add momentum to the legislative and regulatory reforms.

6.2 Trade liberalization

In recent years, Jordan has taken many steps at multinational, regional and bilateral levels to open its economy to international competition and expand trade. In addition to liberalizing trade in goods and services through its WTO membership, Jordan has made commitments on the WTO Agreements. In 1998, Jordan joined the Euro- Mediterranean Association Agreement, and is a member of the Arab Common Market Agreement and the Arab Free Trade Area Agreement of 1998. Jordan has entered into several bilateral agreements with other Arab countries and European trading partners to promote trade and investment and entered in 2000 into a Free Trade Agreement with the United States. Memberships in these agreements illustrate the changes that have occurred over half a decade. The agreements stipulate that member countries must reduce trade-distorting policies in agriculture such as domestic support programs.

6.3 Import Policies

Historically, Jordan's import regime was restrictive and characterized by high tariff and non-tariff barriers. Since late 1989, there has been a notable change in the direction of trade liberalization through gradual reduction of tariff and non-tariff import restrictions. In 1995, new import policies were set to eliminate import bans on all food items, and at the same time established a new tariff system in which importers have to pay a tariff rate of 30 percent of the value of products, plus 20 percent surcharges and taxes. Onions, garlic, potatoes, dried legumes, red meat, and animal feed are exempted from tariffs and surcharges. Jordan joined the World Trade Organization (WTO) in 2000, and as a result had to lower its weighted average of tariff to 12 percent over a period of ten years in equal annual cuts. All its non-tariff restrictions are converted to tariff based duties.

6.4 Export Policies

Traders of agricultural products are allowed to export without restrictions; all that is needed to engage in export activity is a certificate of registration of the business enterprise. In addition, Jordan has adopted an export promotion plan since 1989 with the aim of reducing the anti-export bias, increasing manufacturing exports, diversifying economic activity, and attracting more foreign investment. Several export incentives were introduced. The main incentive schemes are: duty drawback systems, duty exemption of production inputs, export credit guarantee, pre-shipment-rediscounting, and encouraging exporters to participate in national, regional and international trade fairs.

7. A study on Community and Household-Level Impacts of Institutional Options for Managing and Improving Rangeland in the Low Rainfall Areas of Jordan

E. Al-Karablieh et al prepared a paper for the International Conference on Policy and Institutional Options for the Management of the Rangelands in dry Areas, held in Tunisia from 7-11 May 2001 entitled “Community and Household-Level Impacts of Institutional Options for Managing and Improving Rangeland in the Low Rainfall Areas of Jordan”.

The paper concluded that there are four rangeland management options practiced in the low rainfall areas in Jordan, mainly traditional tribal system which is known also as Open Access, cooperative management, governmental reserves and common private rangeland. Sheepherders can use different combinations for rangelands management options depending on several factors such as institutional power, household characteristic and herding practices.

Several problems are impending resources uses at each management option under different grazing type. There are common problems for all options such as drought conditions, overgrazing and land degradation, large number of sheep. Community-specific characteristics could play a significant role in the cost of hand feeding. Herders in communities having access to, or near, the governmental reservoir or having a cooperative rangeland; are expected to have lower feeding costs compared with herders in communities far away from rangeland.

The result shows that the herders integrating crop and livestock have a lower probability to opt tribal management option. The existence of governmental shrubs near the community decreases the probability to adopt tribal grazing by 31%. The accessibility to government reservoir increases the probability of using tribal rangeland by 55%. Most of herders opt a management option that combines tribal and governmental shrubs. The herders who hired shepherds for their flock have a higher probability to adopt tribal grazing; the shepherd can go for long distances with sheep and not necessarily come back home at the evening. They can spend 3-4 days in the tribal rangeland with flock before coming back home.

Membership in rangeland cooperative is the main factor that explains the adoption of cooperative rangeland in which the exploitation of the cooperative rangeland is usually strict to members of the cooperative. Utilizing the cooperative rangeland reduces the probability of utilizing other tribal rangeland. The herders are satisfied with tribal and cooperative rangelands to provide their livestock with sufficient feed.

Large flock size owned by sheepherders' increases the probability of utilizing the reservoir. Sheepherders with small flocks can provide their sheep with sufficient feed without relying on reservoir. Sheep flock managed by shepherds can move a long distance and they are less reliable on governmental reservoir. The older sheepherders are less probable to utilize the reservoir, either they have a small flock size or they integrate crop and livestock by cultivating cereals in large plots they owned.

Policy makers, researchers and different institutions whom concern is rangeland improvement in Jordan have to give enough attention to the access rules of grazing in rangeland. Most successful rules found under the Tribal (T), and Tribal and Cooperative (T+C) management options. This gives the impression that the government should not interfere directly in rangeland management. In conclusion, we can say that collective action and participatory approach management of rangeland seems as an attractive idea to improve rangeland in Jordan.

8. A Study on Collective Action, Property Rights and Devolution of Rangeland Management: Selected Examples from Africa and Asia

Tidiane Ngaido and Michael Kirk carried out a study on Collective Action, Property Rights and Devolution of Rangeland Management: Selected Examples from Africa and Asia. The paper addressed that empowerment of rangeland users is the major slogan of rangeland devolution policies. The new paradigm shift in the management of common rangeland resources which are the livelihood base of pastoralists and, in particular, of poor rural households in developing countries, aims at devising a new resource management system conducive to efficient, equitable and sustainable management.

Presently, many states are reformulating their land and resource management policies and devolving decision-making power to local communities and organizations. However, this devolution process comes at a time where these countries are also facing environmental degradation, which endangers the natural production base, and dire shortages of funds to sustain development efforts of rangeland resources. This raises many concerns regarding whether states in developing countries and countries in transition are really convinced that local institutions are efficient resource management structures or that mainly acute financial constraints are pushing them to relinquish their formerly appropriated stewardship roles. In the former case states are striving to find efficient and sustainable solutions and partner organizations for the management of rangeland resources. In such cases, states are real partners of the devolution process and would be willing to use participatory approaches and develop enabling frameworks that would empower local communities. In the latter case, however, the devolution process may consist of transferring the management burden to these communities without a clear assessment of the situation, in particular of their existing capacities and competencies, and a framework that enables local institutions to fill the vacuum and reclaim their traditional roles and rights. Under both circumstances the challenge is whether local institutions have the strength and the capacity to take over roles that are being reassigned to them.

The paper explored the different instruments used by the states to enhance the capacity of local institutions and communities to manage rangeland resources and sustain pastoralists' livelihood strategies. The devolution process is complex and requires a clear understanding of the implications of each devolution instrument. We contend in the paper that the objective of the devolution is to strengthen pastoral society's livelihood strategies, improve the efficiency of rangeland management and ensure the overall community welfare.

9. A study on Rangeland degradation and socio-economic changes among the Bedu of Jordan: results of the 1995 IFAD Survey

R. Blench prepared a study on Rangeland degradation and socio-economic changes among the Bedu of Jordan. The paper described the pastoral system of the Bedu of Jordan as it existed in 1995, and summarizes the reasons for the changes that have occurred over recent years. The likely course of future development is outlined. The classic literature on the Bedu in Jordan and neighboring countries has shown regular patterns of transhumance, following traditional routes and associated with particular tribal and sub-tribal groupings. This situation has been shown as if it still existed in quite recent reports. However, in reality, it has all but broken down in favor of a more opportunistic system using trucks and telecommunications to exploit remote pastures.

The main reasons for the changes in the Bedu behavior can be summarized as follows: availability of trucks to move animals and water; telecommunications to assess the availability of pasture; closing of national the frontiers to the pastoralist movement; breakdown of traditional authority systems; and a relatively liberal political climate.

A socio-economic baseline survey of Jordan's badia rangelands was conducted in 1995, as part of the preparation for a project or the conservation of the rangelands. This survey aimed to devise the socio-economic matrix into which a feasible project could be slotted for providing baseline data against which the overall impact of the project could be measured. The study indicated that there are essentially two views of land tenure in the rangeland areas; “complex” and “simple”. Rights in pasture are viewed, especially by anthropologists, as highly elaborated and sanctioned by traditional society. Numerous interlocking systems of rights existed in the past and development can only be effective if these are respected or strengthened. The alternative view, “simple” one, is that although tenure may exist in theory it is non-functional today. In other words, although pastoralists can explain their rights in a region of pasture these rights cannot be made operational, except through agriculture or related types of land development. Traditional tenure has to all intents and purposes broken down.

Traditional theory holds that rights to pasture are not held by individuals and that, in principle, all producers are free to exploit it. This theory has not been operative through much of the history of this area (Nesheiwat, 1991). The evolution of the hema system essentially allocated pastures to individual subgroups, where authority was exercised via a sheikh. Several key elements of the hema system allowed it to survive for many centuries, for the following reasons:

- A high degree of militarization of society which allowed violent retribution against rulebreakers;
- The slow pace of movement to a given pasture (on foot);
- The fact that herding was done more directly by the owners of the animals; and
- Actual herd sizes were smaller implying less competition for pastures.

These conditions have all been transformed within the last half-century. The Bedu have come under control of central Government, they have acquired trucks to transport animals, herding is largely done by hired shepherds and herd sizes are now very large. Many individuals or families perceive themselves as having rights in rangeland and can classify an area as their “traditional” grazing area. However, this does not mean they have any mechanism to prevent outside herds from coming in and exploiting the grazing. In general, this pattern seems quite acceptable because of the uncertain nature and inter-annual fluctuation of forage resources. If you do not allow someone to graze “your” area this year, in another year your herds may have access blocked elsewhere. In the same way, there is a strong resistance to private or individual ownership of the rangeland. While notions of rights subsist in a conveniently ambivalent form, they can persist. If private ownership meant the erection of fences across the rangelands, there would be considerable resistance.

The study recommended to take immediate action prevent the uprooting of woody vegetation for firewood, a strategy should be adopted to encourage the bringing to market of more mature animals, the use of feed supplements, mineral blocks and industrial by-products by herd-owners should be encouraged, since the poor nutrition of animals fed only on cereals is an important reason for herders whose animals subsist largely on feeds to continue using the rangeland in certain periods, the use of fertility drugs without strict veterinary supervision should be discouraged, and veterinary services should be monitored and improved.

B. Results/Achievements of the survey:

1. General information:

1.1.Villages of the collected sample

The distribution of the collected sample is shown in table (1) , all farmers presented at Al Majdyah community were reached and they estimated at 35 % of the selected sample followed by Muhareb community were they composed 23 % of the selected sample and the remaining percent 42% was from the neighboring community , Al-Hatmyah

Table (1): Name of villages of the collected data

Village	No. of farmers	%
Mhareb	11	22.9
Al Majdyah	17	35.4
Al Hatmyah	20	41.7
Total	48	100

1.2. Farmers Educational level

Secondary educational level was dominant among farmers with a percent of 29 % (Table 2). Meanwhile illiteracy estimated at 23 % among them followed by preparatory education estimated at 21% of farmers.

Table (2): Farmer educational Level

Educational Level	No. of Farmers	%
Illiterate	11	22.9
Read and Write	4	8.3
Primary school	4	8.3
Preparatory	10	20.8
Secondary	14	29.2
Diploma	2	4.2
University	3	6.3
Total	48	100

1.3. Farmer Experience in agricultural activities;

The overall average of farmers experience in agriculture estimated at 27 years for the whole sample the minimum was 5 years and the maximum years was 50 years as shown in the table 3. Around 44% of the farmers have average agricultural experience of 35 years which indicated that agricultural in practiced since long time ago .

Table (3): Farmers agricultural experience

Agricultural Experience (years)	Av. Years	No. of farmers	Min.	Max.	% of Total Farmers
1-20 years	14.18	22	5	20	45.8
21-40 years	35.86	21	25	40	43.8
above 40	49	5	45	50	10.4
Total	27.29	48	5	50	100

1.4. Farmers time in working in agriculture

Results of the survey indicated that 73% of farmers presented at communities' area are a full time working in agriculture. However, 27 % of them are a part time working in agriculture as shown in table 4.

Table (4): Nature in working in Agriculture

Agricultural work	No. of farmers	%
Full - time	35	72.9
Part - time	13	27.1
Total	48	100

1.5. Farmers membership to comparatives and cooperatives types :

Only 31% of farmers has mentioned that they are member of a cooperative at communities areas, the majority are not participating in any cooperative activities (Table 5), for members participating in cooperatives its mainly charity cooperatives as indicated by 73% of farmers and 27 % of farmers members to cooperative cooperation (Table 6)

Table (5): Farmers participation in cooperatives

Cooperative Membership	No. of farmers	%
Yes	15	31.3
No	33	68.8
Total	48	100

Table (6) Nature of cooperative

Cooperative Nature	No. of farmers	%
Collaborative	4	26.7
Charitable	11	73.3
Total	15	100
Name of association	No. of farmers	%
Al Rahmania association	11	73.3
Qaser Al Mashta association	4	26.7
Total	15	100

1.6. Family Structure and agricultural work

The average family size according to the surveyed sample at the target communities estimated at 8 persons. The average number of children under 15 years was 2 persons (Table 6).the overall number of family member of the whole sample is 378 persons. The national overall average family size is 5.6 people according to the Department of statistics census 2010.the majority of family members (81%) of them do participate in the agricultural work (Table7).

Table (6): family size and total number of family members

Family Structure	N		Min.		Max.		Sum		Mean	
Total Family	48		2		18		378		8	
Sex	M	F	M	F	M	F	M	F	M	F
< 5 year	8	3	1	1	2	3	9	5	1	2
(5 -10)	12	9	1	1	2	2	17	11	1	1
(11-15)	13	12	1	1	3	6	21	26	2	2
(16 - 60)	30	30	1	1	4	4	64	50	2	2
> 60 year	3	2	1	1	1	2	3	3	1	2

Table (7): Family member's participation in agricultural work

Agricultural participation	N	%
Yes	39	81.3
No	9	18.8
Total	48	100

The average number of sons participate in the agricultural work is around 2 persons , while it was estimated at 3 for daughters whom participate in the agricultural work (Table 8), they are mainly engaged with these activities all year (11 to 12 months) as shown in table 9.

Table (8): Number of Family members who participate in agricultural work

No. of family members	N	Min.	Max.	Sum	Mean
Husband	1	1	1	1	1
Wife	1	1	1	1	1
Sons	19	1	4	39	2
Daughters	9	1	7	25	3

Table (9): Number of months of family agricultural work

No. of months	N	Min.	Max.	Sum	Mean
Husband	38	1	12	430	12
Wife	24	3	12	279	12
Sons	25	3	12	285	11
Daughters	9	12	12	108	12

1.7. Type and wages of hired labor for agricultural activities.

Farmers hire seasonal labor to work at their farms with an average number of 3 workers per season (table 10), the average number of permanents labor numbers for crop production is 5 workers and 3 workers for livestock activities, they are mainly hired for around 9 months for the crop production activities and for almost all year for the livestock activities (table 11).

The average labor wage of seasonal labor is estimated at 244 jd/month and for permanent labor is estimated at 250 JD/ Month for crop production activities goes up to 268 JD/month for livestock activities (Table 12) .

Table (10): Number of hired labor for the different agricultural activities

No. of Laborers	**No. of farmers**	**Min.**	**Max.**	**Mean of labor**
Seasonal labor	9	1	10	3
Permanent labor (crops production)	2	5	5	5
Permanent labor (livestock)	5	1	9	3

Table (11): Number of months per year for hiring labor

No. of Months	**No. of farmers**	**Min.**	**Max.**	**Mean of months**
Permanent labor (crops production)	2	6	12	9.00
Permanent labor (livestock)	5	9	12	11.40

Table (12): Labor wage (JD/month)

Labor Wage (JD/month)	**No. of farmers**	**Min.**	**Max.**	**Mean of wage**
Seasonal labor	9	60	500	244
Permanent labor (crops production)	2	250	250	250
Permanent labor (livestock)	5	250	300	268

The hired labor for crop production are engaged with the activities of seeding and plowing as indicated by 55 % of farmers and hired labor for livestock activities are for grazing and livestock watering table 13.

Table (13): Kind of Agricultural activities performed in hired labor

Crop production activities	**No. of farmers**	**%**
Planting	1	11.1
Harvesting	1	11.1
Seeding & plowing	5	55.6
Seeding & harvesting	1	11.1
Seeding & plowing & milking	1	11.1
Total	9	100
Animal production Activities		
Livestock watering	1	20
grazing	4	80
Total	5	100

2. Land tenure system

2.1. Family land holdings (land cultivated and uncultivated)

The maximum number of owned plots of the surveyed sample is estimated at 5 plots the average distance from the of plots from the villages is estimated at 2 km which means that the majority of plots exists within communities areas (table 14). Most of the farmers own lands at community area with an average area owned of an 98 dunums, its mainly cultivated with an average area cultivated on 87 dunums . Few farmers only own 5 plots they are 5 persons with average area of 71 dunums.

Table (14): Total area owned and area cultivated at communities area.

Field information	**Distance from the village**				**Total area (du)**				**Cultivated area (du)**			
	N	**Min.**	**Max.**	**Mean**	**N**	**Min.**	**Max.**	**Mean**	**N**	**Min.**	**Max.**	**Mean**
Plot 1	48	0	15	1.54	48	10	1	98.23	44	0	1	87.17
Plot 2	29	0	16	2.09	30	9	1000	106.4	30	0	1000	97.2
Plot 3	16	0	6	1.52	16	5	300	87.94	15	0	300	8.8
Plot 4	9	0	3	1.33	9	10	1000	183.11	9	0	1000	167.78
Plot 5	5	0	2	0.8	5	15	180	71.6	5	0	180	59

2.2. Purpose of plant production at communities areas.

The main purpose of planting barley at community areas is for feeding livestock as indicated by the interviewed farmer whom plant barley, same applies for farmers planting shrubs and alfalfa. However, olive plantation is only for household consumption as shown in table 15.

Table (15): Main purpose of production in the cultivated plots

Main purpose of production		**Plot1**		**Plot2**		**Plot3**		**plot4**		**Plot5**	
		No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Barley	For Feed	31	100	22	100	11	100	6	100	3	100
Wheat	For Feed	1	100	0	0	0	0	0	0	0	0
Olives	Household Consumption	5	100	1	100	0	0	0	0	0	0
Shrubs	For Feed	6	100	5	100	3	100	0	0	0	0
Alfalfa	For Feed	1	100	0	0	0	0	0	0	0	0

2.3. Land ownership system for the different plots

It was noticed that all land presented at communities area in the surveyed sample are privately owned , around 67 % of farmers who own plot no.1 indicated that its individually owned by the farmers himself and 15% of the land is owned by the family and few farmers own land jointly with other relatives. Same applies for the other plots owned where individual ownership is the dominant among other types of ownership as shown in table 16. It was also notices that around 77% of farmers inherited their lands and only 15% of them purchased it (Table 17). The topography of land is simple slope as indicated by more than 60% of the interviewed farmers (Table 18)

Table (16): Land ownership for the different plots

Land ownership	**Plot1**		**Plot2**		**Plot3**		**plot4**		**Plot5**	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Individual ownership	32	66.7	17	56.7	9	56.3	6	66.7	2	40
Family ownership	7	14.6	5	16.7	2	12.5	0	0	1	20
Joint ownership with relatives	5	10.4	2	6.7	2	12.5	0	0	0	0
Rented	4	8.3	6	20	3	18.8	3	33.3	2	40
Total	48	100	30	100	16	100	9	100	5	100

Table (17): Way of land acquisition

Getting field	**Plot1**		**Plot2**		**Plot3**		**plot4**		**Plot5**	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Inherited	37	77.1	16	53.3	7	43.8	1	11.1	2	40
Purchased	7	14.6	9	30	5	31.3	5	55.6	1	20
Rented	4	8.3	5	16.7	4	25	3	33.3	2	40
Total	48	100	30	100	16	100	9	100	5	100

Table (18): Land topography of owned plots

Topography field	**Plot1**		**Plot2**		**Plot3**		**plot4**		**Plot5**	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Sharp slope	12	25	4	13.3	1	6.3	0	0	0	0
simple slope	30	62.5	18	60	11	68.8	6	66.7	3	60
Flat	6	12.5	8	26.7	3	18.8	3	33.3	2	40
Valley	0	0	0	0	1	6.3	0	0	0	0
Total	48	100	30	100	16	100	9	100	5	100

More than 50% of the farmers consider their land to be low fertile soil and need to be rehabilitated to be more productive (table 19) and its managed by the farmer himself with the help of relatives in some cases (table 20) , the prices of purchased land varies between 500 to 1103 JD/ per dunum .however the current price of land has increased on average for more than 3000 JD/du as shown in table 21.

Table (19): Soil fertility of plots

Soil Fertility	**Plot1**		**Plot2**		**Plot3**		**plot4**		**Plot5**	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Low	22	45.8	12	40	8	50	4	44.4	3	60
Moderate	18	37.5	12	40	6	37.5	3	33.3	2	40
High	8	16.7	6	20	2	12.5	2	22.2	0	0
Total	48	100	30	100	16	100	9	100	5	100

Table (20): land management

Cultivated manager	**Plot1**		**Plot2**		**Plot3**		**plot4**		**Plot5**	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Householder	43	91.5	21	72.4	11	68.8	7	77.8	3	60
Relatives	2	4.3	3	10.3	2	12.5	0	0	0	0
Rented	0	0	3	10.3	2	12.5	2	22.2	2	40
Ncare	2	4.3	2	6.9	1	6.3	0	0	0	0
Total	47	100	29	100	16	100	9	100	5	100

Table (21): land value (JD/du)

Field information	**Value of purchased plots**				**Plots current average price**			
	N	**Min.**	**Max.**	**Mean**	**N**	**Min.**	**Max.**	**Mean**
Plot 1	7	2	5000	1103.14	41	300	11000	2963.41
Plot 2	8	1	2000	465.06	24	600	11000	3558.33
Plot 3	4	40	1000	585	12	700	6000	2775
Plot 4	4	40	1000	510	8	700	5000	2525
Plot 5	2	800	1000	900	4	700	5000	2425

2.4. Planted and harvested area the production of different crops at communities' area.

The average cultivated area of planting barley at communities' area estimated at 246 dunums which indicates that large areas are planted with barley. However, due to drought conditions and shortage of rainfall precipitation the harvested areas of barley is only estimated at 46 du,

The cultivated area on average for olives estimated at 11 dununs, all the production is used for household consumption, no records was found for selling or storing of the production for both barley and olives (table 22).

Table (22): Total area cultivated and area harvested of barley and olives at communities area

Barley	**No. of farmers**	**Min.**	**Max.**	**Mean**
Cultivated area (du)	37	3	2200	246.08
Harvested area (du)	6	4	200	45.67
Total production quantity (ton)	2	1	1	0.75
stored Production quantity (ton)	1	1	1	1
Olives	**No. of farmers**	**Min.**	**Max.**	**Mean**
Cultivated area (du)	5	2	30	11
Harvested area (du)	4	2	30	11
Total production quantity (ton)	1	1	1	1
stored Production quantity (ton)	0	0	0	0

3. Grazing and Range Management

3.1. Grazing Management

Results of analysis of grazing management illustrate in Tables (23 – 27). The results show that the herd is grazing mainly by family members (64.1%) including both the householder and the son. This is expected result for the high cost of hiring a shepherd and small size of herd. About (35.9%) of respondents stated that they hired Shepherds (93% of shepherds are Syrian) to graze livestock with a monthly salary ranged between 200-300 JD. All respondents referred that their herds expend less than one month inside pastures.

Table (23): Grazing management - Who grazing the herd (n = 39)

Item	Frequency	Percent
Householder head	16	41.0
The Son	9	23.1
Shepherd	14	35.9
Total	39	100.0

General village land are relatively the only source of grazing, whereas 22 farmers (out of (23 respondents) stated that their flocks are grazed in general village land with no terms or conditions, without any procedures for resources and activity management (Table 24). The period of grazing in village land averages 42 days and ranged between 7-120 days. Only one respondent rented a field to graze his herd.

Table (24): Management and access to rangeland

village name	Frequency	Percent
Mharb	6	27.3
Al majdyah	5	22.7
Al hatmyah	8	36.4
Al mattabah	1	4.5
Al ktaifa	1	4.5
Al mwaqer	1	4.5
Total	22	100.0

Table (2) shows that the respondents use three main sources of grazing the herd including: green barley (n=4), un-harvested barley (n=22) and barley residues (n=3). Their herd is mainly grazed at Al-Hatmia, Al-Majdia, Muaqer and Mhareb villages. All respondents agree that the terms of access for such land is to pay to can use the land. Al-Hatmia village the main region uses for grazing un-harvested barley, Al-Majdia uses for grazing barley residues and Muaqer for green barley. The herd moves a distance ranged between 2.7 and 8.5 Km and spent about 1-2 months in fields. Transport cost is zero because the moved distance by the herd is small.

Table (25): Main sources of grazing the herd

Item	Sources of grazing		
	Green barley	**Un-harvested barley**	**Barley residues**
Name of village	Al-Majdia (n=1) Al-Hatmia (n=1) Muaqer (n=2)	Mhareb (n=3) Al-Majdia (n=4) Al-Hatmia (n=14) Al-Mattaba (n=1)	Al-Majdia (n=2) Al-Falej (n=1)
Average distance from village (Km)	8.5	2.7	3.0
Transport cost (JD/head)	None	None	None
Terms of access/rent cost	to pay to can use the field	to pay to can use the field	to pay to can use the field
Duration spent in rangeland (days)	52.5	39	30
Problems	- Poor pastures - Drought	- Water shortage for livestock	----

The majority of respondents stated that the pastures in their communities are in a bad status. Table (26) shows the main results of grazing in village rangeland. Reasons behind unavailability of mechanism to manage community pastures are varied. About (62.5%) of respondents attributed the absence of such mechanism to poor pastures and plant cover, followed by drought, absence the role of institutions, and unavailability of cooperation.

Table (26): Reasons for unavailability of mechanism to manage pastures

The Reasons	Frequency	Percent
Poor pasture and plant cover	25	62.5
No institutions to implement management pasture mechanism	1	2.5
Poor of cooperation among farmers to finding a mechanism	1	2.5
Drought prevented any mechanism	12	30.0
No public pasture lands over there	1	2.5
Total	40	100.0

3.2 Management of Village Pastures

Table (27) shows that half of respondents stated that village pastures not need any management procedures. However, (32.5%) believed that they can manage village pastures. Also half of the respondents proposed that the terms required for managing village pastures is to allocate a specific area for each family. All respondents agreed that they are not seized community pastures and also there are no conflicts or problems among inhabitants relevant to community pastures, while the other half propose to manage village pasture by the government. Village pastures utilize for 3.2, 2.5, and 0.7 months in good, middle, and bad years, respectively. Local institutions have no role in village pastures management.

Table (27): Management of village pastures

Management of community pastures	**Frequency**	**Percent**
Did you expect that you can manage pastures in your community?(n=40)		
Yes	13	32.5
No	7	17.5
Village pastures not need management	20	50.0
Terms you require to manage these pastures (n=8)		
Specific area for each family	4	50.0
The governmental organizations would Manage pastures	4	50.0
Are farmers seized pastures and allocate for themselves?(n=40)		
Yes	3	7.5
No	37	92.5
Are there conflicts and problems on pastures in your community? (n=40)		
Yes	5	12.5
No	35	87.5
Are neighboring communities grazed in the community pastures? (n=40)		
Yes	13	32.5
No	27	67.5
Are there arrangements between your community and neighboring (n=40)		
Yes	2	5
No	38	95
Average period (in months) you expend in village pastures in good years	3.2	
Average period (in months) you expend in village pastures in middle years	2.5	
Average period (in months) you expend in village	0.70	

pastures in bad years		
Existence any role of institutions in village pastures management (n=40)		
No	40	100

3.3. Management of Other Pastures

Table (28) shows the main results of management in other pastures. About (71%) of respondents are not moving to other pastures. This means that they depend heavily on supplemental feed taking into consideration the bad status of community pastures. The respondents referred only to Al-Faeyz Tribe that has the responsibility on some pastures. Most of livestock owners (91%) move without his family. The majority of owners (82%) move in cooperation with other individuals. Procedures of using such pastures not clear, all interviewed owners not responded to this question. Local institutions have no role in management because they are not interested in grazing activities. All respondents stated that the pastures are deteriorated. Poor plant cover is the major problem encountered by farmers while using the pastures. Drought, absence of legislations, and overgrazing are the root reasons of pastures deterioration.

Table (28): Management of other pastures

Management of other pastures	**Frequency**	**Percent**
Moving to other pastures		
Yes	11	28.9
No	27	71.1
Name of pastures		
- In 2009: Al-Mattabah (n=1), Al azraq (n=1), Al kharana (n=2), Amrah palace (n=1), Mhareb (n=1), Al falej (n=1)		
- In 2010: Al mdesasat (n=2), Al mattabah (n=1), Amrah palace (n=1), Al kharana (n=4), Al azraq (n=1), Al falej (n=1), Al-Yateemah (n=1).		
Tribal name that has the responsibility (n=2)		
Al-Faeyz	2	100
Did you move with family members? (n=11)		
Yes	1	9.1
No	10	90.9
Did you move with other individuals from the same community? (n=11)		
Yes	9	81.8
No	2	18.2
Who arrange the transport or herd movement? (n=11)		

Herd owner	9	81.8
Shepherd	1	9.1
Herd owner and the shepherd	1	9.1
Are the local institutions have a role in the arrangement of these movements? (n=11)		
No	11	100
Reasons for institutions have no role in the arrangement of these movement (n=11)		
No interesting from local institutions in grazing activities	11	100
Period you spend in these pastures	Average= 5.1 months	
Status of pasture (n=11)		
Deteriorated	11	100
Well-managed	0	0
Reason you guess that make the pasture in this status (n=11)		
Drought	11	100
Problems encountered by farmers while using the pastures (n=11)		
Poor plant cover	11	100.0

3.4 Livestock and Grazing Resources

Table (29) shows that the stable method is among the three methods dominating (46%) of livestock raising. It is followed by semi-stable (36%) and mobile (18%).

Table (29): Method of livestock grazing

Methods	**Frequency**	**Percent**
Mobile	7	17.9
Semi- stable	14	35.9
Stable	18	46.2
Total	39	100.0

Table (30) shows that the average flock size was 377 heads; average sheep herd was 243 heads and constitutes (91%) of total flock while average goat herd was 32 heads constituting (9%) of total flock.

Table (30): Number of flock

Composition	Minimum	Maximum	Mean
Total flock	8	2900	377
Sheep	8	2800	243
Goats	3	100	32

The majority of farmers (94%) are using part or whole their fields for grazing livestock. Table (31) shows that barley and Alfa Alfa are the main grazed crops in farmers' fields with an average one month.

Table (31): Source of grazing livestock

Source	Average No. of livestock grazed in farmers field	Average No. of days	Average quantity of straw
Harvested Barley	59	34	0.83
Un- harvested Barley for grazing	207	39	---
Alfa Alfa	150	36	183

Small ruminants in Jordan depend mainly on rangeland and cereal stubble grazing as their major feed sources. However, farmers usually supply their sheep with barley grain and wheat bran as supplemental feed, but with insufficient quantities due to the high costs. Cereal straw is an important source for winter feeding. Table (32) shows that the main feed contents comprise barley grain, straw, and bran constituting 71%, 18.4%, and 6.3%, respectively. The total herd size for the survey livestock owners is 2900 head of sheep and goat. The total feed quantity for the whole sample is 1127.6 tons. This means that each head consumed 389 Kg/year, and 1.1 Kg/head/day. However, livestock owners are depend heavily on purchasing the needed quantities rather than on their own production. Using of supplemental feeds ranged between 8-12 months.

Table (32): Feed sources and quantities by the sample (total flock size is 2900 Heads)

Feed source	Total quantity (ton)	Percent	Average Price
purchased barley grain	820	70.84	180 JD/ton
Produced barley grain	5	0.44	180 JD/ton
Straw	209	18.42	120 JD/ton
Green barley	8	0.71	8 JD/du
Concentrated feed	6	0.54	340 JD/ton
Barely bran	2	0.18	200 JD/ton
Barley residues	6	0.55	5 JD/du
Wheat bran	66	6.10	200 JD/ton
Pasture	2	0.19	---
Dry bread	3.6	0.34	100 JD/ton
Total	1127.6	100	---

Consumption of feed is decreased dramatically from March, April and May. Table (33) summarizes procedures of livestock owners in case of an increasing in feed prices, two-third of livestock owners sale part of their flocks, (16.7%) cultivate barley, and the rest (4.2%) reduced quantity of feeds.

Table (33): Procedures of livestock owners in case of an increase feed prices

Procedures	No. of farmers	%
Barely Cultivation	4	16.7
Sale of the flock	16	66.7
Reduced quantity of daily feeds	1	16.7

3.5. Water sources for livestock

Table 34 showed that 54% of farmers has mentioned that water is not available at pasture land for livestock watering the major source of water for livestock watering is water collecting pools as indicated by 42% of farmers and 21% of farmers use Artesian wells as other source of livestock watering (table 35)

Table (34): Availability of water sources in pasture

Availability of water sources	No. of farmers	%
Yes	19	46.3
No	22	53.7
Total	41	100.0

Table (35): Type of water sources available in pastures

Water sources	No. of farmers	%
Artesian water well	4	21.1
Water Collecting well	8	42.1
Water collection pit	3	15.8
Water Tanks	3	15.7
Valley	1	5.3
Total	19	100.0

4. Water harvesting

4.1. Farmers perceptions of water harvesting:

Table (36) showed that around 94% of farmers have indicated that they heard about water harvesting , there are different sources of their knowledge , the main source are from the different projects worked at communities area as indicated by 60% of farmers and around 36% of farmers have heard about water harvesting form other farmers (Table 37).

Table (36): Farmer's knowledge about water harvesting

Farmer ever heard about water harvesting	No. of farmers	%
Yes	45	93.8
No	3	6.3

Table (37): Information source about water harvesting

Information source	No. of farmers	%
Field days	2	4.4
Projects	27	60.0
farmers	16	35.6
Total	45	100.0

Results of the survey showed that 69% of farmers do implement one of the different types of water harvesting techniques at their lands (table 38) , it also showed that the different techniques implemented are water collecting pools (44%) and water collecting ponds (44%), in addition to soil dams(37%) as shown in table 39.the average area implemented with water harvesting techniques at farmers' fields estimated at 73 dunums and farmers do have a good experience with dealing with such techniques as they had indicated that in average their experience is estimated at 11 years. (Tables 40, 41)

Table (38): Implementing water harvesting

Implementing water harvesting	No. of farmers	%
Yes	33	68.8
No	15	31.3

Table (39): Water harvesting techniques that farmers implemented

implemented technique	Responses		Percent of Cases
	N	Percent	
Water collecting Wells	18	43.9	52.9
Soil dams	15	36.6	44.1
Vallerani water harvesting	5	12.2	14.7
Technique	2	4.9	5.9
Artesian water wells	1	2.4	2.9
Water collecting pond	18	43.9	52.9
Total	41	100.0	120.6

Table (40): The area implemented by harvesting techniques (du)

Item	Minimum	Maximum	Mean
The area(du)	4	400	73.23

Table (41): Farmers experience in applying water harvesting techniques (year)

Item	Minimum	Maximum	Mean
The experience (year)	1	43	10.79

The farmers reasons for not implementing water harvesting techniques at their lands was due to capital shortage as indicated by 63% of them and also due to the lake of knowledge about such techniques (table 42).

Table (42): Reasons for not using water harvesting techniques

The reasons	No. of farmers	%
Doesn't know about water harvesting techniques	3	13.6
Capital shortage	14	63.6
No experience	2	9.1
doesn't care	1	4.5
multi-ownership land	1	4.5
injustice when there implement of development projects	1	4.5
Total	22	100.0

4.2. Farmers' awareness to different kinds of water harvesting techniques.

Farmers are aware to the different types of water harvesting techniques , 34% of them have an ancient collective well and around 13% have a collective pond , it was also noticed that there are no water springs presented at communities area(table 43) ,

Table (43): Farmer awareness to the different types of water harvesting techniques

Type of water harvesting techniques	Yes		No	
	N	%	N	%
Own ancient collective well	16	34	31	66
Own a collective pond	6	12.8	41	87.2
Own an artesian well	3	6.4	44	93.6
The existence of water springs in the village	0	0	47	100

Around 56% of farmers expressed about their desire to have an cooperative to manage community grazing lands (table 44) , however 52% of them indicated that pastures are very degraded and limited at communities area (table 45). The main source of water for irrigation at communities' area is from rainfall (62%) and from collecting wells (13%) as shown in table 46.

Table (44): Farmers interest to participate in a cooperative to manage village grazing land

Farmer interest to participate in cooperative	No. of farmers	%
Yes	27	56
No	21	44

Table (45): Farmer's reasons for not participating in a cooperative to manage village grazing land

The reasons	No. of farmers	%
Have no interest	4	19.0
no pastures	11	52.4
live far from the village	1	4.8
have a job , no time	1	4.8
avoid problems with close relationship	3	14.3
Don't have livestock	1	4.8
Total	21	100.0

Table (46): Irrigation sources at communities' area

Irrigation source	Responses		Percent of Cases
	N	Percent	
Rainfall	33	62.3	70.2
Artesian well	7	13.2	14.9
water Collecting well	6	11.3	12.8
Water authority	7	13.2	14.9
Total	53	100.0	112.8

4.3. Land improvement practices

Farmers in the surveyed sample as indicated with a percent of 51 % that they do implement land improvements practices at their fields (table 47) , around 79% of farmers do the improvements to one of the plots that they do own (table 48) and it is done with the help of farmer himself (42%) and with the help of NCARE and other projects (29) as shown in table 49. The amount of money they had obtained through the different sources to do these improvements estimated on average with 448(JD), the improvements included terraces (38%) and rock and stones removal (29%) in addition to other types of improvements as shown in table (51).

Table (47): Number of farmers implementing land improvement works on land

Item	No. of farmers	%
Yes	24	51.1
No	23	48.9
Total	47	100.0

Table (48): Number of plot that the farmers do land improvement on it

Number of plots	**No. of farmers**	**%**
One plot	19	79.2
Tow plots	3	12.5
Three plots	1	4.2
Four plots	1	4.2
Total	24	100.0

Table (49): Who helped farmers to adopt land improvement?

Item	**No. of farmers**	**%**
No one	10	41.7
Canadian project	7	29.2
NCARE	7	29.2
Total	24	100.0

Table (50): Amount of money that farmers obtained for improvements their land (JD)

Item	**Minimum**	**Maximum**	**Mean**
JD	70	1200	448.57

Table (51): The improvements that applied on land

Plot number	**Plot 1**				**Plot2**				**Plot3**				**Plot4**			
Land area (du) (average)	63.83				84.67				142				90			
Response	Yes		No		Yes		No		Yes		No		Yes		No	
Land Improvements	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Improve field fertility by adding Manure	3	12.5	21	87.5			5	100			2	100			1	100
Protection from water and wind erosion	5	20.8	19	79.2	1	20	4	80	1	50	1	50			1	100
Stones and rocks removal	7	29.2	17	70.8	2	40	3	60	1	50	1	50	1	100		

Water passages	1	4.2	23	95.8			5	100			2	100			1	100
Collecting pools	12	50	12	50	1	20	4	80	1	50	1	50	1	100		
Terraces	9	37.5	15	62.5	1	20	4	80			2	100			1	100
Planting tress As fences	1	4.2	23	95.8			5	100			2	100			1	100
Planting shrubs	3	12.5	21	87.5	3	60	2	40	2	100					1	100
Water collecting well	4	17.5	19	82.6			5	100			2	100			1	100
Concrete water reservoir	2	8.7	21	91.3			5	100			2	100			1	100

In the other hand and despite of the mentioned above improvement practices that farmers are doing at their land about 96% of farmers expressed about the need of their lands for such improvements (table52) and they had mentioned about the obstacles they do face in not cultivating and utilizing their whole area list as the capital shortage (71%) and the unfeasible production (11%) and water shortage (11%) as another main obstacles they do face as shown in table 53.

Table (52): Farmer's land that needs improvement practices and maintenance

The land needs	No. of farmers	%
Yes	45	95.7
No	2	4.3
Total	47	100.0

Table (53): Farmers reasons for not utilizing the whole land

The reasons	Responses		Percent of Cases
	N	Percent	
shortage of capital	32	71.1	78.0
Unfeasible production	5	11.1	12.2
don't care about land cultivation	1	2.2	2.4
Multi-ownership of land	1	2.2	2.4
problems in marketing	1	2.2	2.4
unavailable water	5	11.1	12.2
Total	45	100.0	109.8

4.4. Constraints of adopting water harvesting techniques :

Constraints for not adopting water harvesting techniques are related to capital shortage as indicated by 57% of farmers and the lake of knowledge (14%) on how to implement such techniques as another constraint (table 54).

Table (54): The obstacles and constraints for not adopting water harvesting techniques from farmer's point of view

The obstacles and constraints	No. of farmers	%
There is no rainfall	1	7.1
shortage of capital	8	57.1
require large area	1	7.1
Not accept the idea	1	7.1
Requires constant maintenance	1	7.1
no knowledge about it	2	14.3
Total	14	100.0

4.5. Participants of mechanized Vallerani water harvesting

Farmers participants in the mechanized Vallerani water harvesting has started implementing during 2004 through the project (table 55), most farmers interviewed at the surveyed sample has mentioned about their interest to be part of the project activities and have expressed about their interest in the in-kind contribution in implementing project activities (Table 56).

Table (55): Time of participation in applied of Vallerani water harvesting technology

The year	No. of farmers	%
2004	3	42.8
2005	2	28.6
2006	2	28.6
Total	7	100.0

Table (56): Number of farmers that have interest to participate in implementing Vallerani water harvesting at their lands

Item	No. of farmers	%
Yes	46	97.9
No	1	2.1
Total	47	100.0

Farmers interest to be part of project activities is related for their interest in cultivating of desert land and make it useful (50%) and for increasing the crop production (33%) and for providing pasture lands(17%) and as shown in table 57. The total area at communities' area covered with the mechanized Vallerani water harvesting estimated on average with 108 du. (table 58). The production option, that farmers followed in applying this technique included forage shrubs only (71%) and planting barley and shrubs (14%) as shown in table 59.

Table (57): The reasons of participation of Vallerani water harvesting technology

The reasons of participation	**Responses**		**Percent of Cases**
	N	**Percent**	
To provide permanent pasture lands	1	14.3	16.7
Cultivation of desert land and make it useful	3	42.9	50.0
To encourage and revive wildlife	1	14.3	16.7
Increase of crop production	2	28.6	33.3
Total	7	100.0	116.7

Table (58): The area covered by Mechanized Vallerani water harvesting (du)

Item	**Minimum**	**Maximum**	**Mean**
The area(du)	16	540	108.57

Table (59): Production options farmer adopt in applying with Mechanized Vallerani water harvesting (du)

The crops	**No. of farmers**	**%**
Forage Shrubs only	5	71.4
Forage Shrubs and barley	1	14.3
Barley only	1	14.3
Total	7	100.0

4.6. Benefits of applying Mechanized Vallerani water harvesting

The interviewed farmers participating in applying Mechanized Vallerani water harvesting have been assessed in terms of investigating the benefits of such a technique on their land it was noticed that 43 % of them have indicated it has a High level of improvement on their lands and 43 % of them has mentioned that it has a moderate level of improvement only 14% of farmers have mentioned that it has little level of improvements , which indicated here a good level of farmers satisfaction in implementing this technique at their land (table 60). Even farmer had indicated about their interest to rent the Vallerani machine and use it by themselves at their land if its available and the value they are willing to pay for renting it estimated at 2 (JD) per dunum (table 61)and had expressed about their willingness to expand using this machine in larger areas of their land.

Table (60): Assessment of the Mechanized Vallerani water harvesting compared to the land was before.

The assessment	No. of farmers	%
A little level of improvement	1	14.3
A moderate level of improvement	3	42.9
High level of improvement	3	42.9
Total	7	100.0

Table (61): Value farmers may pay to rent Mechanized Vallerani water harvesting (JD)/du

Item	Minimum	Maximum	Mean
Pay(JD)/du	1	5	1.79

5. Conclusions:

The survey results will assist in developing an integrated technical, policy and institutional options (TIPOs) for sustainable water management to facilitate the rural communities' role in conserving water and improving their livelihood, and develop policy and institutional framework for the implementation of appropriate water saving strategies that will conserve scarce water resources and promote the conservation of natural resources.

Data collected on current land property rights and current arrangements for the community-used rangelands in the Badia indicated that general village land is relatively the only source of grazing for an average of 42 days with no terms or conditions, without any procedures for resources and activity management. Three main sources for grazing the herd including: green barley, un-harvested barley and barley residues. The terms of access for such land are to pay to can use the land. The herd moves a distance ranged between 2.7 and 8.5 Km and spent about 1-2 months in fields. Transport cost is zero because the moved distance by the herd is small. The majority of respondents stated that the pastures in their communities are in a bad status. Reasons behind unavailability of mechanism to manage community pastures including: the absence of such mechanism to poor pastures and plant cover, drought, absence the role of institutions, and unavailability of cooperation.

Half of respondents stated that village pastures not need any management procedures. The other half of respondents proposed that the terms required for managing village pastures is to allocate a specific area for each family. All respondents agreed that they are not seized community pastures and also there are no conflicts or problems among inhabitants relevant to community pastures. Village pastures utilize for 3.2, 2.5, and 0.7 months in good, middle, and bad years, respectively. Local institutions have no role in village pastures management. Flocks of the majority of respondents are not moving to other pastures. This means that they depend heavily on supplemental feed taking into consideration the bad status of community pastures. The respondents referred only to Al-Faeyz Tribe that has the responsibility on some pastures. Procedures of using such pastures not clear, all interviewed owners not responded to this question. Local institutions have no role in management because they are not interested in grazing activities. All respondents stated that the pastures are deteriorated. Poor plant cover is the major problem encountered by farmers while using the pastures. Drought, absence of legislations, and overgrazing are the root reasons of pastures deterioration.

Three methods for livestock raising are used, stable method is dominated, followed by semi-stable and mobile. The average flock size was 377 heads; average sheep herd constitutes (91%) of total flock while average goat herd constitutes (9%) of total flock. The majority of farmers (94%) are using part or whole their fields for grazing livestock. Small ruminants in Jordan depend mainly on rangeland and cereal stubble grazing as their major feed sources. However, farmers usually supply their sheep with barley grain and wheat bran as supplemental feed, but with insufficient quantities due to the high costs. Cereal straw is an important source for winter feeding. The main feed contents comprise barley grain, straw, and bran constituting 71%, 18.4%, and 6.3%, respectively. The total herd size for the survey livestock owners is 2900 head of sheep and goat. The total feed quantity for the whole sample is 1127.6 tons. This means that each head consumed 389 Kg/year, and 1.1 Kg/head/day. However, livestock owners are depend heavily on purchasing the needed quantities rather than on their own production. Using of supplemental feeds ranged between 8-12 months.

Water harvesting is well known technology to farmers at communities area around 94% of farmers have indicated that they heard about water harvesting , main source of the knowledge is through different projects worked at communities area as indicated by 60% of farmers and around 36% of farmers have heard about water harvesting form other farmers .

The farmers reasons for not implementing water harvesting techniques at their lands was due to capital shortage as indicated by 63% of them and also due to the lake of knowledge about such techniques.

Constraints for not adopting water harvesting techniques are related to capital shortage as indicated by 57% of farmers and the lake of knowledge (14%) on how to implement such techniques and the high cost of establishing water harvesting.

Farmers have strong interest to be part of project activities as its very useful for cultivating desert land and make it useful (50%) and for increasing the crop production (33%) and for providing pasture lands(17%) .

The total area at communities area covered with the mechanized Vallerani water harvesting estimated on average with 108 du. The production option that farmers followed in applying this technique included forage shrubs only(71%) and planting barley and shrubs(14%) as shown in table 59.

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II. PLAN OF WORK

Component 1: Interventions, Out scaling & Dissemination: Technologies development and fine tuning of water harvesting (WH),

Water Harvesting and Mechanization activities

Activity 1: Introducing mechanized establishment of forage shrubs from seeds inside the WH micro-catchments. (2 sites)

Objectives:

- Optimize the soil hydro-physical conditions that are suitable for germination and emergence of forage shrubs' seeds at the nursery, and enhance further growth of seedlings in the field.
- Test new potential seedbed preparation and seed placement techniques that can create favorable soil and water conditions in the seedbed zone and that provide easy operation of the seeder.
- Mechanize the direct seeding of forage shrubs inside the WH structures by developing or modifying special seeder to do this job.

Methodology:

Stage 1: On this stage a nursery experiment (to be designed and agreed with the vegetation team) will be carried out (February – May 2011 and 2012) to study and investigate the growth behavior of some selected species of fodder shrubs under open nursery conditions to a specified age under different seeding soil mediums, different pot sizes and different watering regimes.

Different seeding mediums (as the experiment's treatments) could be peat moss (P), clayey soil (C), sandy soil (S), native soil brought from the Badia watersheds (N), manure (M) and combinations of one or more of mentioned mediums, for example, N+P, C+S+M, or any other combination.

Depending on the results obtained from this experiment, the best two or three mediums that guarantee good water holding capacity, rapid germination and low emergence resistance, will be selected for field trials of establishing forage shrubs from seed inside WH structures.

The parameters to be assessed are:

- Number of days before first emergence and before 50% of seeds have emerged

- Emergence percentage through emergence count on a daily basis
- Medium emergence resistance (Penetration force), once at different moisture contents.
- Medium moisture content under wetting and drying (daily), and medium water holding capacity (once)
- Shoot's length, roots' length and roots' surface area (once after specified age of seedling)

Stage two: (**November 2011 – September 2013**):

On this stage, forage shrubs establishment trials will be carried out in two watersheds of the project area, where the shrub seeds will be mixed with the selected mediums (from stage 1) and the seed-medium mixture will be manually laid inside the WH micro-catchments in a narrow strip, width of which represents the best pot size that showed best results in the experiment of stage1. The parameters to be assessed over two seasons are:

- Survival percentage of fodder shrubs will be recorded monthly over two years
- Browse productivity per shrub will be estimated by the reference unit technique each year on May.

Stage 3: (April 2012 – September 2013) in this stage:

- A traditional seeder will be modified to perform the mechanized direct seeding inside WH micro-catchments (April – December 2012). The seeder should be able to open soil and place the seed-medium mixture at the proper depth and rate. The mechanical works and fabrication process will be carried out at the UOJ workshop.
- Field mechanized trials of shrubs establishment will be carried out and monitored through the rain and dry seasons (December 2012 - September 2013) in one project site.

Sites Selection & Baseline Data Collection:

For manual and mechanized trials, a field of 1 ha area and of soil depth exceeding 0.8 m will be selected in two Benchmark project watersheds, where the slope ranges between 3 and 7 %. Spacing between contour furrow/ridges will be 8 m.

The amount of rainfall for each rain event during the rainy seasons will be collected. Particle size analysis to determine the soil texture for the soil of the experimental fields will be made. The soil structure and vegetation cover (on March to April) will be also described.

Milestones:

- May 2011: Nursery experiment is finished. The best two soil mediums that will be used in direct seeding of forage shrubs in the Badia were selected.
- November 2011: The fields for manual direct seeding trials are selected, prepared and WH furrow/ridges are opened, and baseline data are collected.
- April 2012: The primary results of the field trials are worked out and the seeder modification have started.
- December 2012: The modifications on the seeder are finished and the fields with WH structures are ready to carry out the mechanized direct seeding trials.
- September 2013: Two-year final result of the manual trials, and one-year results of the mechanized trials are ready.
- May every year: Annual report is ready.

Activity 2: Developing the mechanized transplanting of forage shrubs inside the furrow/ridge WH micro-catchments using 1-2 months old seedlings. (2sites)

Objectives:

- Develop a specialized transplanter unit (modify a traditional one) that is able to work inside the WH structures.
- Test the new transplanter, and on-field evaluate and compare the mechanized technique (MT) of planting forage shrubs inside the WH micro-structures versus the traditional technique (TT) by assessing survival percentages, browse productivities, and machine field capacities.

Methodology:

The activity will be divided into two stages:

First stage is the design and fabrication/re-machining of some mechanisms and components of the transplanter that need modification, followed by tuning trials to guarantee proper function of the transplanter unit either separately or integrated with a plow. This stage should be finished before the rainy season of 2011/2012. The fabrication can be performed either at the workshop in the Faculty of Agriculture (UOJ) or contracted with a workshop at local market.

Second stage includes the evaluation of the new mechanized transplanting technique and comparing it with the traditional one by carrying out a field experiment (or trial). In this experiment, of at least two different forage shrubs species, will be established from seedlings using the two techniques (as the main experiment treatments) in the 2011/2012 season (and monitored over two seasons) in two watersheds of Benchmark project. The experimental design and plantation variables will be agreed and arranged with the vegetation work subgroup.

Sites Selection:

A field of 1 ha of even distributed natural vegetation cover, and of soil depth exceeding 0.8 m will be selected in two Benchmark project watersheds, where the slope ranges between 3 and 7 %. Spacing between contour furrow/ridges will be 8 m.

Baseline Data:

The amount of rainfall for each rain event during the rainy seasons will be collected. Particle size analysis to determine the soil texture for the soil of the experimental fields will be made. The soil structure and vegetation cover (on March to April) will be also described.

Measurements and Assessments:

- Survival Percentage of fodder shrubs will be recorded monthly over two years
- Browse productivity per shrub will be estimated by the reference unit technique each year on May.
- Machine capacity, effective field capacity and field efficiency will be calculated by measuring actual time spent, speeds and area covered while performing each of the two techniques.

Milestones:

- Before the beginning of the 2011/2012 rainy season:
  - ✓ The transplanter unit is modified, tested and ready for work (end of October 2011), and
  - ✓ WH structures opened and planted, and baseline data collected (End of November 2011).
- By June of each year, all measurements are tabled, evaluated, analyzed and reported.
- By the end of the project, the experiment results and outputs are published.

Activity 3: Introducing and testing two new mechanized micro-catchment opening and plant establishment techniques (1 site)

Objectives:

- To study and evaluate two new WH and cultivation techniques which are the Double Furrow (DF) and the Wide Furrow (WF) with baked transplanting area, and compare them with the Vallerani furrow (VF) opening technique upon their impact on soil physical conditions inside the micro-catchment and on successful establishment and production of plants there.
- To develop appropriate and affordable machinery (ploughs) that can perform these new techniques.

Methodology:

The activity will be performed in two stages:

First stage is the design and fabrication of a special furrow opener (plough) that can open the two new suggested micro-catchments (DF and WF). This stage should be started and finished before the rainy season of 2010/2011. The fabrication of the plough can be performed either at the workshop in the Faculty of Agriculture (University of Jordan, UOJ) or contracted with a local workshop.

The second stage is carrying out a field experiment. This experiment will be designed and carried out over three years starting from 2010/2011 season, where the three mechanized contour furrow/ridge techniques (the new DF and WF, and the Vallerani one VF) will be the main treatments and four different plantation arrangements will be the variables to be investigated. These plantation arrangements (agreed and arranged with the vegetation subgroup) are:

- No plants are planted inside the micro-catchment (C),
- Planting forage shrub alone (Atriplex or similar shrub) (S) ,
- Seeding Barley alone (B), and
- Intercropping forage shrub and Barley (SB).

The slope and spacing between contour furrow/ridges will be identical for all treatments.

Site selection:

A field of 0.6 ha of even distributed natural vegetation cover and of soil depth exceeding 0.8 m will be selected in one of the Benchmark project watersheds, where the slope ranges between 3 and 7 %. Spacing between contour furrow/ridges will be 8 m. The field is preferred to be sited close to a weather station.

Baseline Data:

The amount of rainfall for each rain event during the rainy seasons will be collected. Particle size analysis for the soil of the experimental field, the water tension at field capacity (FC) and permanent wilting point (PWP), and soil bulk density for every 20 cm layer of the soil profile will be determined.

Measurements and Assessments:

Moisture content: for the surface soil in the seed zone (core method) and in the soil profile layers (TDR) at different points (every 20 cm vertically and 20 cm horizontally). Measurements will extend 80 cm from each side of the midpoint of the micro-catchments and down to a depth of 80 cm. Monitoring will be made each year every one month after the rainy season, starting from March through the dry season until October.

Thickness of the silt deposit (scaled wooden sticks method): in the bottom of the furrow micro-catchments of all plots, and in the raised bed of DF technique.

Plant productivity: Once every year for both the forage shrub and Barley (by the end of April).

Depth of stored and available water in the soil profile will be calculated using moisture content measurements.

Seasonal WH efficiency will be evaluated using the calculations of depths of stored water.

All measurements will be assessed at least for two years over two seasons.

Milestones:

- Before the beginning of the 2010/2011 rainy season:
- ✓ The furrow opener for DF and WF techniques should be fabricated, tested and ready for work (end of October 2010), and
- ✓ Planted WH structures (with all measurement instrument installed and all baseline data collected) are ready (End of November 2010).
- By November of each year, all measurement data for the three years are tabled, evaluated, analyzed and reported.
- By the end of the project, results and outputs are journal published.

Activity 4: Refinement of Laser Guiding System (LGS) used with the contour WH micro-catchment opening.

Objectives:

- The objective of this activity is to ease and improve the operation of LGS. Firstly, less time will be spent by the tractor driver on the LGS monitoring and more time to concentrate, while driving, on the furrow opening and on monitoring the operation of other tractor systems. Secondly, less time and effort will be spent by the LGS operator on transmitter relocation inside the worked field. With one location of the transmitter, the receiver will be able to cover more area and work more contour furrows.

Methodology:

The improvements on the LGS consist of:

- Replacing the old receiver with new longer one which allows the enlargement of the interception range of the signal sent by the transmitter.
- The elevation mast of the receiver will be excluded from the system.
- The multi-grade transmitter can be replaced with a cheaper single-grade one (Optional).

Starting from June 2010, the improvements of the system should be first discussed and approved with the LGS manufacturer or supplier (before September 2010), ordered and installed, then tested and evaluated in the field. Expected date of completion is March 2011.

All installation works and brackets fabrication will be done at the UOJ workshop. The materials and tools needed for fabrication and installation will be available at the workshop

Activity 5: Cisterns improvement and maintenance + new cisterns

Objectives:

- To assess the impact of traditional and project assisted flood diversion practices for crop production in the semi-arid (agro-pastoral) area of al Badia benchmark.
- To suggest alternative and economically viable methods of surface water harvesting for domestic uses and livestock.

- Improve the performance efficiency of the cisterns in terms of storage capacity, and water quality
- Develop an integrated plan to attain sustainability

Methodology:

- Community water-harvesting practices for crop production, domestic use, stock watering and associated impacts will be reviewed using the available literature and personal observations and/or experiences in the Badia agro-pastoral area. ICARDA water harvesting experiences, study reports of practical studies and other similar studies in the area will be utilised to compile this study. Local people will also be consulted during various occasions (during repeated project site visits, field days, etc.).
- Rehabilitation plan for each cistern will be prepared, including lining, sedimentation tanks, routing canals, sedimentation traps, and cisterns doors as well as pumps installation when necessary…etc.
- Monitoring plans for all 18 Cisterns will be conducted.
- Water quality parameters (Turbidity, TDS, PH,...) will be tested

Data needed:

The rainfall events, as well as the catchment area for each cistern will be measured. Storage capacity of the implemented structures will be analyzed. Besides, field visits will be made. Sedimentation rates are also a dominant factor for this activity.

However, we are seeking to produce maps identifying the sites of all existing cisterns in the targeted area. Those maps shall be very helpful for any future development plans.

Milestones:

End of each year an annual report is to be delivered.

Activity 6: Fine tuning of field layout and arrangement of intermittent and continuous contour ridges developed in phase 1 (2 sites).

Objectives:

- To test Barley cultivation under 2 water harvesting techniques as compared to conventional cultivation.
- Test different layout arrangements for contour earth ridges (intermittent and continuous).
- Evaluate water harvesting techniques in terms of production per unit area.

Methodology:

Two experiments will be conducted for this purpose. One experiment is already established at Majideyya with 13 treatments that will be revived. The second experiment will involve only Barley treatments implemented in Majideyya experiment but located in Mhareb.

The Majideyya experiment will be as follows:

- T1: (NV) - Native vegetation, land resting with protection.
- T2 : (NVCR) - Native vegetation under contour ridges.
- T3: (BT50) - Traditional cultivation of Barley, 40 kg/ha.
- T4: (BT100) - Traditional cultivation of Barley, 80 kg/ha.
- T5: (BCR50) - Barley in modified contour ridges, 40 kg/ha.
- T6: (BCR100) - Barley in modified contour ridges, 80 kg/ha.
- T7: (BCS50) – Barley (seeding rate of 40kg/ha) in contour strips of 2:1 catchment to cultivated area ratio.
- T8: (BCS100) - Barley (seeding rate of 80kg/ha) in contour strips of 2:1 catchment to cultivated area ratio.
- T9: (D2L1FS) – Fodder shrubs planted in Vallerani pits size 2 with 5 lines of pits followed by a continuous contour ridge.
- T10: (D2L2FS) – Fodder shrubs planted in Vallerani pits size 2 with 10 lines of pits followed by a continuous contour ridge.
- T11: (D4L1FS) – Fodder shrubs planted in Vallerani pits size 4 with 5 lines followed by a continuous contour ridge.
- T12: (D4L2FS) – Fodder shrubs planted in Vallerani pits size 4 with 10 lines followed by a continuous contour ridge.

- T13: (FS800) - Fodder shrubs under continuous contour ridges.

The Mhareb experiment will be as follows:

- T1: (BT50) - Traditional cultivation of Barley, 40 kg/ha.
- T2: (BT100) - Traditional cultivation of Barley, 80 kg/ha.
- T3: (BCR50) - Barley in modified contour ridges, 40 kg/ha.
- T4: (BCR100) - Barley in modified contour ridges, 80 kg/ha.
- T5: (BCS50) – Barley (seeding rate of 40kg/ha) in contour strips of 2:1 catchment to cultivated area ratio.
- T6: (BCS100) - Barley (seeding rate of 80kg/ha) in contour strips of 2:1 catchment to cultivated area ratio.

Data Required:

Soil moisture content for 0-20cm, 20-40cm and 40-60cm depth intervals for all plots in the cultivated area only and in the control (land resting plot) at a rate once every 10 days. Gravimetric soil samples using a suitable auger will be used.

Soil bulk density for the 3 depth intervals using undisturbed core samples

Biomass production from each treatment

Rainfall data

Milestones:

- Preparing a suitable site in Mhareb with an area of 8 ha. (August 2010).
- Experiment layout in the field finished (August 2010).
- Planting the experiment sites (November 2010).
- Data collection (continuous over period).
- Reports.

Activity 7: Check dams: Earth check dams (2 sites)

Objectives:

- To demonstrate the use earth check dams together with a suitable land use in participation with the local community.
- To rehabilitate some of the existing check dams and make them functional again.

Methodology:

- The selection of one site in Mhareb and one site in Majideyya with an area not exceeding 15 hectare per each site.
- Prepare a topographic map for each site.
- Determine the locations and dimensions of existing check dams within the site (if found).
- Plan the site with earth check dams designed to suit the planned land use.
- Implement the check dams and start using the land.

Data Required:

- Topographic map with 0.5 meter interval.
- Soil wetted depth behind the check dams measured as depth in centimeters after each runoff event.

Milestones:

- The 2 sites for check dams selected with the agreement of the local communities (October 2012).
- The topographic map for both sites prepared (May 2012).
- Check dams planned and designed in both sites (August 2012).
- Check dams construction and/or rehabilitation finished (October 2012).
- Land use for the 2 sites agreed on by the related community members (November 2012).
- First season report ready (June 2012).
- Second year report ready (June 2013).

Activity 8: Water harvesting and conservation effects on Pistachio and Almond in the JUST site

Objective:

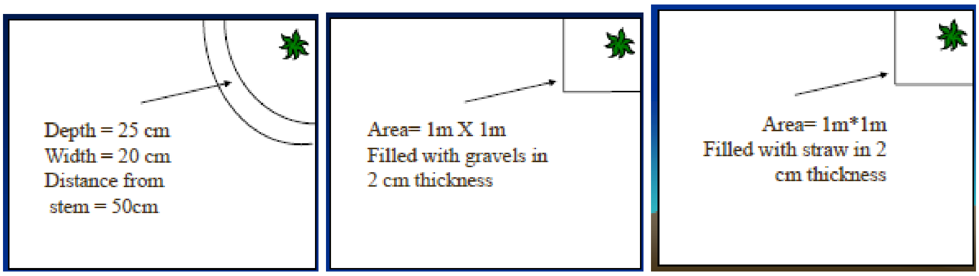
- Implement new research activities aiming to increase the efficiency of water availability to the plants and reducing evaporation.

Methodology:

An experiment will be conducted with the following treatments:

- Treatment 1: Use of local gravels to be spread over the area around the tree species. (Horizontal and Vertical)
- Treatment 2: Use of the plants straw to cover the soil in order to reduce the evaporation around the plant species
- Control Treatment.

TDR tubes will be removed and cleaned then reinstalled all over the experimental catchments and measurements will be taken



A1: VERTICLE GRAVEL COVERAGE

Depth = 25 cm

Width = 20 cm

Distance from stem = 50cm

A2: HORIZANTAL GRAVEL COVERAGE

Area= 1m X 1m

Filled with gravels in

2 cm thickness

A3: HORIZINTAL STRAW COVERAGE

Area= 1m*1m

Filled with straw in 2 cm thickness

A4: CONTROL – NO TREATEMENTS.

Activity 9: Water harvesting and conservation effects on Olive trees in the JUST site

Objective:

- Implement new research activities aiming to increase the efficiency of water availability to the plants and reducing evaporation.

Methodology:

- An experiment will be conducted with the following mulching treatments:
- Straw
- B- Olive Pomace (olive cakes)
- C- Volcanic Tuff.

Data collection: Soil moisture (TDR), plant growth and development, soil nutrients, Organic matter, EC, pH, Phenolic compounds, leave samples

Activity 10: Design of Marabs and water spreading

Objective:

- To demonstrate the use of marabs for Barley production using properly designed water spreading structures.

Methodology:

- Selection of the marabs.
- Preparation of a topographic map with an interval of 0.2 meter for each site.
- Design and planning of the structures in the field.
- Construction of the water spreading structures.
- Land preparation and seeding with Barley–Vetch mixture.

Data Required:

- Biomass production per unit area from the treated area as well as from outside the treated area for comparison.
- Rainfall data.

Milestones:

- Selection of one marab in Mhareb and one marab in Al-Majideyya with an area of not less than 10 hectares for each site and agreed on by the related community members (August 2010).
- Preparation of a topographic map for each site with a 0.2 meter interval finished (October 2010).
- Planning and designing of suitable water spreading structures finished for the selected sites (December 2010).
- Implementation of the water spreading structures finished (June 2011).
- Plantation of sites with Barley-Vetch mixture (November 2011).
- Reporting (July 2012 and July 2013).

Activity 11: Test of adapted promising barley genotypes and fertilizer combinations under Marab conditions.

Objectives:

- Improvement of barley production under Marab conditions through the selection of adapted genotypes.

Methodology:

Treatments:

- Five barley genotypes
- Nitrogen and phosphorus fertilizers rate:
  - ✓ F0: No fertilizer application;
  - ✓ Fn: 50 Kg N/ha only

The treatments will be arranged in a split plot design with Fertilzer as main plot and genotype as a split plot. Each treatment will be replicated 3 times.

Data Collection:

- Date of planting, date to heading: From 50% germination to 50% heading, date to maturity: From 50% germination to 50% maturity, plant height, number of tillers, grain yield: Fresh and dry weights (g/m^2) and heading and ma^{t}urity.

Activity 12: Diversification of cropping systems through planting barley and vetch mixtures.

Objective:

- Identify the best combination of intercropping systems

Methodology:

Treatments:

- Barley
- Barley/ vetch 1: 1
- Barley/ vetch 1: 2
- Barley/ vetch 1: 3

Activity 13: Storage dams

Objectives:

- Construct a storage dam of limited water capacity as a water source for different uses in the Badia.
- Disseminate the idea of alternative water sources to improve the productivity of Badia.

Methodology:

- Study the selected watershed (the Badia Benchmark site) and all adequate sub-watersheds within it with the help of the hydrological study that was done during phase
- Select a suitable site that can provide the planned dam with the desired storage capacity.
- Preparation of a topographic map for the location of the dam and surrounding area, with a 0.5 meter interval.
- Survey the land properties in the vicinity of the dam and the corresponding land uses.
- Discuss with the local community members the best utilization of the stored water.
- Organize a committee from the local community to manage the water use of the storage dam.
- Start the design of the dam with all the required details for construction.
- Implementation of the dam and associated facilities (i.e. spillway, entrance, outlet).

Data Required:

- Types of water uses and the corresponding volumes of water required.
- The period of time during which the dam should supply water.
- The distribution of water demand along the time period required.

Milestones:

- Selection of dam site finished (March 2011).
- Topographic map for the dam location prepared (May 2012).
- Water utilization plan finished (May 2012).
- Water management committee formed and trained (April 2012).

- Design of dam completed (June 2012).
- Construction of dam finished (September 2012).

Rangeland Rehabilitation and Management activities

Activity 1: Introducing New Fodder Shrubs

Objectives:

- To demonstrate to the community the benefits of water harvesting for improving forage resources in the Badia.
- To implement the awareness-extension activities especially for local community.
- To improve livestock production and associated grazing practices in the Badia.
- To evaluate the effect of WHT on the native vegetation regeneration and improvement.
- To multiply and reintroduce the shrubs species collected from the rangelands.

Methodology:

Seed collection (shrubs)

- Seeds will be collected from the available fodder shrubs at the site.
- Or seed from other sources (NCARE, ICARDA, especially new species to be introduced in this phase of the project).
- Seeds will be reintroduced within the WHT.

Shrubs plantation

Seedlings of Atriplex, Haloxylon, etc. will be planted on December 2010-January 2011 in the micro-catchments. Shrubs will be spaced at 2m within the different types of WHT.

Data to be collected (new and old sites)

- Survival: will be recorded on three sampling dates (one month after plantation, at the end of growing season usually in June, and in October).
- Biomass: The reference unit technique will be used for biomass estimation

Milestones:

- Spring 2010: Seed collection of existing fodder shrubsReintroducing seeds inside the experiment site within WHT
- December2010-January 2011: planting of 1 to 2 months old fodder shrubs. These will be brought from a nursery or from other sources after agreement on species to be introduced.

Activity 2: Native vegetation study

Objectives:

- Vegetation classification and taxa of the study area (plant species)
- Vegetation mapping by integration of geographic Information System (GIS)
- Monitoring the changes of biodiversity during project period in the protected site.

Methodology:

- Preliminary surveys in May-June 2010 and in October-December 2010 for the documentation of natural vegetation cover in the area.
- Transect – quadrate method will be used.
- Botanical composition of each quadrate will be studied during the project period, considering the following data;
  - ✓ Cover percentage (visual estimation as percent of ground covered by plant canopy of the species), stone cover and root mat cover percentage will be estimated.
  - ✓ Total number of each species will be counted in each quadrate every season.
  - ✓ Plant Taxa will be identified fully to the species level according to the available flora references.
  - ✓ Plant height.
  - ✓ Diversity.
- Species frequency, abundance, density and relative density will be calculated.

This work will be repeated along the project duration and in each season; plant survey will take place from March-June and again in October in the old and new sites.

Milestones:

- Every spring from 2010 on: botanical survey inside the experiment site using quadrate methods
- After each survey: species list with richness, abundance, frequency, etc., will be prepared from inside and outside the interventions.
- Development in vegetation cover will be determined.

Activity 3: Estimation of Forage Production for grazing management (2 sites)

Objectives:

- Determination of grazing capacity / sustainable stocking rate.

Methodology (old and new sites):

- Number of shrubs will be selected for each species per treatment.
- Selected plants will be marked to collect the necessary measurements.
- Reference unit method will be used for shrubs biomass estimation.
- Random quadrates of native vegetation will be harvested for their biomass estimation.

Data to be collected

- Shrub height excluding inflorescence (cm).
- Shortest and longest canopy diameters (cm).
- Record the general shape of shrubs selected before and after grazing.
- Construct biomass prediction equations. (OR already established)

Milestones:

- March – May: Number of shrubs from the shrubs grown at the site will be selected randomly and marked for estimating the biomass production.
- June of each season: estimation of biomass production and rain use efficiency.

Activity 4: Collection and Reseeding of native plants

Objectives:

- To multiply and reintroduce the annual native species collected from the rangelands.
- Local community training and increasing awareness in seed collection and multiplying through awareness-extension activities.

Methodology:

Seed collection is the first step in native rehabilitation either by direct seeding or transplanting, as it's the source of the material to be used in such process. Seed collection should be given priority because seed production in desert species is erratic and seeds of a particular species are often unavailable from wild stocks when needed. Seeds will be collected from different sources:

- From native plants found in the site: seeds will be collected during the three stages of the project.
- From other sources: NCARE gene bank, ICARDA, others.

<u>Regenerating native vegetation cover by using WHT:</u>

- Direct seeding; in which the collected seeds will be directly broadcasted in the experimental site in all treatments to test the regenerating ability of the collected plant species by direct seeding.
- Transplanting; in which seeds first germinated in the greenhouse then seedlings will be transplanted to the experimental site and planted in all treatments to study the possibility of seeds collected from plant to grow by transplanting method under different WHT.

<u>Methodology for direct seeding:</u>

Seeds from native plants will be collected from the watershed area in different dates during the study. Taking into consideration the following;

- Collection from species within the plant community;

- The plant community looks healthy and clean and bearing enough seeds with large size, no signs for diseases, or unwanted colors or presence of insects;
- The collection made from the community by picking up seeds from plants at different locations within the community;
- Not more than 25% of the seeds to be collected from the left, right and the middle of the community;
- The communities will be chosen to be 100m apart, unless there is a very healthy community;
- Avoiding picking up from single plants without community even if it was good looking;
- Seeds from each species will be kept in separate paper bag and sent to the laboratory for cleaning; Seed bags will be kept in refrigerator at 4o C.

Number of seeds of each plant species will be planted randomly in plots. In each plot one species seeds will be seeded, the soil surface scratched to form a thin soil layer to cover the planted seeds.

<u>Data collected:</u>

Data will be collected every 2 weeks on germination date; germination percentage; and seedling length.

<u>Methodology for transplanting</u>

- Seeds collected will be germinated in a greenhouse.
- Seeds will be monitored for emergence date and percentages, and seedling length during their life cycle in the green house. Emergence dates, number of emerged seeds and the height of the plant seedlings when transferred to the field will be recorded.
- Emerged plants will be transferred to the experiment site on January to March. Where planting of one plant from each species in each of the sub treatments. Transplanted seedlings will be irrigated at the transplanting time. The plants will be monitored during the plant life cycle.

<u>Data collected:</u>

- The seedlings height; flowering and fruiting dates will be recorded.
- Seeds produced by each plant species will be harvested and counted.

Activity 5: Develop proper grazing management options and Grazing behavior of Small ruminants

Objectives:

- To investigate the rangeland (native vegetation) biodiversity.
- To promote equitable use of the rangelands.
- To investigate the plant preference among native vegetation of small ruminants as will as their behavior under the selected rangeland.

Methodology:

- Complete the range vegetation characterization: Definition of vegetation types and toponyms polygons; identify species with special use for animal or medicinal plants with specific conservation need and estimate carrying capacity for several rainfall events.
- Assessing stocking rates.
- Discuss with community possible management options with and without improvement: rotational grazing,
- Discuss with community alternatives of site grazing: mobility to cultivated zones (residual grazing) and other rangeland sites (noting that community have to be careful not contributing to overgrazing of others communities' land); parking and hand feeding; destocking; regulating (and not stopping) access of external flocks,
- Choice of one grazing management plan and identification of related regulations with community members and transhumants.
- Monitoring of the state of the resource, animal productivity and herder's income.
- animal behavior and plant preference will be investigated

Activity 6: Livestock integrated package

Objective:

- Integrate rangeland-livestock production by the sustainable management practices transfer.

Methodology:

- Flushing: supplying animal growers with barley, wheat bran, soybean, vitamins and alfalfa to be provided before mating.
- Synchronization using sponges with PMSG.
- Salt and mineral cubes.
- Vitamin AD3E.
- Health program (vaccination, internal and external parasites).

Component II: Watershed modeling, monitoring and management

Activity 3: Data collection (inside and outside watershed based on the indicators)

Objectives:

- Identify parameters based on the indicators and model inputs parameters (requirements)
- Review the available data and define the gaps
- Design tools for data collection
- Collect (gaps) and verify data and document the information into database

Methodology:

- Define the required parameters based on the selected parameters and the models requirements
- Collect secondary data and measured data
- Develop forms for data collection
- Standardize analysis methods and measurement procedures
- Enter and document data

Activity 4: Run the simulation model

- Verification: test the model outputs after calibration with independent data (stream flow, sediment /nutrients concentration or load) without adjusting model parameters
- Calibration: match model outputs with measured data with adjusting model parameters without destroying model structures i.e. change the parameters in the normal range of each parameter.

Activity 5: Evaluate scenarios (micro-level)

The purpose of the model is to simulate the process under the tested conditions and to be used to test various scenarios of land use and interventions to evaluate the impact on the study area. This will also enable the use of the model for other similar areas (activity 6).

Activity 6: Out scaling (macro level)

The activity will target the simulation of the impact of water harvesting technologies in other areas similar to the study area (Link with group 1 and 3).

Component III: Socio Economic Work-Plan

Activity 1: Assessment of the potential constraints for adoption of water harvesting technology in the Badia.

Objective:

- Identify constraints for widespread adoption of project technical interventions in the Badia agro-pastoral system

Methodology:

- Identify, using GIS and suitability maps, areas in the Badia, including Mhareb and Majdiah, suitable for water harvesting technologies.

- Conduct household survey to collect the relevant socio economic data associated with farmers' perceptions toward adoption of water harvesting technologies where suitable.
- Collect relevant data using a well-structured questioner to cover: farmers' characteristics, herd characteristics, resources, agricultural activities and information related to perception, knowledge and constraints to water harvesting technology.
- Run statistical analysis using exploratory data, descriptive statistics and econometrics.

Data to be collected:

The questionnaire will be designed to capture information about the following aspects:

Farmers' socioeconomic characteristics, type and amount of resources owned and used by the families, , livestock herd characteristics and management options of pastoral and feed resources, agricultural activities and other off-farm activities, resource characteristics and use strategies for farm, household and off-farm activities, type of water harvesting technology used, and other factors related to water harvesting technology adoptioninformation about the technical, institutional and policy factors relevant to technology adoption.

Milestones:

- Survey design and questionnaire development and pre-testing. July 2011.
- Socioeconomic survey: August-September 2011.
- Data entry: October 2011.
- Data Analysis: November 2011.
- Report writing: January-April 2012.

Activity 2: Assessment of the impacts of property rights on the adoption of water harvesting technology in the Badia.

Objective:

- Assess the extent to which current land tenure system, land property rights and their policy options for community-used rangeland are affecting adoption of technological options (water harvesting technologies, and rangeland management) and to improve the utilization and management of rangeland resource and conserve the natural resources.Identify alternative policy options to improve the utilization and management of rangeland resource.

Methodology:

- A literature review for current land property rights and arrangements for the community-used rangelands
- A community field survey will be prepared to collect information on both current land property rights in the Badia and arrangements for the community-used rangelands.
- A randomly selected household survey from each surveyed community will be conducted using structured questionnaire.

<u>Data to be collected</u>

Community characteristics including land and pasture resources, demography, livestock holdings, livelihood options, and land institutions, community access to grazing land and terms, rangeland management procedures and arrangements, basic household demographic characteristics, education, employment, wages and earnings, household economic activities and income, land property rights including holding system, how the holder got the land, who manage the land, and utilization from the land

Milestones:

- Survey design and questionnaire development and pretesting. July 2011.
- Socioeconomic survey: August-September 2011.
- Data entry: October 2011.
- Data Analysis: January 2011.
- Report writing: January-April 2012

Activity 3: Assessment of potential income generating activities for target Communities in the Badia

Objectives:

- Promote the understanding of local communities in Jordan Badia of the role the income generating activities for poverty reduction and development.
- Develop community action plans for adopting income generating activities

Methodology:

A survey will be prepared to collect needed information on rural income generating activities, data on household income from different sources. The survey also will measure the potential income generating activities to be implemented according to community's preferences and farmers' willingness to conduct such activities.

The sample size will be drawn according to the total number of households in the targeted area.

Meanwhile, personal interviews with selected stakeholders and representatives in the target communities will be arranged and carried out in the field. The data collection process will be carried out through visits to the sampled households where several members of the household may interview by enumerators.

Data to be collected:

- Patterns of rural income diversification, assets, activities and rural income generation, rural wage employment, urban agriculture, gender and rural employment, livestock and crop production

Milestones:

- Survey design and questionnaire development and pretesting. July 2011.
- Socioeconomic survey: August-September 2011.
- Data entry: October 2011.
- Data Analysis: 2012.
- Report writing: 2012.

B. SATELLITE SITE OF SYRIA

I. PROGRESS

Activity 1: The Vallerani Water Harvesting system

1. Introduction

The Syrian Arab Republic lies on the eastern coast of the Mediterranean Sea with rainfall rates more than 600 mm in the coastal region. Depending on annual rainfall rates, the country is divided into five agro-ecological zones:

- 1st agro-ecological zone: Rainfall rate varies from more than 350 mm to not less than 600 mm.
- 2nd agro-ecological zone: Rainfall rate varies from 250 – 300 mm to not less than 250 mm.
- 3rd agro-ecological zone: Rainfall rate is more than 250 mm and not less than 250 mm. Agro-ecological Zones in Syria
- 4th agro-ecological zone: Rainfall rate varies from 200 – 250 to not less than 200 mm.
- 5th agro-ecological zone: Rainfall rate is less than 150 mm.

The study area is classified under 5th agro-ecological zone which is cold in winter and temperature drops at most times to less than 0 ^{o}C and hot in summer at temperature more than 34 ^{o}C resulting in high evaporation. These conditions do not contribute to the development of stable agricultural production system.

About 85% of the area lies within the arid and semi-arid zones and is largely rangeland. The annual average rainfall ranges between 100 and 300 mm and is highly variable both within and across seasons. The population in region is poor and vulnerable to the effects and risks of seasonal changes in the harsh climatic conditions. Frequent droughts coupled with mismanagement of resources such as overgrazing contribute to rapid land degradation in these fragile ecosystems. This leads to loss of biodiversity of rangeland species and declining productivity, reducing the already low incomes of local communities and encouraging migration to urban areas. Degraded rangelands are more vulnerable to wind erosion leading to further degradation. The loss of vegetation over large areas reduces the carbon absorption rate, ultimately contributing to net increases in green house gas emissions and to global warming. Furthermore, the expansion of land degradation in the rangelands is, negatively, affecting the adjacent more productive lands and threatening their productivity.

Reversing the process of land degradation needs innovative, participatory community-based approaches and practices to better manage the natural resources (land and soil) and vegetative cover, and to halt degradation. These include using appropriate rainwater harvesting techniques and introducing drought tolerant range species that can survive drought. So long as rangelands are common resources, collective action is critical to any sustainable management. Understanding local community organizations and how they can be supported in order to facilitate the adoption of range management technologies such as micro-catchment is, therefore, important.

2. Objectives

Overall objective:

- Improve livelihood and reduce desertification in the steppe area.

Specific objectives:

- Development of an institutional framework suitable for community-based implementation and management of micro-catchment water harvesting systems.
- Optimization of the design parameters of micro-catchment water harvesting systems and verification or adaptation of the Vallerani system to the particular geo-physical conditions of the selected environments.
- Identification of the biophysical and socio-economic parameters for the optimal application of micro-catchment water harvesting.
- Improvement of the capacity of communities to manage common natural resources.

3. Methodology:

3.1. Site description:

Qaryatin is located at 120 km northeast of Damascus at 37 08 90 longitude and 34 08 11 latitude and 855 m above sea level. It is marked by hot and dry summer and cold winter and annual average rainfall of 114 mm.

The area of the selected site is 100 ha (1000 * 1000 m) with slopes ranging between 2-6% and these are the prevailing slopes of the Syrian steppe. Soil depth is ranging between 25-90 cm according to the topographical nature and erosion.

The soil depth of the area ranges between 25-90 cm according to topographic slope, soil properties, rainfall intensity over the past years, and vegetation density. Lab analysis of samples and sections showed that soil type is as follows:

- Low slope lands: loamy sandy clayey soils with 25% stones and average salinity of 2-16 mmho/cm.
- Gully and streams lands: sandy low-texture deep soils containing 45% of granules.
- Medium-slope and low deep lands: low-texture and sandy loamy clayey soil with 15% granules and salinity ranges between 8-16 mmho/cm.

Measurements of soil moisture were conducted on samples taken for studying soil depth in 12 points during September 2004 on a horizon of 45 cm. The study has showed that field capacity is 25.8 and wilting point 11.4.

The topography of the area is characterized by 1) slight slope of 1-2% in the south, 2) slight slope of 2-3% in the middle, 3) medium slope of 3-5% in the north and medium slope of 5-8% in the north-east where several seasonal streams and gullies are present.

The natural vegetation before the establishment of the project in September 2004 was fragile and soil cannot absorb rainfalls due high runoff resulting from heavy rainfall intensities. The vegetation mostly consists of Artemisia herba-alba, Achillea fragrantissima and Peganum harmala, and mainly locates in gullies and their sides according to rainfall rate.
Average monthly climatic characteristics of Qaryatin site are described in the table 1 for the period 1958-2010.

Table 1: Long term average climatic characteristics of Qaryatin site

Climatic element	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Annual**
Rainfall mm	14.9	14.2	24.2	17.1	9.9	0.6	0.0	0.0	5.2	8.3	12.1	11.8	118.3
Air temperature ̊ C	6.5	6.4	8.9	13.2	21.4	23.9	26.2	25.1	23	17.6	12.1	6.9	15.9
Max. temperature ̊ C	10.3	12.5	14.1	22.1	28.9	32.7	34.1	33.9	31	25.4	18.2	13	23.0
Min. Temperature ̊ C	0.65	-0.2	2.1	6.4	11.5	14.3	17.2	16.7	13.3	7.9	6.1	1.3	8.1
Relative humidity %	74.1	64.2	57.9	51.4	35	44.2	45.3	49.1	48.7	50.3	68	73.1	55.1
Wind speed	3.4	3.8	3.6	4.1	4.3	4.6	6	4.4	3.6	3.2	3.1	4.5	4.05
ETo mm	42	61	86	136	223	222	217	224	196	143	80	41	1671

3.2. Implemented activities:

Implemented tasks:

- Selection of sites depending on socio-economic conditions of local community and their suitability for constructing mechanized techniques in terms of climatic and topographic conditions.
- Conduction of chemical soil analyses at selected sites and probing for depth estimation.
- Conduction of topographic survey at accurate scales /contours each 0.5 m/ and drawing of maps for study preparation.
- Pinpointing of the research study on maps and its projection on the actuality using accurate topographic equipment.
- Plowing by Vallerani machine mounted on 128 hp tractor and by Pakistani plough according to the study.
- Establishment of an adjacent field, including hand-made bunds at the same diameters of Vallerani bunds and the same spaces for research and economic comparison.
- Training of farmers and technicians on contour projection and construction of hand-made bunds.
- Planting of all rows with various seedling of varieties of Atriplex (Halimus, Vermiculata and Leucoclada) and direct seeding as mentioned in the research worksheet.
- Installation of adequate equipment for taking readings as stated in the study /runoff – infiltration – growth size – grazing capacity – kinds of erosion (sheet – on rills and gullies).
- Determination of the profiles of all gullies and wadis for studying the technique effect on erosion control.
- Design of maps for infiltration, soil depth, vegetative cover, and slopes; and diagrams for general sites and others for the locations of gullies and wadis.
- Placement of tags for all treatments and replications, and big panels for project sites.

Implementation method:

The implemented methods are presented in Table 2.

Table 2: Methods implemented in 2010-11

No.	Block A-R1	Slope %	Block B	Slope %	Block C	Slope %
1	Vi – 9 line * 12 m	4.5	Vc – 5 line * 6 m	3.0	Vi – 7 line * 6 m	2.5
2	Vc – 12 line * 6 m	4.0	Rest – 36 m	3.0	Rest – 51 m	2.3
3	p – 5 line * 12 m	4.0	p – 6 line * 6 m	3.0	p –5 line * 12 m	2.0
4	p – 10 line * 6 m	3.5	p – 3 line * 12 m	2.9	Vc – 10 line * 6 m	2.0
5	Vi – 6 line * 6 m	3.5	Vi – 6 line * 6 m	2.9	Vi – 6 line * 12 m	2.0
6	Rest – 36 m	4.0	Vc – 3 line * 12 m	2.7	p – 17 line * 6 m	2.0
7	Vc – 3 line *12 m	3.5	Vi – 3 line * 12 m	2.7	Vc –10 line * 12	1.7
	Total A 3.3 h		Total B 3.3 h		Total C 3.3 h	

Vi – Vallerani intervention   Vc – Vallerani continues   P – Pakistanian plow   Rest - Vegetation Control

4. Results/Achievements in 2010-11:

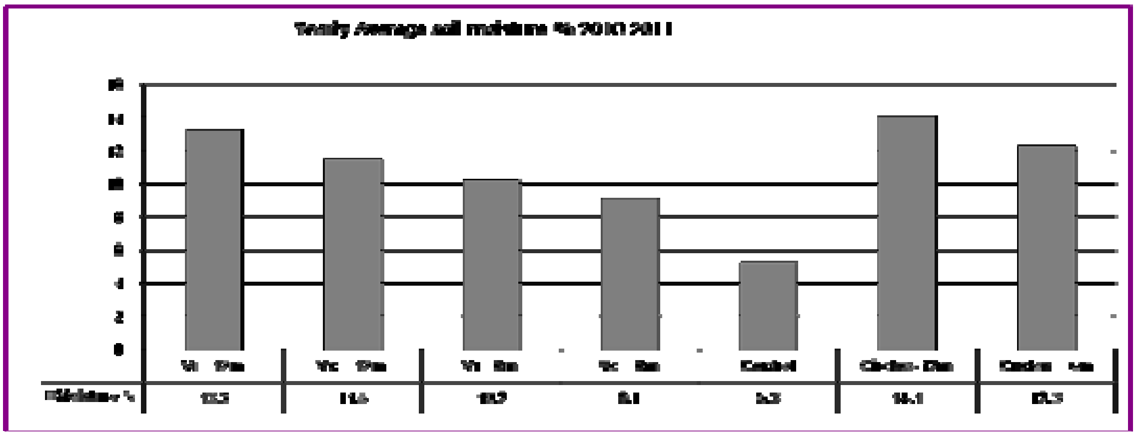
4.1. Climatic conditions:

Climatic properties for 2010-11 were recorded using an electronic meteorological station installed on Qaryatin project site.

Data showed that the highest rainfall rate was 26.3 mm in February, while no worth-mentioning rainfalls during August and September. Rainfall distribution was random throughout the year with a total rainfall of 94.4 mm. The maximum monthly air-temperature was 24.3 in July and the minimum was 6.2 in February. However, the annual air-temperature was 14.3, affecting the monthly and annual evaporation. The maximum monthly evaporation was 291 mm in June and the minimum was 42.5 mm in November and the total annual evaporation was 1693.8 mm with the maximum relative humidity of 91.5 in April and minimum of 37 in June. The annual rate of air speed was 3.6 m/sec.

4.2. Effect of the interventions on soil-moisture:

Data showed that the soil moisture value was in order from high to low for intermittent Vallerani with 12 m spacing, manual bunds with 6 m spacing, continuous Vallerani with 12 m spacing, intermittent Vallerani with 6 m spacing and finally the control.



4.3. Effect of the interventions on shrubs survival:

Seedling survival rate increased for hand-made technique as compared to other techniques with 6 and 12 m spacing and it ranged between 93 – 94% followed by continuous Vallerani with 12 m spacing (83%) and then intermittent Vallerani with6 m spacing (74%).

The Seedling survival rate decreased to 35% for Pakistani plough with 6 m spacing and 67% for continuous Vallerani with 12 m spacing.
The survival percentage of the three varieties of atriplex Halimus, Vermiculata and Leucoclada was high on Vallerani bunds, while it was clearly lower for Pakistani and control. This percentage was in the following decreasing order for the varieties: Halimus, Vermiculata and Leucoclada.

4.5. Grazing capacity:

Grazing capacity (Table 3) increased from 2.1 and 2.2 ha/head/year in the case of the treatments “12 m spacing for Vallerani intermittent and manual bunds” to 3.1 and 3.5 ha/head/year in the case of Vallerani and manual bunds with 6 m spacing and intermittent Vallerani with 12 m spacing, respectively.

Grazing capacity increased by decreasing spacing between cultivation rows (6 m) for all techniques, and it decreased for Pakistani lines vs. Vallerani.
Gracing capacity at 12 m line spacing decreased as compared to 6 m lines.

Table 3: Grazing capacity

Treatment	hectare/sheep/year
Vi-12m	2.1
Vi-6m	3.4
Vc-12m	3.1
Vc-6m	3.5
P-12m	25.3
P-6m	27.1
Circ.12m	2.2
Circ.6m	2.8
control	33.4

II. PLAN OF WORK 2011-12

The activities on the Vallerani water harvesting system conducted in 2010-11 will be continued in 2011-12.

REGIONAL PROJECT ACTIVITIES

Activities conducted in 2010-2011

Technical support:

- ICARDA scientists made several visits to Egypt, Jordan and Morocco to provide technical backstopping and follow-up on the field work and to discuss methodologies and progress made in modeling.

Training and workshops:

- ICARDA organized a training course on suitability analysis using GIS in Amman, Jordan for participants from Egypt, Morocco, Jordan, Syria and Iraq.
- Participants from Jordan benefitted from a training course on “Irrigation management” organized by WLI project
- A participant from Morocco benefitted from a training course on “Innovative methods of irrigation scheduling of olive trees” organized by the project on “Irrigation of olive trees”

Publications:

- Revision and finalization of the 3 final reports of the first phase of the benchmark project

Website:

- The Website of the benchmark project was re-adjusted to include the information concerning the second phase.

Activities proposed for 2011-2012

Technical support:

- This activity will continue

Training:

- A training workshop on “Modeling water flows and allocation at different scales (tertiary canal, sub-basin, basin)
- Scientific writing (Journal articles, reports, presentations…)

Workshop:

- Organize traveling workshops of the satellite sites to the benchmark sites

Publications:

- Re-activate the newsletter of the project

Web site:

- Update the project web-site.

Proposed Project Budget 2011-2012

Table 1: 2012 budgets by country

Items	Badia BM	Rainfed BM	Irrigation BM	Algeria	Tunisia	Syria	Sudan	Iraq	Palestine	Total
Personnel	7,000	7,000	7,000							**21,000**
Operations	9,000	9,000	9,000	1,500	1,500	1,500	1,500	1,500		**34,500**
Travel	7,000	7,000	7,000	1,.500	1,.500	1,.50 0	1,.500	1,.500		**28,500**
Equipments & Supplies	7,000	7,000	7,000	2,000	2,000	2,000	2,000	2,000		**31,000**
Training	7,000	7,000	7,000						2,500	**23,500**
Dissemination	8,000	8,000	8,000	2,000	2,000	2,000	2,000	2,000		**34,000**
Sub-total	**45,000**	**45,000**	**45,000**	**7,000**	**7,000**	**7,000**	**7,000**	**7,000**	**2,500**	**172,500**

Table 2: Summary of Regional and national budgets

1. Regional Activities and Coordination	**Amount**
Technical Support & Management	60,000
Regional Training Workshops	40,000
Consultants	17,500
Sub-Total Regional Activities	**117,500**
2. National Activities	**172,500**
3. Contingencies	10,000
4. Indirect Costs	62,500
Total budget 2012	**362,500**

Water Benchmarks Project Contacts

Yasser Mohawesh (*Badia* BM Coordinator)
National Coordinator, Researcher
NCARE, Amman, Jordan
E-mail: yasser_ncartt@yahoo.com

Bahri Abdeljabar (Rainfed BM Coordinator)
Regional Head of Tadla Research Center INRA
P. O. Box: 567 Beni-Mellal, Morocco
E-mail: bahriabdeljabar@gmail.com

Farid Herda
Laboratory of Bioclimatology
National institute for research in Agronomy (INRAA), Algiers, Algeria
E-mail: f_herda@yahoo.fr

Atef Abdul Al
Head of Water Harvesting Section
General Commission for Scientific Agricultural Research (GCSAR)
P. O. Box: 113, Damascus, Syria
E-mail: atefabdulaal@yahoo.com
E-mail: f_herda@yahoo.fr

Netij Ben Mechlia
Professor of Agro-methodology/Agronomy
INAT P.O.Box: 43, AV. Charles Nicolle 1082
Tunis
Tunisia
E-mail: netij.benmechlia@iresa.agrinet.tn

Hamdy Khalifa (Irrigated BM Coordinator)
Director of Soils, Water & Environment Research Institute
Agricultural Research Center (ARC), Giza, Egypt
E-mail: hekhalifa@yahoo.com

Abbas Elsir Mohamed Elamin
Director, Human Resources Development
Agricultural Research Corporation (ARC)
P. O. Box: 126 Wad Medani, Sudan
E-mail: abbaselsir09@yahoo.com

Raad Omar Salih
Head of Soil Science Research Department
State Board for Agricultural Research
Ministry of Agriculture, Baghdad, Iraq
E-mail: rosalih2007@yahoo.com

Mohammed Karrou (Project Coordinator)
Water and drought management specialist
ICARDA, Aleppo
P.O.Box 5466 ICARDA
Aleppo, Syria
E-mail : m.karrou@cgiar.org

Theib Y. Oweis (Project Manager)
Director, Integrated Water and Land Management Program (IWLMP)
P.O.Box 5466 ICARDA
Aleppo, Syria
E-mail: t.oweis@cgiar.org

This Project is funded by AFESD

Integrated Water and Land Management Program
International Center for Agricultural Research in the Dry Areas
P.O.Box 5466, Aleppo, Syria
Tel: 963-21-2213433/2213477/2225112
Fax: 963-21-2213490/2225105
E-mail: m.karrou@xgiar.org
t.oweis@cgiar.org
Website: http://icardahost.icarda.cgiar.org8081/wbm/index.php