Component F
Develop methodologies to improve soil, agronomic, irrigation water and drainage management for salinity control

Comprehensive Assessment Report Prepared for Project Midterm Review

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The Iraq Salinity Project is an initiative of Government of Iraq, Ministries of Agriculture, Water Resources, Higher Education, Environment, and Science and Technology, and an international research team led by ICARDA – the International Center for Agricultural Research in the Dry Areas, in partnership with the University of Western Australia, the Commonwealth Scientific and Industrial Research organization (CSIRO) of Australia, the International Water Management Institute (IWMI), Sri Lanka, and the International Center for Biosaline Agriculture (ICBA), Dubai, United Arab Emirates.

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This technical report series captures and documents the work in progress of the Iraq Salinity Project, in its seven research themes, working at the regional, farm and irrigation system scales. Technical reports feed into the *Iraq Salinity Assessment*, a synthesis and solutions to solving the problem: Situation Analysis (Report 1); Approaches and Solutions (Report 2) and Investment Options (Report 2).

Key words: southern Iraq, central Iraq, spatial distribution, remote sensing, irrigation, salinity mapping.

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Executive Summary

The objective of the Component F is to identify the best soil, agronomic, irrigation and drainage management practices for salinity management at the farm level. Based on the land quality classification, governorates with low to medium salinity (6-20 dS/m) were identified from which districts with the lowest land quality were chosen. Three sites were selected in central and southern Iraq to cover areas suffering from salinity to carry out the study: Dujaila in Wasit Governorate; Musayab in Babil Governorate and Abu-AlKhaseeb in Basrah Governorate. Thirteen outstanding farmers were selected at Dujaila, 17 at Musayab, and 15 at Abu-Alkhaseeb. The criteria for the selection of outstanding farmers was based on their records of marketed crops in addition to the field trips made by the staff to check the actual field situation including the best-bet salinity management techniques they practice. Results of the analysis indicates that outstanding farmers use a range of best-bet practices, these include practices such as leveling of land before planting, applying a heavy irrigation prior to planting (preseason leaching), post-harvest mixing of crop residues with soil, use of rotation, use of high tolerant crop to salinity for 2 to 3 seasons before cultivation of wheat, drain or deep ditch around the farmlands, and deep plowing to breakdown the hardpan below plow layer. Detailed analyses of these best-bet practices are being done now to understand their cost-benefit ratios, scientific explanations for their effectiveness, and their long-term sustainability in managing salinity.

1. Introduction

The irrigated areas in central and southern Iraq (the Mesopotamian Plain) have a long history of development. These areas were the birthplace of civilization and have relied on the waters of the Tigris and Euphrates River systems for their ongoing viability. The area is very flat and lies at the downstream end of the large river basins that includes Turkey and Syria. There are also regional groundwater aquifers that flow towards the coast under the Plain and discharge over most of the lower Plain. As a consequence, shallow water-tables of varying salinities and depths underlie the area. Over the long history of irrigation, these shallow groundwater levels have risen closer to the surface and salinity has been further exacerbated. It is believed that Iraq is losing thousands of hectares of agricultural cropping land as a result of salinity.

The irrigated areas experience semi-arid climate with average annual rainfall below 250 mm and annual evaporation rates being extremely high, around 2000 mm per year (FAO, 1998). As a consequence the crop water requirement is also very high, approaching 4000 to 5000 m^3 per hectare. This is nearly 4-fold higher than annual rainfall, therefore necessitating intensive irrigation to sustain crop production.

1.1. Salinity problem in Iraq

Irrigation throughout the region occurs as long thin strips adjacent to the rivers that take advantage of the better soils and minimizes the transport of water. All irrigated areas are serviced by delivery infrastructure and all have some form of drainage. Previously, the drainage from irrigation was either returned to the river, or seeped into the regional groundwater system - in most cases eventually returning to the river over the long term. Today, the drainage infrastructure has fallen into disrepair, rendering the system ineffective and contributing extensively to the current salinity crisis.

Recently, the demand for water from the Tigris and Euphrates River basins has increased dramatically in Turkey and Syria. This has caused a reduction in flow at the downstream end of the basins, though the exact reduction varies from year-to-year. Greater water withdrawals and return of saline drainage water back into the rivers in upstream countries has reduced the quality of water that flows into the Iraqi part of the basins. This apparent water scarcity and water quality deterioration, together with inefficient delivery and drainage systems combine to present the current problems of increasing salinization of irrigated fields and reduction in productivity. The deterioration of drainage infrastructure and lack of maintenance in the recent past has further compounded the situation. The recent events of climate change may have affected water availability and quality in the Tigris and Euphrates River basins, although data on climate change effects on the water balance in Iraq are not yet available to quantify the possible implications of the climate change. A promising project started in 1994, was the Main Drain designed to collect the discharge from the drains in the Lower

Mesopotamian Plains and carry it to sea. When complete, the diversion of drainage systems in the cultivated lands may have a positive effect on the problem of salinity in the Plain.

Salt management or salinity control is a critical component of irrigated agriculture in arid and semi-arid regions. Successful crop production cannot be sustained without maintaining an acceptable level of salts in the root zone.

1.2. Objectives

The objectives of this Project Component are to identify the best soil, agronomic, irrigation and drainage management practices for salinity management at farm level. This can be accomplished through farmer survey data collection and analysis to:

(a) help identifying the outstanding farmers in the selected sites, possibly in differing salinity affected areas,

(b) determine what makes these farmers outstanding, in terms of soil, agronomic or irrigation techniques,

(c) benchmark the outstanding farmers with surrounding farmers, and

(d) determine what are the best practices used by the outstanding farmers that can be usefully promoted in other areas.

2 Milestones Achieved

1. Data collection (bio-physical and socio-economic) completed (JULY 2011)
2. Surveys of farmers' practices in the selected project sites completed (AUG 2011)
3. Desk analysis of the collected data completed (AUG 2011)
4. Identification of outstanding farmers (SEPT 2011)
5. Analysis and identification of best-bet of soil, agronomic, irrigation & drainage practices completed (OCT 2011)
6. Identification of new technologies for improved salinity management in the selected sites (AUG 2011)
7. Pilot plots (PP) established in the project selected sites (OCT 2011)
8. Field days in the pilot plots to disseminate knowledge on best practices (SEP 2011)
9. Demonstration trials in the pilot plots (APR 2012)

3 Key outputs

1. Identification of the best soil, agronomic, irrigation and drainage management practices for salinity management at farm level under current conditions
2. Prepared and shared activity reports F1.5, 1.6, 2.1, 2.2, 2.3, 2.4, 3.1 and 3.2.
3. Prepared a two-page flyer informing stakeholders of our research achievements

4. Prepared a 12-page conference-style paper informing stakeholders of F2.4 activity
5. Demonstration of the best-bet practices to farmers
6. Four technicians received training on field salinity sampling and use of EM38, Amman, Jordan – September 25-26, 2011

4 Challenges

1. Dissemination of the recommended practices adopted by the outstanding farmers among farmers of the region and the country
2. Only partial support from farmers in cultivation of lands suffering from salinity in many ways, e.g. supplying seeds of salinity-tolerant crops and some other expenses, either at subsidized price or free of charge.
3. Availability of irrigation water is a critical element in cultivation of saline lands. Therefore, changing the traditional irrigation method of flooding toward the sprinkling remains a vital solution for shortage of water. In this case, the simple portable (movable) type sprinkler systems can be easily adopted for small farms.
4. Using of flushing machine in areas with installed blocked tile drains of Dujaila Site would help in improving soil conditions of thousands hectares suffering from salinity.

5 Assessment of the Remainder of the activities

1. Demonstration of promising best-bet practices on pilot farms and dissemination of knowledge on these practices through organization of field days (NOV 2011-NOV 2012)
2. Review outcomes from current activities and lessons learnt (SEPT 2012)
3. Develop plans for further research to refine the promising best-bet practices, for filling knowledge gaps and impact of addressing the gaps, and prepare research proposals for submission to donors and Iraqi government (SEPT 2012-FEB 2013)
4. Twelve technicians will receive training on laser-guided levelling, Erbil, Iraq – May/June, 2012
5. Six technicians will receive training on use of field equipment for assessment of soil water balance and salinity, Erbil, Iraq – May/June, 2012
6. Training on surveys and data collection at the farm level, Baghdad, Iraq – April/May, 2012

Please find latest version of the Monitoring & Evaluation (M&E) Framework for Component F in Appendix 2.

6 Materials and Methods

6.1 Site selection and characterization

Based on land quality classification, governorates with low to medium salinity were selected in the first stage. Within each of these selected governorates, the districts with the lowest land quality were chosen. The precise identification of the outstanding farmers was undertaken based on published and unpublished reports and sources of information documenting them as "success stories" in agriculture using three criteria; a) highest reported yield per unit area, b) meeting the governorate yield target continuously, and c) positive reputation of the farm among officials, authorities and neighboring farmers.

Three sites were selected in central and southern Iraq to cover areas suffering from salinity to carry out the study: Site 1: Dujaila, Wasit Governorate; Site 2: Musayab, Babil Governorate; and Site 3: Abu-AlKhaseeb, Basrah Governorate (Figure 1).

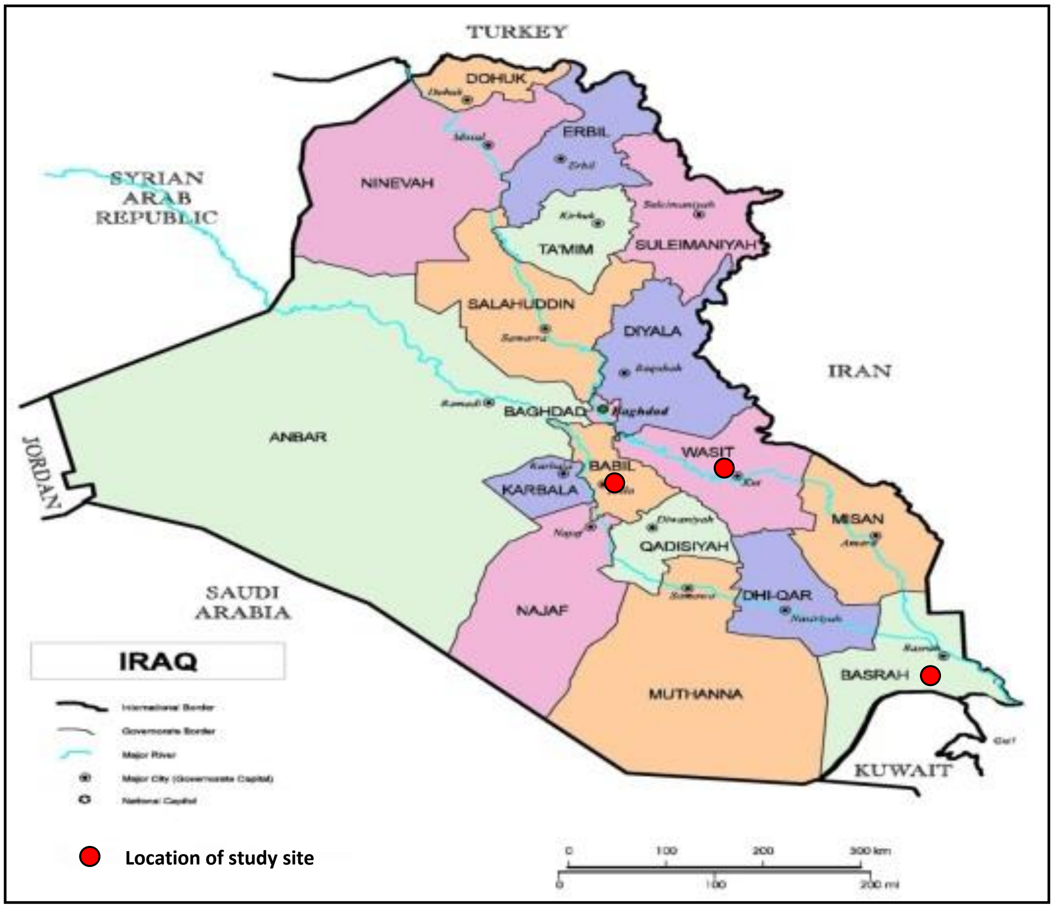


Figure 1. Location map of the study sites.

6.2 Weather

The climate is of semi-arid kind. Table 1 presents the 30-year average weather conditions for the three selected study sites. The annual average minimum and maximum temperatures at Dujaila site are 15.4 and 30.1^{o}C, respectively; whereas at Musayab site is 16.6 and 31.1 ^{o}C, respectively. The annual cumulative rainfall at Dujaila site (141.4 mm) is approx. 33% higher than at the Musayab site (106.5 mm). In general, the two sites are very similar in terms of long-term weather conditions.

Table 1. Mean monthly temperature, precipitation and solar radiation for two of the study sites during the past 30 years.

	Dujaila				Musayab			
Month	Temp (C^o)		Rainfall (mm)	Solar radiation (MJ m^{-2} d^{-1})	Temp. C^o		Rainfall (mm)	Solar radiation (MJ m^{-2} d^{-1})
	Min	Max			Min	Max		
Jan	4	15	29.6	23.3	8	17	21.5	25.0
Feb	6	18	28.6	31.9	7	19	17.6	32.8
Mar	10	23	22.6	39.7	11	24	13.5	40.5
April	15	29	21.8	48.3	16	30	13.7	48.3
May	21	36	5.2	55.2	22	37	7.0	56.0
June	24	40	0.1	58.6	25	41	0.0	58.6
July	26	43	0.0	58.6	27	44	0.0	58.6
Aug	25	43	0.0	54.7	26	43	0.0	54.7
Sept	22	40	0.2	47.4	23	41	0.0	47.4
Oct	16	33	3.5	36.2	17	34	4.8	36.2
Nov	10	24	12.2	25.9	11	25	11.6	26.7
Dec	6	17	22.4	21.6	7	18	16.5	22.4
Total			**141.4**				**106.5**	

6.3 Soils

General conditions, soil conditions, and farming for three Sites are given in Tables 2-4. In general, the topography of three Sites is nearly leveled. Soils at Dujaila and Musayab sites are medium texture soils (silty clay loam and sandy clay loam, respectively) classified as Typic Turifluvents whereas soils at Abu-AlKhaseeb site (loam to sandy clay loam) are classified as salted, gypsic, Turifluvents. These are poorly drained, moderately saline (10-20 dS/m) soils and parent material of all soils is the river alluvium. Examples of salt-affected soils at the three Sites are given in Figures 2 and 3.

Table 2. General conditions, soil conditions, and farming for Site 1.

Parameter	Description
Natural conditions	Suitable
Soil Classification	Typic, Turifluvents
Physiography	Silted, Basin
Topography	Nearly level
Parent materials	River Alluvium
Climate	Semi arid
Drainage	Poor
Water table	Shallow
Soil Capability class	Good
Salinity	Moderately saline
Soil texture	Medium to heavy (Silty clay loam to Silty Clay)
Field crops	wheat, barley, maize, sorghum
Vegetables	tomato, cucumber, pepper, okra

Trees	date palms, citrus, apricot
Irrigation water quality	Medium
Source of irrigation water	Tigris river
Farming constraints	Medium
Animal husbandry	Cows, sheep, poultry, fish

Table 3. General conditions, soil conditions, and farming for Site 2.

Parameter	Description
Natural conditions	Suitable
Soil Classification	Typic, Turifluvents
Physiography	Silted, Basin
Topography	Nearly level
Parent materials	River Alluvium
Climate	Semi arid
Drainage	Poor
Water table	Shallow
Soil Capability class	Good
Salinity	Moderately saline
Soil texture	Medium (Loam to Sandy clay loam)
Field crops	wheat, barley, maize, sunflower
Vegetables	tomato, cucumber, pepper, okra, egg plant, melon
Trees	date palms, citrus, olive, apricot
Irrigation water quality	Good
Source of irrigation water	Euphrates river
Farming constraints	Medium
Animal husbandry	Cows, sheep, poultry, fish

Table 4. General conditions, soil conditions, and farming for Site 3.

Parameter	Description
Natural conditions	Medium
Soil Classification	Salted, gypsic, Turifluvents
Physiography	Silted, Basin
Topography	Nearly level
Parent materials	River Alluvium
Climate	Semi-arid
Drainage	Poor
Water table	Fluctuated (tide and ebb)
Soil Capability class	Good
Salinity	Moderately saline
Soil texture	Medium (Loam to Sandy clay loam)
Field crops	wheat, barley, maize, sunflower
Vegetables	tomato, cucumber, pepper, okra, egg plant, melon

Trees	date palms orchard
Irrigation water quality	Medium to poor
Source of irrigation water	Shat-Alarab
Farming constraints	High
Animal husbandry	Cows, sheep, poultry, fish

6.4 Water

The irrigation water quality ranges between 1.0 and 1.3 dS/m at Dujaila and Musayab sites whereas it ranges between 2.5 and 6 dS/m at Abu-AlKhaseeb site. The source of irrigation water is the Tigris River in the case of Dujaila, Euphrates River in the case of Musayab, and Shat-Alarab River in the case of Abu-AlKhaseeb site. The water table is between 0.5 and 1.5 m from the surface in the case of Dujaila and Musayab sites whereas it fluctuates in the case of Abu-AlKhaseeb site depending on the discharge from Iran and tide and ebb effect in the sea.

Fig. 2. Salt-affected land of limited uses at Sector C, Dujaila.

Fig. 3. Salt-affected lands at Musayab Site.

6.5 Cropping systems

The cropping systems in Dujaila and Musayab sites is a mix of field crops such as wheat, barley, maize and sunflower, vegetables such as tomato, cucumber, pepper, okra and tress such as date palms, citrus, olive and apricot. Whereas at Abu-AlKhaseeb site, there are no field crops grown except some for animal feed, it is dominated by date palm orchards, vegetable and tree plantation. The farm productivity is moderate with wheat yields ranging from 2 to 2.5t/ha. In addition to growing crops, many farmers also raise animals such as cows, sheep, poultry and fish.

6.6 Survey questionnaire

A questionnaire form was prepared and adopted by the staff based on many visits to farmers' fields (Figures 4-6). The form was used to gather information to get a clear picture of the current status of farmers' fields and most agricultural activities including problems and constraints facing farmers in cultivation of saline lands. Furthermore, the survey was conducted to collect additional information on the practices they carry out to manage salinity. A total of 45 questionnaire forms were distributed to 13 farmers at Site 1, 17 farmers at Site 2, and 15 farmers at Site 3. To accomplish this task, questionnaire forms were designed to cover socio-economic status of framers as well as bio-physical parameters of their cultivated lands (Appendix 1).

6.7 Analysis of biophysical and social-economic data

A precise analysis of the questionnaire forms and the comparison among farmers for the same site was done. Analysis of biophysical data included parameters such as: soil type and characteristics, current status of soil salinity, water quality, and agricultural practices used by farmers. Estimation of these parameters was based on mean values and range values among farmers of the site.

Analysis of social-economic data included the following parameters: family size and members involved in agricultural work, their level of education, standard livings, type of land holding, role of government in extension, farmer skills, type of housing, and of managing their lands. The same procedure was used to express the final results among the farmers at the three Sites. In general, values were given as range from minimum to maximum for the digitized properties. Other types of answers are description of cases. The analysis is expected to lead to many important and conclusive results regarding biophysical data and socio-economic data.

6.8 Profiling of outstanding farmers

A questionnaire survey was conducted to collect information on the practices carried out by outstanding farmers to manage salinity. The control farms for comparison were chosen based on their representation of the general situation within the district or the governorate with regard to salinization, land quality and productivity, and farm incomes. These control farms represent the norm under which the majority of farming enterprises are currently operating. The basic indicators used in defining the research and the control farms were the level of salinity, yields of major crops and overall profitability of the farm. Information sources with respect to the geography, soils, land and water resources, and weather were obtained from field sampling and various issues of national, governorate and district reports. In addition, the records of the district land management departments were also consulted.

6.9 Identification of farmer best-bet practices

Selection of outstanding farmers was mainly based on criteria related to adoption of practices in management of salinity, yield produced and marketed, and cost-benefit analysis of total input and output. These practices that have been used by farmers resulted in great reduction in soil salinity and increase the productivity of cropland. At the same time, most farmers used at least two practices in managing their lands salinity. Also, the reduction in soil salinity ranged between nearly 50 to 70%. This reduction was sufficient to improve soil environment and cultivate land to crops.

Fig 4. First teamwork visit to Agricultural Office, Site 1, Dujaila.

Fig. 5. Visiting Musayab Site, Babil Governorate.

Fig. 6. Visiting farmers at Abu-Alkhaseeb.

7 Results and Discussion

Thirteen outstanding farmers were selected at Dujaila, 17 at Musayab, and 15 at Abu-Alkhaseeb. These farmers were selected because they met the selection criteria mentioned in the methodology. The criteria was based on their records of marketed crops in addition to the field trips made by the staff to check the actual field situation including the best-bet salinity management techniques they practice.

7.1 Survey results

The questionnaire prepared and adopted by the team gave a better picture on the status of outstanding farmers' productivity and major agricultural constraints. Also, the frequent visits conducted by the team improved the understanding of the problems and constraints facing the farmers in cultivation on saline lands.

7.2 Socio-economic status of farmers

It is evident that most members of the outstanding farming families take important part in agricultural work (Table 5). This helps the outstanding farmers generate higher incomes. At the same time, the low-income families push their family members to contribute in agricultural works as an alternative to the machinery work, thus reducing input costs.

There are neither centers nor groups facilitate renting of machines at subsidizes prices affordable for the farmers of the sites. Therefore, the farmers are placed in difficult position to decide whether they leave their lands barren or continue cultivating depending on their ability to work in the field carry out practices by hand or they may skip some land preparation practices. In addition, some farmers may be forced to rent machines at higher price. In fact, this action has negative impact on the motivation of family members toward getting higher education. Most youth are discouraged from continuing education; instead they are involved in field work helping family members. Also, it is clear that the women are playing an important role in field work which has negative effect on their original roles at home in taking care of the children and others.

Analysis of the questionnaire forms indicates that most of outstanding farmers have tendency to raise animals besides their fields. Raising animals helps meet their needs from animal products. However, this activity may give wrong conclusions in some cases where some farmers stick with the production of animal feed rather than management and cultivation of saline lands for the production of grains. Some farmers are not sure about the sufficiency of irrigation water for their cultivated crops as well as the requirements for fertilizers and high yielding seeds. Therefore, the risk associated with cultivation of their saline soils is high.

Economic status of most of the farmers is between medium to poor (monthly family income ranging from $300 to $700). Some of farmers' economic status is between medium and good (greater than $700/month). This stems from the fact that those families are depending on other sources for living, and not the produce from their lands. Such families involve in raising animals (cattle, sheep, or poultry) at the same site or they work far from their fields for other farmers or member of families working in cities for governmental sectors (ministry of defense or ministry of interior affairs) far from agricultural work. So, the main tasks are on immediate family members - husband, wife, and children and the work is confined to small area for the production of animals with no use of the larger area.

The role of governmental establishments was very limited or non-existing at these sites. Extensionists are not of much help to farmers in cultivating their saline lands in scientific ways, depriving them of getting benefit from other countries' experiences. Also, there are no roles for NGO or other organizations in providing help to the farmers.

Even outstanding farmers have very limited knowledge of the correct use of fertilizers or pesticides according to recommendations of MoA - level of each farmer's application of fertilizers or pesticides is not known by extensionists. Also, farmers have no idea about the use of bio-pesticides to control the weeds. The use of chemical- or bio-pesticides is limited to farmers who own more than 30 ha of land.

Most farmers are not able to use their entire landholdings, but only 30% at best; the remaining is affected by large salt accumulation. In this regards, it was observed that a layer of salts (Sabakh), with brown color and some salt-tolerant native vegetation, covers large tracts of lands.

The use of farmer's saline lands depends basically on the level and type of governmental support through providing of fuel, fertilizers, seeds, pesticides, and machinery at subsidized prices.

Although, supply of water was assured in the areas under investigation, unreliable water conveyance and distribution is very common. In addition, the transporting canal is not usually lined and when they are lined, they need a lot of maintenance. The poor transporting canals force most farmers to use pumps to lift the water remaining in these canals for their purpose. This action is an additional cost to cost of cultivation.

Some farmers live far away from their cultivated lands such as in the center of the district or nearby town far from the village because of better access to health and other services there.

Sometimes farmers (mostly related) agree to cultivate their lands jointly. In this case, the land is large enough to be economically cultivated and serviced. They grow vegetables in plastic houses and grow animals. Therefore, their land productivity is more stable, they can rent machines, and buy pump and consequently, they are in good position to accept recommendations to increase the cultivated area during the successive seasons.

Table 5. Analysis of socio-economic data based on questionnaire forms of the outstanding farmers at the three investigated sites (Dujaila, Musayab, and Abu-Alkhaseeb).

Parameter	Site 1 Dujaila (13 Farmers)	Site 2 Musayab (17 Farmers)	Site 3 Abu-Alkhaseeb (15 Farmers)
Number of family members	6 – 32	4-30	2-20
Number of working members	2 – 18	1 – 16	3 -12
Engagement of members in farm work	Very limited – Good	Limited - Good	Limited –Good
Education	Primary school - High Education	Primary – University	Intermediate-University
Women contribution in farm work	Limited	Yes	Yes
Standard of living*	Poor - Medium	Medium – Good	Medium
Other agricultural activities	Livestock farming (6)	None (12) - Animal farming (5)	Animal farming (15)
Land owner	The farmer	- Farmer (3) - Contract (14)	- Farmer (6) - Contract (9)
Type of land holding	Contract (Law# 35)	Contract (Laws # 35 and 117)	Contract (Laws # 35 and 117)
Role of governmental establishments	None – Very limited	None	None
Role of extension workers	None – Poor	None	None
Role of NGO	None	None	None
Household income distribution	Family shares the income	Farmer keeps it all	Farmer keeps it all
Experience doing agriculture	3-30 years	20-30 years	20 years
Type of housing	- Rural (4) - Village (9)	Bricks, field	Bricks, field
Reasons not to cultivate all land	- low return (1) - salinity and water shortage (12)	Salinity, water shortage (17)	Water salinity (15)
Criteria for crop and variety selection	tolerant to salinity	- tolerant to salinity - local market	- tolerant to salinity - local market

*Poor: less than USD 300/month; medium: USD 300 – 700/month; good: greater than USD 700.

7.3 Biophysical status of the sites

Dujaila Site

The 13 outstanding farmers interviewed for this study practice some techniques which distinguishes them from their neighbors. Among these practices noted in this area are the followings:

1. Levelling of land before cultivation.
2. Preseason application of heavy irrigation (*Tarbasa*). It is to leach before cultivation.
3. Post-harvest mixing of plant residues into soil surface
4. Use of rotation, for legumes (clover, alfalfa, broad beans, or mung beans) after grain crop
5. Avoid fallow during summer season by plowing land to breakdown the capillarity and minimizes the capillary action
6. Use of high tolerant crop to salinity (barley or local variety) for two to three seasons before cultivation wheat. After this practice, wheat, corn, legumes, and vegetables replace barley at times.
7. Dig a drain or deep ditch around the land or part of the land to lower the groundwater and collect the surface leaching water from land particularly during the first seasons and connect to the collective drain in the area.
8. Deep plowing in breakdown the hard layer below plow layer. Farmers noticed irrigation water stands at the upper part of soil surface with poor percolation which resulted in death of seedlings and failure of germination. Farmers are trying to use a big machine (rotor) to breakdown the hardpan layer.
9. Level or line of seeding far from salinity effect for crops like cotton, sunflower, and mung beans. Vegetable crops are cultivated in the same way.
10. Continuous cultivation of land is a must to keep their soils far from resalinization processes.

On evaluation of yield and land productivity of these cultivated lands after application of the abovementioned practices, we noticed an improvement in yield as a result in improvement of physical, chemical, and biological properties of soil.

Musayab Site

Seventeen farmers were selected based on soil salinity and the use of practices in management their saline lands. Most farmers use post-harvest crop for animal feed and normally utilize the entire land for cultivation. The area of farming unit is between 30 and 60 donum (7.5-15 ha). Lands are utilized according to “Contract of Land” number 35 and 117. Farmers are practicing the followings to manage their saline lands:

1. Dividing the land into parts to control irrigation, leveling, and other agricultural practices
2. Conventional plowing to 30 cm depth and giving preseason heavy irrigation to leach some salts.
3. Planting most tolerant crops to salinity (Barley, alfalfa, okra, and egg plants) to a portion of land.
4. Farmers expand these practices to other portions of the land.
5. After few seasons, farmers replace the salinity tolerant crops with wheat.

6. Few farmers use subsoil plowing to depth of 70 cm in the reclamation process.
7. Farmers mix residual plants with soil to improve physical conditions of the soil.
8. Some farmers add straw on the soil surface to increase the rate of germination and increase the water soil water holding capacity.
9. Some farmers add manure (poultry) and mix it with soil in vegetable production.
10. Some farmers plow the land during summer season to minimize the capillary action.
11. Deepen the irrigation channels to more than one meter for storing more water which can be used at time of water shortage.

Abu-Alkhaseeb

Evaluation of the forms indicates that the 15 outstanding farmers are practicing the following to manage their saline lands:

1. Cultivation of vegetable crops in plastic houses using manure layer and the sand layer to manage salinity of irrigation water.
2. Use of cycle method of irrigation with high-saline and low-saline waters. In this respect, farmers use the low-saline water (RO type) every other season.
3. Using of mineral fertilizers (soil or foliar application) although they are expensive, to maximize yields.

Table 6 presents comparison between the three sites of the biophysical survey findings.

Table 6. Analysis of biophysical data based on questionnaire forms of the outstanding farmers at the three investigated sites (Dujaila, Musayab, and Abu-Alkhaseeb).

Parameter	Site 1 Dujaila (13 Farmers)	Site 2 Musayab (17 Farmers)	Site 3 Abu-Khaseeb (15 Farmers)
Soil Type*	Si. C. L. – Si. C.	Loam - Si. L.	Si. C. L. - Si. C.
Soil EC (dS/m) (Before practicing)	30-70	10-12	10-20
Soil EC (dS/m) (After practicing)	15-23	4.6-7.8	7-15
Irrigation water quality:			
EC (dS/m):	1.0-1.3	1.3-1.8	2.5-6.0
Distance of source (Irrig. wat.) (km)	0.3-3.0	3-35	Close to (Shatt Al-Arab)
Surface plowing	Disking/mold plow	Disking/mold plow	Disking
Sub soiling	2 /13	1/17	None
Major crop	Barley/wheat	Wheat/corn	Vegetables/alfalfa
Variety	Local	Ibaa (wheat) Corn (Hybrid)	Local
Mixing of plant residue	2/13	Yes	Yes
Seeding method	Manual (11/13) Machine (2/13)	Manual	Manual
Irrigation method (Flooding)	Gravity (6/13)	Pumps	- Plastic House:

	Pumps (7/13)		Drip - Forage crop: Flood.
Preseason irrigation	9/13	Yes	None
Over irrigation	3/13	None	Yes
Fallow with plowing	9/13	9/17	Dividing
Machinery	Renting (9/13)	1/17	8/15
Machines belong to farmer	4/13	16/17	7/15
Sprinkler irrig. sys.	None	None	None
Drainage facilities	None	Deteriorated	None
Reuse drainage water	None	1/17	None
Rotation	Wheat or Barley-legumes (4/13)	Wheat/Corn-legumes (17)	None (9/15) Veg.-alfalfa (6/15)
Crops cultivated	Field crops + vegetables (3/13)	Wheat, corn, vegetables, alfalfa (17)	Forage, vegetables,
Orchards	3/13	None	Date palms
Availability of water	Rational	Rational (weekly)	Shatt Al-Arab (Tidal)
Irrigation Water sufficiency	Insufficient	Insufficient	Available
Fertilizer use	Yes	Yes	Yes
Herbicides use	2/13	None	None
Bio-pesticides	None	None	None
Organic farming	None	None	None

*Si: Silt, C: clay; L: Loam

7.4 Best practices used by the outstanding farmers

Thirteen outstanding farmers were selected at Dujaila, 17 at Musayab, and 15 at Abu-Alkhaseeb. The criteria for the selection of outstanding farmers was based on their records of marketed crops in addition to the field trips made by the staff to check the actual field situation including the best-bet salinity management techniques they practice such as: leveling of land before planting, applying a heavy irrigation prior to planting (preseason leaching), post-harvest mixing of crop residues with soil, use of rotation - legumes (clover, alfalfa, broad beans, or mung beans) followed by wheat, use of high tolerant crop to salinity (barley) for 2 to 3 seasons before cultivation of wheat, drain or deep ditch around the farmland, deep plowing to breakdown the hard layer below plow layer, and different ways of seeding by furrow irrigation

Site 1. Dujaila:

Evaluation of practices used by the outstanding farmers with the main objective of living with salinity to solve related problems, farmers continue cultivation their lands. Outstanding farmers got improved yield with successive cultivation. Scientific evaluation of these practices indicates that some of them are overlapped and some of them are expensive.

Among these practices that can be promoted to other farmers are as follow:

1. Mix of harvested plants with the surfaces soil (Fig. 7). This practice is inexpensive, simple, and does not required effort and can be done by mold plow. The benefit of this practice is big in improving soil properties. The soil of the area is Clay or Clay Loam and it is needed an amendment to loose soil aggregates and improve aggregation. . It is believed therefore, that the best soil amendment is plant straw, leaves, and residues. Decomposition of plant remains would improve physical and biological properties of soil and may add nutrients to the rhizosphere which in turn improve soil environment for root development.
2. Deep plowing using the rotor (Fig. 8) to breakdown the hardpan or hard layer below the plow layer. This layer has been formed after decades in using the common plow under moist conditions, which resulted in compaction of such layer. Using the rotor at depths of 60-80 cm below soil surface in lines every 4 to 6 m apart would be very efficient in breakdown the hard layer. This practice can be repeated every other five years to assure the movement of salts and water below the root zone.
3. Digging of a drain or deep ditch around the land would provide best draining and discharge the excess irrigation water (Fig. 9). This practice may work well when the remaining plant materials are mixed with the upper soil layer and avoiding the fallow during summer months.
4. Adoption of rotation system using tolerant varieties of wheat or barley followed by legumes and avoiding leaving land fallow would provide the best conditions to improve soil environment.
5. Cultivate of salinity tolerant crops during the first seasons mainly barley. In this respect, land is divided, levelled, and cultivated to cops (Fig. 10).

From the above-mentioned practices, it is hard to separate each one from the rest in implementation them on the field scale. The overlapping is expected and sometimes farmers are practicing more than one practice at the same time. For instance, farmers do the leveling, mix plant materials, and plant rotation and so on.

Fig. 7. Practicing of mix post harvest plants with soil at Dujaila

Fig. 8. Use of rotor to breakdown hardpan in deep plowing at Dujaila

Fig. 9. Digging of a drain or deep ditch around the land at Dujaila

Fig. 10. Cultivate of salinity tolerant crops (barley) at Dujaila

Site 2. Mussayab:

Practices of outstanding farmers that can be promoted to other farmers in the area are as follow:

1. Dividing the whole land into parts to control irrigation, leveling, and other reclamation practices.
2. Starting with few pieces of the land and planting most tolerant crops to salinity (Barley, alfalfa, okra, and egg plants) (Fig. 11).
3. Farmers expand these practices to other pieces of the land.

4. After few seasons, farmers replace the salinity tolerant crops by wheat.
5. Farmers mix post-harvest plants with the soil to improve physical conditions of the soil (Fig. 12).
6. Some farmers plow the land during summer season to minimize the capillary action (Fig. 13).

Site 3. Abu-Alkhaseeb:

Practices adopted by farmers of the area in cultivation of vegetables are as follow:

1. Cultivation of the plastic houses to vegetable crops by using the manure layer and the sand layer to manage salinity of irrigation water (Fig. 13).
2. Use of cycle method of irrigation with high-saline and low-saline waters. In this respect, farmers use the low-saline water (RO type) every other season.

7.5 Land salinity after practices used by the outstanding farmers

Table 7 explains the practices that have been used at Dujaila Site which resulted in great reduction in soil salinity and the cultivation of lands. It is clear that most farmers used at least two practices in managing their lands salinity. Also, the reduction in soil salinity ranged between nearly 50 to 70%. That reduction was sufficient to improve soil environment and cultivate lands to crops. Figure 15 presents electrical conductivity of the 13 farmers' lands before practicing (before initiation of the program) and after practicing of the recommended practices at Dujaila Site. The high reduction in salinity upon practicing of the recommended practices is evident in all farmers' lands. Land utilized out of total land owned by farmers at Dujaila Site is given in Figure 16). Most farmers used part of their lands instead of the entire lands at the first seasons of cultivation.

Table 8 and Figure 18 present soil salinity before and after practicing of soil management tools for the 17 farms at Site 2, Mussayab**.** Similarly, high reduction in soil salinity was observed in fields of outstanding farmers. The reduction ranged between 20 and 90% indication the successful practices adopted by farmers in managing soil salinity.

Fig. 11. Cultivate of salinity tolerant crops (okra) at Mussayab Site.

Fig. 12. Mix of post-harvest plants with the soil at Mussayab Site.

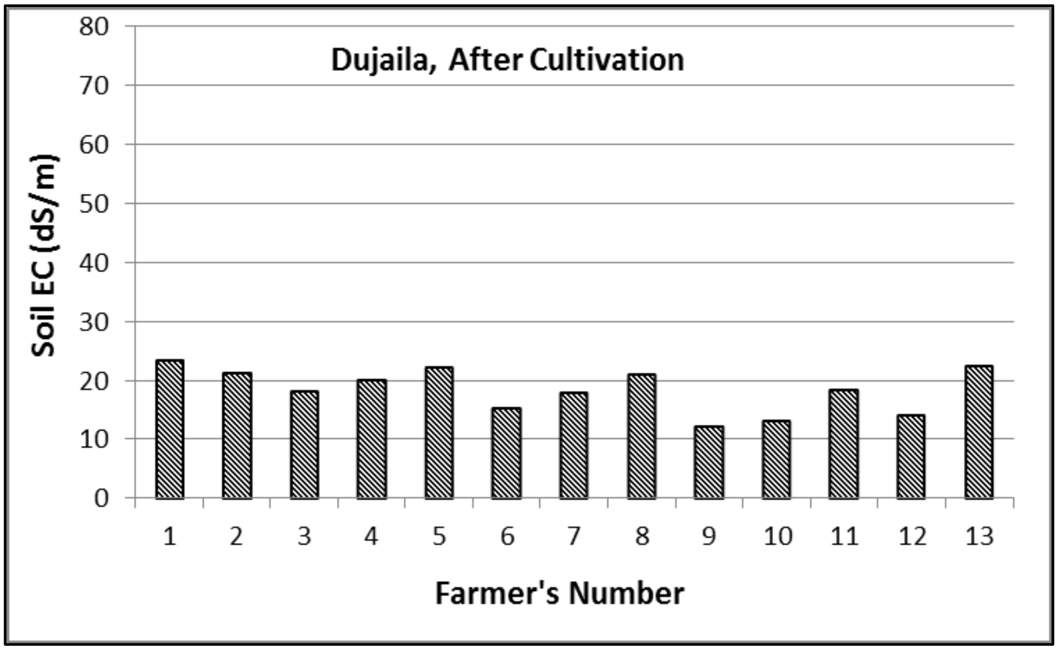
Fig. 13. Plowing of land during summer at Mussayab Site.

Fig. 14. Cultivation of vegetables in plastic house using a bed of manure and a sand layer at Abu-Alkhaseeb Site.

Table 7. Soil salinity before and after practicing of soil management tools and the associated practices at Site 1, Dujaila.

Farmer No.	Soil EC (dS/m)		% Reduction in Salinity	Type of Practicing
	Before+ practicing	After practicing		
1	62.8	23.4	62.7	Rotation + Preseason irrigation
2	70.4	21.3	69.7	Preseason irrigation + Plowing in summer
3	68.4	18.2	73.4	Subs soil plowing + Preseason irrigation
4	46.6	20.1	56.9	Rotation + Preseason irrigation
5	62.3	22.2	64.3	Mixing of plant residue + Plowing in Summer
6	34.7	15.2	56.2	Rotation + Preseason irrigation
7	32.6	18.0	44.8	Mixing of Plant residue + Preseason irrigation
8	49.3	21.0	57.4	Plowing in Summer + Sub soil plowing
9	38.6	12.2	68.4	Drainage + Rotation
10	43.6	13.2	69.7	Rotation + Preseason irrigation + Plowing in Summer
11	36.5	18.3	49.9	Preseason irrigation + Plowing in summer
12	42.3	14.2	66.4	Plowing in summer + Drainage
13	52.6	22.4	57.4	Preseason irrigation + Rotation

+ Soil salinity before initiation of the program.



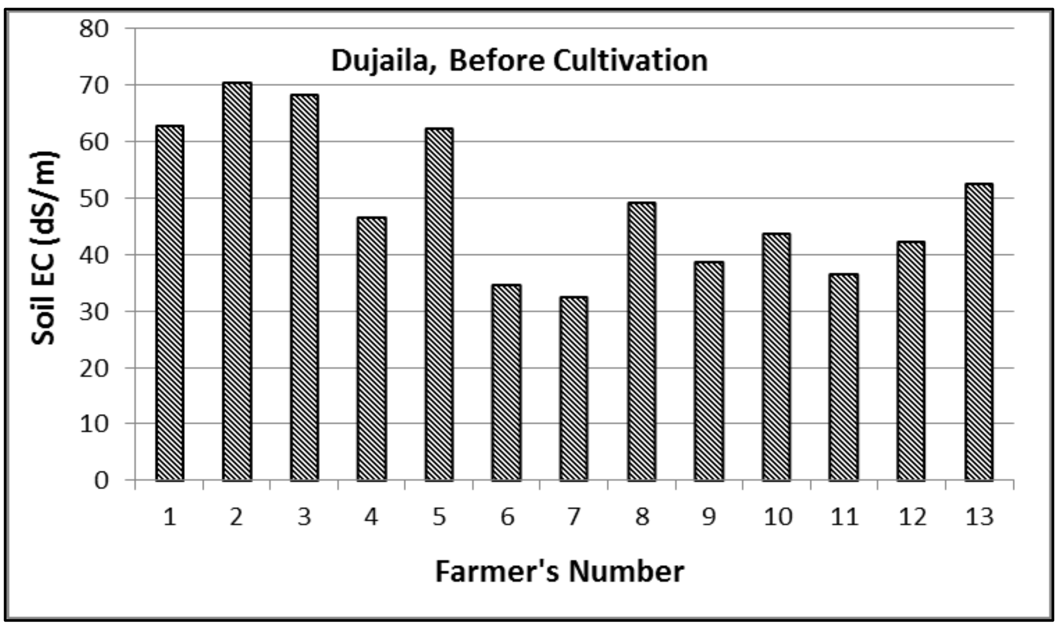


Fig. 15. Soil salinity before and after application of the recommended practices for the 13 farmers at Dujaila Site.

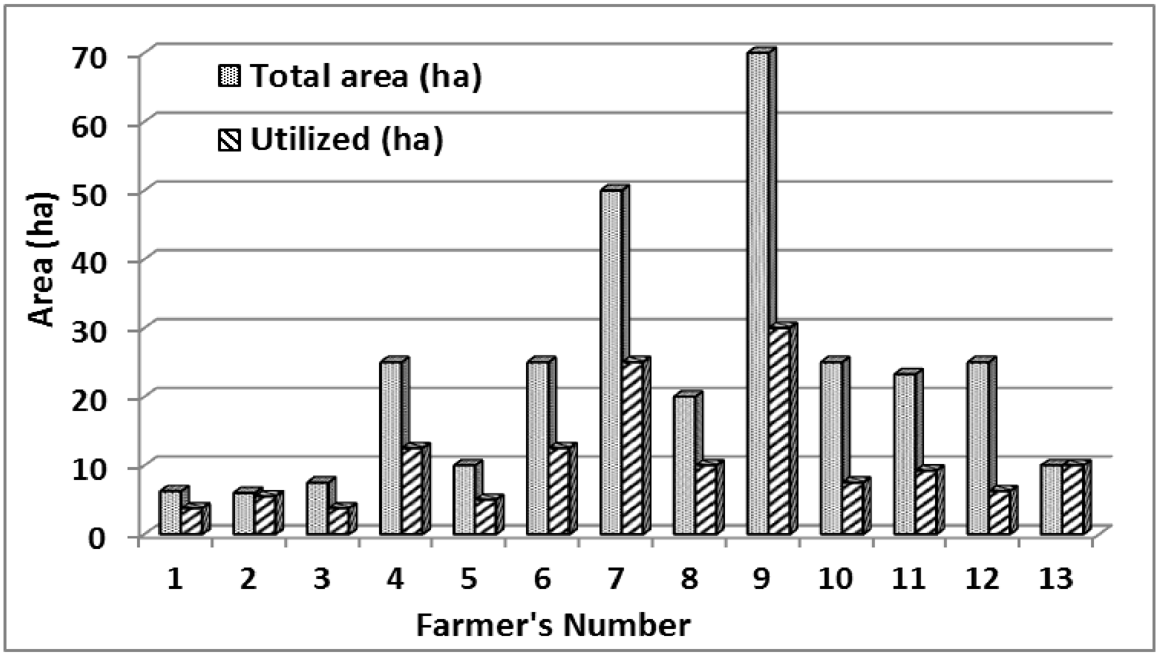


Fig. 16. Total area owned and utilized area at present time by outstanding farmers at Dujaila Site.

Table 8. Soil salinity before and after practicing of soil management tools at Site 2, Mussayab.

Farmer No.	Soil EC (dS/m)		% Reduction in Salinity
	Before+ practicing	After practicing	
1	72.45	11.43	84
2	84.60	8.34	90
3	103.95	7.01	93
4	17.57	13.23	25
5	28.64	5.81	80
6	---	---	---
7	110.40	10.52	90
8	63.90	14.30	78
9	63.60	4.70	93
10	19.20	8.94	53
11	29.55	11.70	60
12	24.90	8.19	67
13	68.40	28.35	59
14	28.50	5.27	82
15	83.25	17.81	79
16	10.41	8.19	21
17	18.90	13.80	27

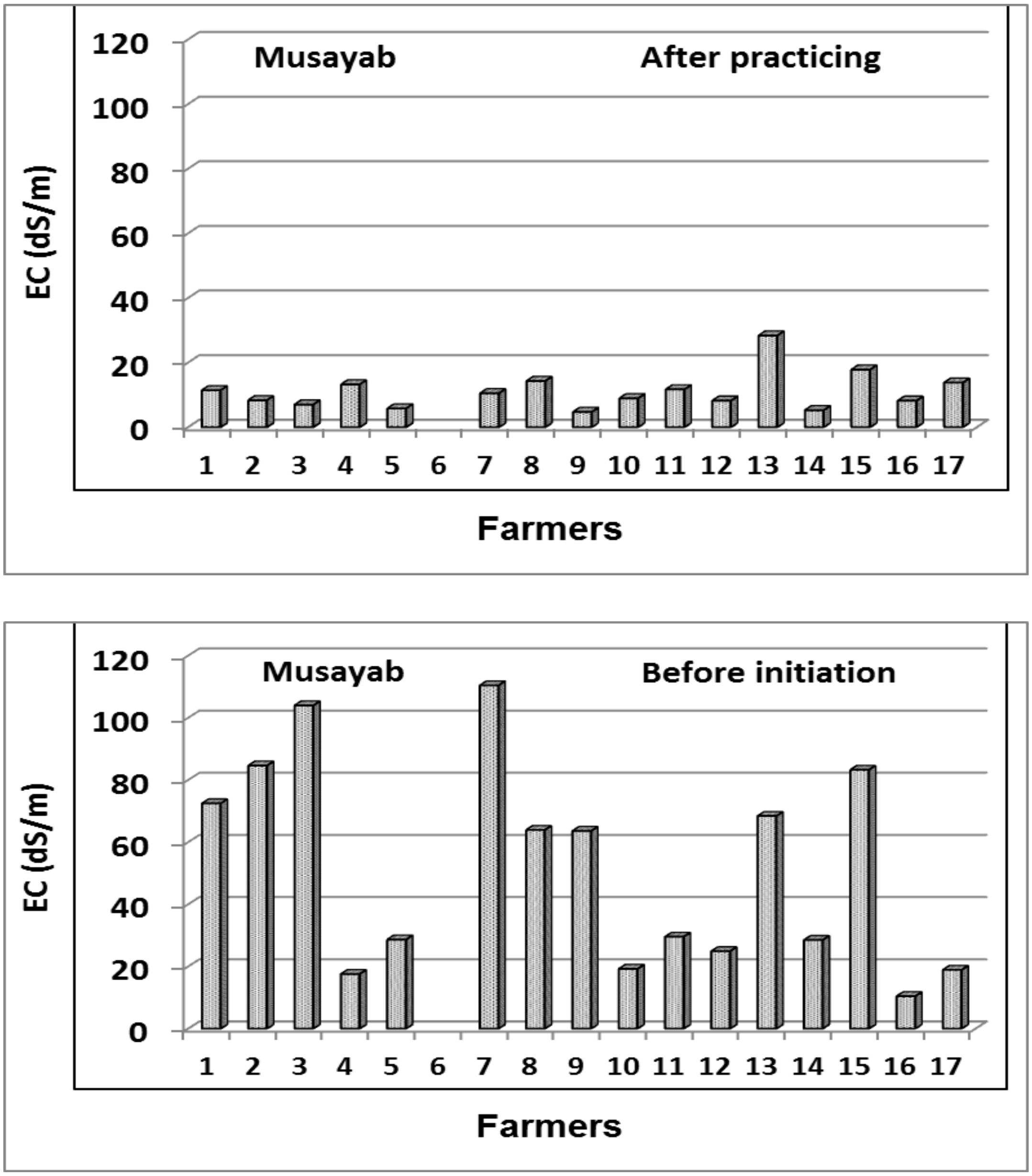


Fig. 17. Soil salinity before and after application of the recommended practices for the 17 farmers at Mussayab Site.

7.6 Cost-benefit analysis: Examples from outstanding farms

Based on analysis of survey data, five practices were used successfully by outstanding farmers and were adopted for this study. These included Crop rotation, mixing of crop residue, mulching, deep plowing, and local open drain. With the exception of deep plowing, and local open drain, others are in general relatively costless practices. They have been used by farmers with very nominal cost in cultivation of major crops and resulted in maximization of yields and profits. Therefore, the benefit/cost ratio will be very high. For deep plowing, it is implemented once every 4 to 5 years mainly to breakdown the hardpan subsoil. This constraint is very common in Iraqi soils and deep plowing helps improve soil environment and improve yield. Estimate of this operation is nearly $200/ha for the four-year cycle or $50/ha for each cropping season. Therefore, the benefit/cost ratio is still high and encouraging. For local open drain, it costs nearly $6000 for a field of 10 ha size. It is operated for at least 10 years with maintenance once every 3 years. From current situation of outstanding farmers, the average marketed yield reached 2 ton/ha during the first year and normally increases with successive season. The average income is $750/ton wheat or $1500/ton/ha for the first year of adopting the drainage system. The total income is nearly $15,000. For this practice, which is adopted by some outstanding farmers, the benefit/cost ratio will be encouraging on the medium- and long-term.

Tables 9-11 present examples of cost-benefit analysis of some recommended practices (deep plowing, rotation, and mixing of crop residue) of outstanding farmers at Site 1 and 2 in production of wheat. Costs are given for old ordinary practice as compared with the new management (using of recommended practices). It is evident that there was an increase in yield by 75% associated with Income Increase of $ 380 per hectare in practicing of deep plowing (Table 9). Similarly, the increase in yield was 125% and income by $ 1,977 with the practice of rotation (Table 10). In this respect, the income increase under rotation is a result of cultivation two crops. In practicing of mixing crop residue, the increase in yield was 80% and income $ 650/ha (Table 11).

Table 9. Cost-benefit analysis of land productivity of wheat for one hectare before and after adoption of recommended practices (deep plowing) by outstanding farmers at Site 1 (Dujala).

Practices	Old Management ($)	New management ($)
Input:		
1. Land preparation	300	350
2. Seeds	60	60
3. Fertilization	150	330
4. Herbicides	---	150
5. Irrigation	160	160
6. Harvest	80	80
7. Miscellaneous	50	50
8. Practice (Deep Plowing)		40
Total	**800**	**1,220**
Revenue:		
Yield (kg/ha)	1,600	2,800
Income	**1066**	**1,866**
Profit	**266**	**646**
Yield increase%	**75**	
Income Increase per hectare ($)	**380**	

Table 10. Cost-benefit analysis of land productivity of wheat for one hectare before and after adoption of recommended practices (rotation) by outstanding farmers at Site 1 (Dujala).

Practices	**Old Management ($)**	**New management ($)**
Input:		
1. Land preparation	300	350 + 100
2. Seeds	60	60+ 20
3. Fertilization	150	330 + 30
4. Herbicides	---	150
5. Irrigation	160	160 + 60
6. Harvest	80	80 + 40
7. Miscellaneous	50	50+ 20
8. Practice (Rotation: wheat, mung bean)	---	---
Total	**800**	**1,220 + 270 (1490)**
Revenue:		
Yield (kg/ha)	1,600	3,600 + 1600
Income	**1066**	**2,400 + 1,333 (3,733)**
Profit	**266**	**2,243**
Yield increase%	**125**	
Income Increase per hectare ($)	**1,977**	

Table 11. Cost-benefit analysis of land productivity for one hectare before and after adoption of recommended practices (mixing crop residue) by outstanding farmers at Site 2 (Musayab).

Practices	**Before Manage. ($)**	**New management ($)**
Input:		
1. Land preparation	300	350
2. Seeds	120	60
3. Fertilization	150	330
4. Herbicides	---	150
5. Irrigation	160	160
6. Harvest	80	80
7. Miscellaneous	50	50
8. Practice (Mix plant residue)	---	100
Total	**860**	**1,280**
Revenue:		
Yield (kg/ha)	2,000	3,600
Income	**1,330**	**2,400**
Profit	**470**	**1,120**
Yield increase%	**80**	
Income Increase per hectare ($)	**650**	

8 Conclusions

1. Farmers of the investigated sites are managing their saline land by adopting some practices from their own without the intervention of governmental or scientific establishments.
2. The adopted practices prove to be successful in reducing land salinity, improve land productivity, and thus maximize yields.
3. With the absence of infrastructures to lower the level of saline groundwater and improve irrigation systems, these practices seem promising in the short- and long-term in managing land salinity in central and southern Iraq.
4. Some successful practices can be disseminated among farmers of the region for better managing lands suffering from salinity.

9 Achievements and Outcomes

1. Sites representing low to medium levels of salinity identified and selected
2. Biophysical and socio-economic status of farmers in the selected areas analyzed, documented and shared with other components of the project
3. Progressive farmers identified, surveyed for their socio-economic status and best-bet practices using detailed questionnaires
4. Best-bet practices analyzed and promising practices short-listed for further testing, demonstration and cost-benefit analysis
5. Progressive farmers adopting best-bet practices engaged for demonstration of their farming practices as pilot farms to their peers
6. Cost-benefit ratios of the promising best-bet practices analyzed and documented
7. Trained component staff on use of EM38 salinity measurement equipment
8. Submitted a two-page flyer on component's achievements to integration component of the project
9. Submitted F2.4 and a 12-page conference paper-style document to Integration component for inclusion in Report 1 of the project

10 Proposed Follow-up Activities

1. Salinity is the major constraint facing agricultural production in central and southern regions of Iraq. In the absence and lack of conventional reclamation engineering work of salt-affected lands, implementation of the recommended practices (deep plowing, crop rotation, mixing of crop residues, mulching and local open field drainage) remain an effective and successful tool in improving soil environment and minimizing the effect of salinity. Therefore, the concept of "Recommended Practices in Cultivation of Saline Lands, RPCSL" can be expanded among farmers in the same area.

2. In the short- and medium-range and even in the long-range, the concept of RPCSL would lead to improve soil conditions of saline lands spreading in the central and southern regions of the country. Expanding implication of the concept of RPCSL to other Governorates rather than the currently involved 3 Governorates would be of prime importance in transfer of this technology.

3. Access to RPCSL may be treated as a key element for improving lands suffer from salinity. At the same time, it offers the chance to solve other problems related to farmers' standard living. For best transfer of these practices among thousands of farmers that need help and support, farmers' field schools (FFS) can be adopted for this project. The FFS is under way in some projects of national concern.

4. Subsurface drainage is practiced in parts of Iraq, and some fields currently under study have provisions for subsurface tile drainage. There are two main drawbacks of conventional subsurface tile drainage system: (1) it may contribute to losses of nutrients by leaching to groundwater, and (2) the water-table cannot be managed so there may be times when there is crop water stress due to low soil moisture in the rooting zone. A new, improved management practice called "controlled tile drainage" is more and more adopted in recent times and has shown promising effectiveness in reducing tile drain discharge and associated nutrients export, and improving crop yields by improved NUE and availability of soil-water during periods of stress. Drainage control is achieved by installing a gate at the end of each tile outlet. Gates are manually closed to stop movement of soil-water and accompanying nutrients and opened to release excess soil-water to improve aeration and timely planting. This technique can be implemented relatively easily in fields with already existing tile drainage systems. We propose to customize this management technique to regulate water table elevation and reduce salinity build-up in tile-drained fields of Iraq by flushing the excess salts before planting and then closing the gates to raise the water table elevation to levels within the root zone.

We envisage that the proposed two activities will help disseminate the message to a larger salinity-affected farmer community, mitigate salinity problem, and improve NUE and WUE leading to improved crop yields at lower inorganic fertilizer and irrigation water application levels.

11 Reference

FAO . 1998. Crop evapotranspiration, Irrigation and Drainage Paper No. 56. Rome. Italy.

Appendix 1

Survey sheet of Outstanding Farmers

Governorate:

Form number:

Farmer's name:

No.	ITEM	
1	**General Information**	
	1. District	
	2. Village	
	3. Location	
	4. Climate	
2	**Site Description**	
	1. Geographic boundaries	
	2. Area	
	3. Topography	
	4. Ownership	
3	**Field Data**	
	1. Soil Textural Class	
	2. Physical characteristics (aggregation)	
	3. Chemical characteristics	EC: pH:
	4. Water quality	EC: pH:
	5. Source of irrigation water	
4	**Agricultural Practices Adapted**	
	1. Levelling	
	2. Surface plowing	
	3. Sub soiling	

	4. Rotation	
	5. crops cultivated	
	6. Utilized area	
	7. Crop species adapted	
	8. Organic matter application	
	9. Mixing of plant residue	
	10. Seeding method	
	11. Irrigation method	
	12. Irrigation water quality	
	13. Irrigation, pre- season	
	14. Leaching requirement	
	15. Plowing in summer	
	16. Fallow	
	17. Machinery	
	18. No. of machines belong to farmer	
	19. No. of irrig. pumps	
	20. No. sprinkler irrig. systems	
	21. Distance from irrig. water	
	22. Removing of accumulated salts by drainage	
	23. Drainage water reuse	
	24. Crops cultivated	- Cereals: - Vegetables: - Forage: - Perennial plants:
	25. Current status soil salinity	
5	**Social Data**	
	1. Family members	

	2. No. Working members	
	3. Engagement of members in farm work	
	4. Education	
	5. Woman contribution in farm work	
	6. Standard living	
	7. Agricultural and non-agric. activities of farmer	
	8. Availability of irrigation water	
	9. Sufficiency of irrigation water	
	10. Land owner	
	11. Type of land holding	
	12. Role of Governmental Establishments	
	13. Role of extension	
	14. Role of NGO	
	15. Farmer's skils	
	16. Promising technologies to improve livelihood of farmers	
	17. Application of fertilizers according to recommendations	
	18. Application of pesticides	
	19. Biological control	
	20. Organic farming	
6	**Challenges and Constraints Facing Farmers**	
	1. Soil	
	2. Water - Distance to source	

	- Sufficiency	
	3. Crop	
	4. Standard living	
	5. Marketing	
	6. Communication	
	7. Decision makers	
	8. Other activities	
	9. Intension to initiate work and the need for support	
7	**Farm Revenue**	
	1. Crop return	
	2. Household income	
	3. Experiences in agric.	
	4. Type of housing	
	5. Reasons not to cultivate all lands	
	6. Selection of crop and variety	
	7. Source of fertilizers and pesticides	
	8. Selection of improved varieties	
	9. Animal grazing within the field	

Appendix 2
Component F: M&E Framework

Activity	Summary	Timeline																											Due	Code	Indicator	Status
		10	2011												2012												13					
		Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb				
F1	Data collection and surveys of farmers' practices in the selected sites - Desk analysis																												Aug-11	F1.1	Database is available on CD (external) and web portal (internal)	**Completed**
																													Jun-11	F1.2	Questionnaire that is ready for trialling in F1.3	**Completed**
																													Jun-11	F1.3	Successful Questionnaire ready for full implementation	**Completed**
																													31-06-2011	F1.4	Survey data complied into Database	**Completed**

																												Sep-11	F1.5	Report available on CD (external) and web portal (internal)	**Completed**
																												Oct-11	F1.6	Report available on CD (external) and web portal (internal)	**Completed**
F2	best-bet practices in terms of soil, agronomic, irrigation and social usages																											Oct-11	F2.1	Report available on CD (external) and web portal (internal)	**Completed**
																												Oct-11	F2.2	Report available on CD (external) and web portal (internal)	**Completed**

																													Oct-11	F2.3	Report available on CD (external) and web portal (internal)	**Completed**
																													Dec-11	F2.4	Report available on CD (external) and web portal (internal)	**Completed**
F3	Demonstration and communication of best-bet practices																												Oct-11	F3.1	Report available on CD (external) and web portal (internal)	**Completed**
																													Oct-11	F3.2	Report available on CD (external) and web portal (internal)	**Completed**

																													Jun-12	F3.3	Measurements are complied into database for comparison against other farmers	**On going**
																													Nov-12	F3.4	Field day organised with (#) farmers participating.	**On going**
F4	development for further implementation																												Nov-12	F4.1	Document available on CD (external) and web portal (internal).	**Not started**
																													Dec-12	F4.2	Report available on CD (external) and web portal (internal)	**Not started**

Sep-12	F4.3	Report made available for F4.5	**Not started**
Sep-12	F4.4	Report made available for F4.5	**Not started**
Feb-13	F4.5	See compone nt I	**Not started**