Final report

A National Framework for Salinity Management

The Case of Iraq Agriculture

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1 Acknowledgments

This report is the result of more than two years of hard work by representatives of five ministries in Iraq led by the Ministry of Agriculture (MoA), Government of Iraq and upported by a consortium comprising the International Center for Agricultural Research in the Dry Areas (ICARDA) (lead), the Commonwealth Scientific and Industrial Research Organisation (CSIRO), the University of Western Australia, the International Water Management Institute (IWMI), and the International Center for Biosaline Agriculture (ICBA). More than 50 scientists were involved in the project activities.

2 Executive summary

This final report synthesizes the results of the Iraq Salinity Project, a research partnership between five Iraqi ministries and national agencies and an international team of researchers, led by ICARDA, specializing in land and water management, crop improvement and plant breeding, geoinformatics, and socioeconomics.

This research builds on previous work and technical studies done in Iraq and on the expertise of Iraqi agencies working to promote agricultural development over the past decades. It provides solutions based on the analysis of historical data and new data compiled in the Iraq Salinity Project and provides methods of implementation to reduce salinity, or reduce the impact of salinity on agriculture and the environment in Iraq.

The solutions and implementations presented in the project documents are a synthesis of a body of research. This research includes field-level and technical studies in southern and central Iraq, a new body of data and information collected and compiled by the research team, and a series of technical and background papers.

Three synthesis reports were compiled based on technical and socioeconomic assessments at multiple scales. Each report represents a stage in the process of analysis:

- Stage 1/Report 1: Overview and scope of the problem
- Stage 2/Report 2: A detailed analysis of the problems and potential solutions and development of a framework for a national, integrated approach to salinity management in Iraq
- Stage 3/Report 3: Investment options to support a long-term strategy of soil and water salinity management in Iraq.

Activities in the project can be summarized as:

- A multi-scale focus – from the farm to the irrigation project, to the whole of the Mesopotamian plain
- A 'bright spots' approach – working with farmers to understand their practical approaches to fighting salinity at the field level and studying ways to scale-up these innovations for use by many other farmers
- Use of soil–water–plant modeling to determine optimal irrigation water allocations to control water tables and soil salinity
- Assessment of optimal solutions for refurbishing irrigation and drainage infrastructure
- Testing new varieties of salt-resistant crops to be used in Iraqi farming. This includes forage crops, which can bring increased income to communities living in areas with degraded soils
- Investigation of the socioeconomic impacts of soil salinity on farmers and national agricultural production
- Mapping of soil salinity and river salinity in the Tigris and Euphrates river basins.

The project's key findings are:

- Virtually no areas are left unaffected by soil salinity and a large amount of agricultural land is lost to salinity each year. Irrigation efficiency is very low mainly because of the degraded irrigation and drainage infrastructure. Farmers of saline soils are using only 30% of their land for cropping and are achieving only 50% of the expected yields leading to losses of approximately USD 300 million per year as a result of salinity

- Salinity in Iraq is a complicated and ongoing issue and short-term projects (for two to three years) will not solve the problem in the long term. No comprehensive study has been undertaken to assess the extent of irrigation-induced salinity. The monitoring network to record spatial and temporal changes and characterize the salt-affected soils in the different parts of the country is almost non-existent
- Irrigation delivery and drainage infrastructure need to be modernized at the irrigation command level and integrated into a broader regional framework. The water allocation requirements for different crops should be revised so that the amount of water applied by farmers is based on crop needs, not infrastructure capacity.

Based on the above, the following recommendations are made by the project team:

- Our data indicates that the salinity of water entering Iraq appears to have been stable since the 1980s. The increases in river salinity occur within Iraq. The increase in salinity in the lower reaches of the Euphrates River – and most probably the Tigris River as well – is derived predominantly from irrigation drainage and saline groundwater. This situation provides excellent opportunities for the Government of Iraq to invest in measures that will halt and even reverse the salinity trends in these rivers
- In many cases, achieving change at the individual farm level is unlikely to result in much change to this regional scale problem. Investment in rehabilitation of the irrigation and drainage infrastructure is urgently required. However, these works, especially drainage works, should consider the downstream effects on water quality
- It is important that the approach to managing salinity in the rivers is done in coordination with investments in drainage infrastructure for the irrigated areas. These actions to control soil and river water salinity need to be taken soon and as part of a comprehensive framework that prioritizes the measures that will deliver the greatest benefit for the least cost
- Rapid classification of land capability, with parallel testing of new plants, will allow government agencies to develop timely management recommendations for farmers. Where halophytic forages are the only option, transfer of knowledge as regards livestock feeding will be required
- To improve farm productivity under saline agriculture it will be necessary to create mechanisms for direct farmer participation in the development, evaluation, extension, and monitoring of technologies, and that highlight livelihood-enhancing and employment-generating opportunities for farm families. Such an approach needs to include a clear understanding of and planning for changes in the mix of farm enterprises associated with irrigated areas and saline lands
- The evolution of systems from mostly crop to mixed crop and forage production may be positive for farmers. Many farmers in the irrigated zone have some livestock already. Livestock production can provide significant new income for the very poor, so the development of systems of adaptation that focus on the integration of crop and livestock systems will have major benefits for disadvantaged people
- Coordination of actions within a National Salinity Management Framework for Iraq is required. A coordinated and concerted approach to salinity management across the three scales (farm, scheme, and region) is the outcome desired by this project.

3 Background

Iraq's agricultural sector is a vital component of the country's economy as it is the largest employer (30% of the labor force) and the second largest industry after oil. Agriculture contributes 7.6% to gross domestic product (GDP) (MoA 2012). Please note that the contribution of agriculture decreased during the period 2003 to 2007 from 14% to 9.2% (Ministry of Planning, 2010). The 2010–2014 national development plan calls for an expected decrease to 6% of GDP in 2014; this despite a proposed investment of USD 9.5 billion in the sector, representing 9.5% of the total investment plan for the period 2010-2014.

Iraq is divided into a rain-fed northern winter grain producing zone and a central and southern irrigated zone that produces vegetables, fruit, and cereals. In the central and southern parts of the country, salinity has long been identified as a major threat to agriculture and has led, in the past, to policies aimed at improving irrigation and drainage practices. Since the 1980s, Iraq's extensive irrigation infrastructure has fallen into disrepair and soil salinity has spread across much of the irrigated areas of central and southern Iraq.

Salt-induced land degradation is a major constraint for agricultural production and the environment. According to the Food and Agriculture Organization of the United Nations' (FAO) estimates, approximately 75% of the total irrigated area of Iraq (more than 2 million ha) is moderately saline and another 25% has levels of salinity that have converted once productive lands into salt-affected wastelands.

The groundwater level underlying the irrigated areas is shallow with normally high salinity levels. Over the long history of irrigation, these shallow groundwater levels and salinities have been further exacerbated.

In recent years, redevelopment of the agricultural production sector has been given a high priority by the Government of Iraq to improve the livelihoods of the rural communities, enhance food security, and decreased dependence on the import of agricultural commodities. Water and land resources are the first two items listed in the MoA strategy document (MoA 2012).

4 Objectives

The project's aim is to assess the drivers of salt distribution and soil and irrigation water salinity at different scales, and to develop methodologies for salinity control and productivity enhancement. The ultimate goal is the achievement of better livelihoods through the improved and sustainable use of available water and soil resources in central and southern Iraq.

The project has four defined objectives:

- Develop a robust conceptualization of the salinization processes in central and southern Iraq based on information available on salinization at the field and basin level and quantify the salt and water fluxes and areas affected by salinity
- Determine appropriate strategic approaches to manage salinity that suit local environmental and socioeconomic conditions
  Assess key productivity limitations to and opportunities for irrigated agricultural systems
- Develop investment options for ongoing salinity management in Iraq.

The project objectives have been addressed at three spatial scales – regional, irrigation project, and farm. Ten project components were formed, each with its own work package. Six components (A through F) studied the technical issues of the salinity-related aspects (two at each spatial scale). One component (G) studied the socioeconomic aspects related to all three scales with strong interactions between the six technical components and the socioeconomic one. Three other project process components (H through J) were implemented – a training component, an integration component, and a communication component.

The project component objectives are:

- Quantify the spatial distribution of soil salinity based on information available on salinization at the field and basin levels and determine its causes in central and southern Iraq (Component A)
- Describe the qualitative and quantitative trends in river and drainage water for central and southern Iraq (Component B)
- Quantify and describe the relationship between groundwater levels, groundwater salinity, and irrigation activity (Component C)
- Assess the current state of irrigation and drainage infrastructure (Component D)
- Demonstrate best-bet practices for different salt-tolerant crops, crop varieties, and fodders (Component E)
- Develop methodologies to improve soil, agronomic, irrigation water, and drainage management for salinity control (Component F)
- Identify and measure the impacts and analyze the socioeconomic and policy constraints and opportunities for the effective use and remediation of saline land and water resources in central and southern Iraq at the basin, irrigation project, and farm scales (Component G)
- Build the capacity of the Iraqi researchers involved in the project (Component H)
- Integrate the project by harmonizing the component outputs and outcomes in the project documents and objectives, developing investment options and engaging with donors (Component I)
- Build the teams and build the network in Iraq, thus ensuring the sustainability of the activities in the post-project phase. Support stakeholder involvement in implementing the project-provided solutions to reduce the salinity impact on agricultural production (Component J).

5 Methodology

The project used 10 work packages to move towards the project objectives. Seven components had their own work plans and methodologies, while three components were implemented at the project level.

5.1 Spatial focus of work

Components A and B focused on the regional scale, describing soil salinity, water salinity, and flows for the Mesopotamian plain – the relatively flat area where the Tigris and Euphrates Rivers flow through and converge to form the Shat Al Arab.

In addition to the regional analysis of soil salinity, Component A also focused on three selected pilot irrigation projects, Dijilah, Mussaieb, and Abu Al-Khaseeb. This project level focus was needed to obtain field validation data. Because of security issues in Iraq, it was not possible to collect region-wide field data.

Component B restricted its analysis to water salinity and flow in Iraq and did not incorporate any transboundary water and salt issues into its work. The rationale for this restriction was that the project sought to provide solutions for implementation in Iraq by the Government of Iraq without the need for international agreements. But this restriction does not imply that solutions are restricted to in-country activities alone.

Components C and D focused on three selected pilot projects for data collection and analysis. The three irrigation projects were selected to provide a range of salinity problems, from medium salinity impact (Mussaieb) to high salinity impact (Dijilah) to extremely high salinity impact (Abu Al-Khaseeb). The locations of the irrigation projects were representative:

- Mussaieb, in the northern part of the Mesopotamian plain, with a very reliable source of water from the Euphrates
- Dijilah with a medium reliable source of water from the Tigris River in the central part of the Mesopotamian plain
- Abu Al-Khaseeb in the Shat Al Arab with a highly saline water resource of low reliability in the southern part of the Mesopotamian plain.

Components E and F focused their activities on field-level implementation, with targeted fields in the three irrigation projects. The variations in the levels of soil salinity between the three projects allowed for the testing of the abilities of a multitude of crop types and crop varieties to adapt to salinity under field conditions. Additional demonstration sites were set up to show best-bet practices to combat salinity.

Component G used the three irrigation projects to collect socioeconomic data. Policy analysis focused on the agricultural sector in Iraq, with special emphasis on irrigated agriculture.

Components H, I and J were project process components, and did not have a location-specific focus.

5.2 Methodology

Component A used a combination of geospatial and field data collection tools to develop an understanding of the spatial distribution of soil salinity in the Mesopotamian plain. The geospatial analysis used two approaches. One, a statistical approach using a variety of indicators linked to field measured soil salinity data, and the other an agricultural production based analysis where the changes in production in irrigation projects were used as indicators of soil salinity.

Additional historical soil salinity data were collected for the three target irrigation projects to provide insights into the temporal changes of soil salinity. Geospatial layers of information were collected to enable an analysis of the large-scale processes contributing to salinization.

Component B focused on the water and salt flow through the Mesopotamian plain and collected water flow and water salinity data for the Tigris and Euphrates systems. These data were analyzed and combined with that from a remote sensing analysis of agricultural production and with historical agricultural production values. The linkages between water quantity and quality and agriculture production, including the historical perspective of production, were used in an attempt to link the multiple variables influencing agricultural production and to understand the influence of salinity on the decline in crop production. To describe the steps needed to develop a salinity management framework at the scale of the Mesopotamian plain, an institutional analysis of the Iraqi water and agricultural sectors was envisioned as a project activity. This was combined with the policy analysis conducted in Component G and the activity within Component B shifted to a further clarification and explanation of the development and implementation of a salinity management framework such as exists in the Murray-Darling Basin in Australia. Another adjustment in the focus of Component B was that the development of a 'draft water quality framework for basin wide management' was deemed impossible, since the development of a framework itself is part of the process of managing salinity and should involve the main political representatives of the relevant ministries of the Government of Iraq. The objective to develop a framework was reduced to describing the process needed in Iraq to develop a salinity management framework (using the Murray-Darling Basin approach as a successful example).

Component C focused on the relations between groundwater level, salinity, and irrigation. To evaluate current practices against 'optimal' ones to reduce salinization of the root zone, the soil–water–atmosphere–plant (SWAP) model (Wageningen University, Netherlands) was used. Based on field measurements at two of the three selected irrigation projects, multiple scenarios were simulated to find the optimal irrigation application depths for a variety of crops, as well as the optimal groundwater level targets.

Component D evaluated the irrigation and drainage infrastructure at the irrigation projects through the use of field visits, photographs, and discussions with farmers. In addition, historical design plans and maps were collected and reviewed. Based on the collected information on the current status of the infrastructure, suggestions were made for rehabilitation in the form of an investment plan.

Component E focused on selection of the optimal crop type and variety. The testing of crop types and varieties focused on three main themes – cereals, forages, and halophytes. Please note that the cereals are winter crops, while the forages and halophytes are perennial ones. The locations of the evaluation trial sites were selected for their soil salinity ranges (e.g. 10–20 dS/m and 20–30 dS/m bracket Abu Al-Khaseeb and the lower soil salinity ranges in Dijilah). With three test sites, two seasons per site, three categories of crops, and several varieties per category, a very large number of plant samples and soil samples were taken and analyzed.

Component F searched for the best-bet soil, agronomic, irrigation, and drainage management strategies to improve conditions related to salinity. The focus of the best-bet practices was on improved irrigation management, as was suggested by the analysis in Component C. Improved irrigation practices were demonstrated, including laser leveling and gated pipe irrigation. Several other practices were recommended based on an evaluation of existing 'progressive farmers' in each of the three selected project sites.

Component G used a dual spatial focus approach to the socioeconomic analysis. One focus was on the institutional aspects of salinity problems in agriculture, applying policy analysis at the government level. This activity included the shared activity listed in Component B. In the other focus at the farm scale, more than 600 surveys were conducted in the three project areas to obtain the farmers' view on the salinity problems, their solutions, and the constraints to increasing their production. The survey also collected data on their farming systems. An analysis of these surveys enabled comparison of the socioeconomic conditions related to agricultural production at the three project sites.

Component H involved the training activities of the project. Training was conducted by the technical and socioeconomic components (A through G) and the main role of Component H was to coordinate, facilitate, and ensure integration between the components on the level of capacity building. Several of the project's training sessions allowed for participation by the different components thus aiding in the integration of activities of the project.

Component I dealt with the integration of project components; attempting to ensure harmonized messages came from the project activities. The main approach of the integration component was to combine the results from the components into three project level synthesis reports. The three reports at the project level were designed to flow logically from knowledge to analysis to identification of investment options. The first synthesis report focused on the current status of water and soil salinity at basin and field levels, agricultural production, irrigation and drainage infrastructure, and socioeconomic status. The second synthesis report contained the proposed solutions at different spatial scales. The first and second reports have large amounts of technical and socioeconomic content and were the basis for the third report. The third report targets the Government of Iraq and the international donor community and identifies potential areas for investment in agriculture to reduce the impact of salinity. Please note that the original project document identified a separate component to develop investment options. The activities of this component have been included in the integration component (I) and the communication component (J).

Component J is the communication component with three different target audiences. One aspect of the component is to allow optimal communication within the project through the use of data portals and discussion sites. This activity complements the meetings of the project technical committee and the regular component meetings. A second aspect is communication to the broader public to raise awareness of the salinity problem in Iraq and the solutions that the project has suggested to reduce the salinity impact in agriculture. This is done through the use of the internet, newspaper articles, and workshops in and outside Iraq. The third aspect of the Component's work is to reach out to the Government of Iraq and the international donor community. The aim was to ensure adoption of the suggested vision for future action in salinity management at the three identified spatial levels in Iraq by detailing and explaining the project's results and recommendations.

5.3 Partners and stakeholders

The project team consisted of five Government of Iraq ministries and five international consulting institutions, The team of ministries was led by the MoA, with support from the Ministry of Water Resources, Ministry of Higher Education, Ministry of Science and Technology, and Ministry of Environment. The international component of the consortium was comprised of ICARDA (the lead institution), CSIRO, University of Western Australia, IWMI, and ICBA. More than 50 individual scientists were involved in the project execution.

The stakeholders were broadly constituted and included the partner ministries involved in the project team, representatives of governorates, local representatives of the ministries involved in water management and agricultural development, as well as national and local universities. Farmers were identified as indirect stakeholders in the development of the salinity management strategies, but as direct stakeholders in the field-based interventions. It has been suggested that the local universities, located in the governorates where the field-based activities took place, need to be involved more in future activities, since these institutes play an important role in the capacity development of the future local decision makers, extension service employees, and farm-related industries.

6 Achievements against activities and outputs/milestones

Objective 1: To quantify the spatial distribution of soil salinity based on information available on salinization at the field and basin levels and its causes in central and southern Iraq

No.	Activity	Milestones	Outputs	Comments
1.1	Quantify the spatial distribution of soil salinity – based on information available on salinization at the field and basin levels – and its causes in central and southern Iraq	1.Relevant remote sensing salinization models that can be disseminated to other regions with similar conditions	Two reports describing methods to estimate soil salinity at the level of the irrigation project, and at the level of the Mesopotamian plain. First report describes the methods, and the second describes the validation of the methods. The Mesopotamian plain analysis indicates that the area with salinity greater than 15 dS/m increased by 10% from 2000 to 2010. However, a year-by-year analysis shows large fluctuations of vegetation cover (both decreases and increases) likely related to other causes than salinity alone	Technical reports 1 and 2
1.2		2. Database of field-mapped soil salinity, and a soil archive	Geographic information system (GIS) layers were compiled for the selected irrigation projects, as well as for the national level Soil salinity data were collected and stored in Excel sheets EM38 data were collected at different times and locations	Technical report 3 includes list of the GIS layers collected
1.3		3.Multi-scale and multi-temporal maps of the spatial distribution of soil salinity	A set of maps was created for the irrigation projects and the Mesopotamian plain showing changes in estimated soil salinity over time	Technical report 4 shows the maps that were developed. Report 5 provides a survey of the saline lands in the Mesopotamian plain

Objective 2: To describe the qualitative and quantitative trends in river and drainage water for central and southern Iraq

No.	Activity	Milestones	Outputs	Comments
2.1	Qualitative and quantitative trends in river/drainage water and agricultural productivity	1. Report on historical changes and current status in terms of quality and quantity of river and drainage water, and sources of salt	A water and salt balance was developed for the Tigris and the Euphrates Rivers, providing some insight into the sources of water-transported salts. It was identified that, at least in the past, the management of Lake Tharthar resulted in a large transfer of salts into the Euphrates' water system. It was concluded that groundwater –surface water interaction and its contribution to salt mass was limited to the lower reaches, with currently less monetary benefits from groundwater interception schemes	Technical reports 6 and 7
2.2		2. Determination of the impact of water availability on current and future agricultural productivity	The study shows fluctuations in irrigated agricultural production in the past that are influenced more by political events and interventions than by water availability or soil salinity. It shows that water availability and soil salinization effects are difficult to differentiate through regional assessment, and need additional ground-based reliable water delivery data. While water availability has an effect on the ability to manage salt accumulation in the root zone, a lower availability of water as foreseen through upstream agricultural development will result in less land available for the optimal production of conventional summer and winter crops	Technical report 8

No.	Activity	Milestones	Outputs	Comments
2.3	Qualitative and quantitative trends in river/drainage water and agricultural productivity	3. Identification of policy and institutional arrangement constraints to sustainable resource management	The report discusses agricultural policy developments in the recent history of Iraq. It shows that farming systems transitioned from state-owned systems into privately owned ones. The system is still in transition through the strong influence of the government on the cropping systems and crop prices. Farmer associations have been adversely affected by national and international political events and efforts are underway to re-establish farmer-based organizations	Technical report 9
2.4		4. Draft water quality framework for basin wide management	During the progress of the project, it was confirmed that it is not possible to develop a salinity management framework by an external project. The process of development has to be conducted by the national government and the national and local stakeholders. To show an example of the process, the process and results in the Murray-Darling Basin were recorded in a report, and the process towards a salinity management framework was described	Technical reports 10 and 11

Objective 3: To quantify and describe the relationship between groundwater levels, groundwater salinity, and irrigation activity

No.	Activity	Milestones	Outputs	Comments
3.1	Quantify and describe the relation between groundwater level, salinity, and irrigation	1. Information on the current status of groundwater levels, groundwater salinity, irrigation practices, and their impact on crop production and environmental degradation	Field-based interaction between soil, water, plant, and atmosphere were analyzed through modeling. The main conclusion is that over-irrigation of crop water demand occurred, and through scenario modeling, optimal water applications and groundwater depths are provided	Reports 12 and 13
3.2		2. Guidelines for farmers on irrigation requirements of different crops under different groundwater depths and soil salinity levels		
3.3		3.Multi-scale and multi-temporal maps of the spatial distribution of soil salinity		

Objective 4: To assess the current state of the irrigation and drainage infrastructure

No.	Activity	Milestones	Outputs	Comments
4.1	Assess the current state of irrigation and drainage infrastructure	1. Description of state of irrigation and drainage infrastructure and its condition across different regions	An inventory of the hardware of two irrigation systems was made during the project and recorded in a report. Please note that the Ministry of Water Resources started improving the hardware during and after the inventory was made	Report 14
4.2		2. Investment plans for pilot scale investments developed	Based on the hardware inventory, an estimate of the investment needed for improvement of the infrastructure was developed and listed	Report 15

Objective 5: To demonstrate best practices for different salt-tolerant crops, crop varieties, and fodders

No.	Activity	Milestones	Outputs	Comments
5.1	Demonstrate the best-bet practices for different salt-tolerant crops, crop varieties, and fodders	1 Identification of better salt-tolerant genotypes of existing crops and forages for salt lands (Syrian trials)	Activities to contribute to objective 5 focused on forages and halophytes; their interaction with soil, salt, and water and their feeding values for small ruminants. Several varieties were tested and results were compiled on their performance. Feeding value was evaluated. The reports present the findings of the field studies and laboratory results	Reports 16 and 17
5.2		2 Understanding of soil/water variability characteristics as related to productivity (Syrian trials)		
5.3		3. Selection of crop management practices for salt-tolerant plants (Syrian trials)		
5.4		4. Identification of the strengths and weaknesses of selected salt-tolerant crops, forages, fruits, vegetables, and others for salt-affected lands (Iraq trials)		
5.5		5. Selection of crop management practices for salt-tolerant plants		
5.6		6. Identification of the strengths and weaknesses of salt-tolerant forages and halophytes for livestock		
5.7		7. Selection of crop management practices for salt-tolerant plants		
5.8		8. Scoping potential of salt-tolerant halophyte forages for livestock systems		

Objective 6: To develop methodologies to improve soil, agronomic, irrigation water, and drainage management for salinity control

No.	Activity	Milestones	Outputs	Comments
6.1	Develop approaches to improve soil, agronomic, irrigation water, and drainage management for salinity control	1. Identification of best soil, agronomic, irrigation, and drainage management practices for salinity management at the farm level under current conditions	Through farmer surveys, coupled with the yields they obtained, farmers were selected for an inventory of farm-based interventions. This indigenous knowledge on interventions was collected and described. Best-bet practices were selected for demonstration sites and field days were organized to provide other farmers with examples of good management practices	Reports 18 and 19
6.2		2. Demonstration of the best-bet practices to farmers		Report 20
6.3		3. Extension and adoption plans to promote these best practices to a wider group of farmers		
6.4		4. Research plans to further develop these best practice techniques for future funding		

Objective 7: Analysis of the socioeconomic and policy constraints and opportunities for the effective use and remediation of saline land and water resources in central and southern Iraq at the basin, irrigation project, and farm scales and to identify and measure their impacts

No.	Activity	Milestones	Outputs	Comments
7.1	Socioeconomic and policy	1. Farm household characterization in the target districts	Several farm surveys were conducted at the four project sites. Results of the surveys and their analyses are presented in the reports. Main conclusion was that the more saline the soil, the less important agricultural income is in the overall family budget. Families in the south of the Mesopotamian plain obtain larger amounts of their income from other sources, including grazing. Agriculture in the south is more intense and focuses on water saving techniques like green-houses. SWOT analyses has been conducted on institutions and policy processes, and are presented in report 24	Technical reports 9, and 21, 22, 23, and 24
7.2		2. The impact of salinity on livelihood patterns analyzed and the economic costs of salinity estimated		
7.3		3. Socioeconomic benefits of technology options for saline agriculture assessed		
7.4		4. Documentation of current water management, institutional arrangements, and policy, their strengths and weaknesses and options to overcome policy and institutional constraints identified		
7.5		5. Socioeconomic, agronomic, technological, institutional, and policy drivers of salinity identified		

Objective 8: Build capacity of Iraqi researchers involved in the project

No.	Activity	Milestones	Outputs	Comments
8.1	Capacity building	Build capacity of Iraqi researchers involved in the project	A total of 21 training courses generated 1185 man-hours of capacity building – 12 training courses in 2011, 5 in 2012, and 4 in 2013	

Objective 9: Project integration to harmonize the component outputs and outcomes into the project documents and objectives, developing investment options and engaging with donors

No.	Activity	Milestones	Outputs	Comments
9.1	Collate information from key component activities	Drafts of key outputs from components	Finalize synthesis report 1 and distribute	Completed in 2012 and available on project website
9.2	Collate information from key component activities	Drafts of key outputs from components	Finalize synthesis report 2 and distribute	Completed in 2013
9.3	Collate information from key component activities	Drafts of key outputs from components	Finalize synthesis report 3 report and distribute	Completed in 2013

Objective 7: Analysis of the socioeconomic and policy constraints and opportunities for the effective use and remediation of saline land and water resources in central and southern Iraq at the basin, irrigation project, and farm scales and to identify and measure their impacts

No.	Activity	Milestones	Outputs	Comments
10.1	A web portal for communication within the project team		Team space for project team	Project team space, for exchanging information between project teams, created in March 2011
10.2	A website for public communication of the project aims, progress, and outputs		Web page	Created on the ICARDA website in 2012 Additional Iraq Salinity Information Platform created in 2012 to serve as a repository for all project information http://iraq-salinity-platform.icarda.org
10.3	Develop an action plan that specifies key audience groups, influence pathways, and communication products to be created		Action plan	Action plan for key audience groups, influence pathways, and communication products was finalized in late June 2011 and mapped to the Iraq Salinity Project cycle An international media and advocacy campaign, developed by the communications team with a global media relations company, was not implemented, as project management felt the cost was too high National communication and national media and information activities were planned, but not implemented as a suitable local staff member was not identified. Three candidates were interviewed; two highly qualified candidates were offered consultancies to manage media and the end of project meeting. Both declined as the salary offered was below their expectations The end of project advocacy meeting and dialogue between policy makers, line agencies, and donors was planned, but not held because of a decision by the project management
10.4	Develop general information material; Call for partners' information; Develop background information and media material; Regular project updates		Call for partners' brochures Media information 10 project summary sheets – English and Arabic	Develop general information materials, such as a project brochure prepared in English (printed) and Arabic (in progress) http://iraq-salinity-platform.icarda.org/Documents/call%20for%20action_adjusted.pdf

No.	Activity	Milestones	Outputs	Comments
10.5	Create global contact list of key target groups		Key contacts list created	List ready for use in January 2012 6 global information broadcasts sent
10.6	Create Iraq contact list of key target groups		Iraqi contact list	Not done. Iraqi project partners did not provide the information, but preferred to distribute materials to their contacts directly
10.7	Create the synthesis report/policy brief of the final research and related information		Synthesis report 1. Situation analysis and assessment Synthesis report 2. Solutions Synthesis report 3. Investment options	Published and promoted in 2012 Published and promoted in 2013 Drafted in 2013, to be uploaded to website very soon.
10.8	Meetings/workshops with donor agencies and development partners		Face-to-face briefings held by project leader and head of communications with representatives of the embassies of Sweden, Germany, UK, Italy, France, and US in Amman	

No.	Activity	Milestones	Outputs	Comments
	Additional outputs delivered which were not part of the initial plan		**27 technical reports** that captured the work in progress of all research components – see: http://iraq-salinity-platform.icarda.org/ www.icarda.org/publications	27 technical reports synthesized the work in progress in the 10 project components. These were not initially planned and were the initiative of the head of communication (Michael Devlin) and the science coordinator (Evan Christian), as a way to capture and share work in progress as global public goods. Development of salinity models by remote sensing in central and southern Iraq. Quantify the spatial; distribution of salt-affected land in central and southern Iraq. List of recent and historical data collected by Component. A multi-temporal salinity mapping in the pilot sites and Mesopotamian region. Quantifying the spatial distribution of salt-affected land in central and southern Iraq. Report B1.4: Water and salt trends and balances for the Mesopotamian plain. Hdrogeology of the Mesopotamian plain. Historical agricultural production data in Iraq. Agricultural policies and institutions in Iraq – a historical perspective. Salt management: the Australian experience. Guide-lines for a salinity management framework in Iraq. Understanding the linkages between groundwater table depth, groundwater quality, soil salinity, and crop production in Al-Mussaieb and Al-Dijilah project areas of Iraq. Relationship between groundwater table depth, groundwater quality, soil salinity, and crop production. Salinity manage-ment in central and southern Iraq: prospects under current drainage condition. State of irrigation and drainage infrastructure in central and southern Iraq. A review of the post war situation. Assessment of the current status of irrigation activity and drainage infrastructure in Iraq. Rehabilitation of irrigation and drainage infrastructure in Iraq. Adaptation of crop and forage genotypes to soils affected by salinity. Halophytes as forages in saline landscapes: interactions between plant genotype and environ-ment change their feeding value to ruminants. Soil and water salinity in Iraq: preliminary analysis of causes, effects and approaches to management. Finding of a study in describing current best practice farmers and their techniques. Compo-nent F: develop methodologies to improve soil, agronomic, irrigation water. and drainage management for salinity control. The impact of salinity in Iraq: a socioeconomic analysis.; Proposed methodology for analyzing the economic and environmental impact of salinity on livelihoods in Iraq. Integrating soil salinity into the national policy and planning framework in Al-Nassiriah district. Policy and institutional options for salinity management in Iraq's agricultural sector: results of a 'SWOT' analysis.
			Creation of the Iraq Salinity Platform to serve as repository for all information created by the project and make it available as a global public good after the project is closed down	Information Platform created in 2013. It contains project information, reports and photos

7 Key results and discussion

Key results can be presented for the three phases of the project. The first phase targeted the description of the current status of agriculture and salinity in Iraq. The second phase focused on the identification of solutions, and the third phase focused on identifying investment areas for the Government of Iraq and the international donor community. These three phases are reported requentially below.

7.1 Phase 1: Description of the current status of salinity and agriculture

Although describing the current status of salinity and agriculture should be a relatively simple task under normal conditions, it was a complicated task for the project. Because of the difficult political situation and the low safety and security levels in some of the rural areas since 2003, only a limited overview of the current status of salinity in Iraq was available and dated from the 1990s. In addition, because of institutional limitations on travel to Iraq most of the international support was done outside the country.

To describe the current status of soil salinity in Iraq, a statistically based model, coupled with remote sensing data as an input, was used to produce a new soil salinity map for the Mesopotamian plain. Please note that because of limited field data, this approach needs further validation. A second approach, also using remote sensing data, created a region-wide map using observations of the shifting agricultural patterns. This resulted in a map showing potentially saline areas. Please note that salinity is not the only factor influencing soil degradation and reduced agricultural production, but that, most notably, the availability of water has a large effect as well. Several remote sensing analysis methods were applied (such as selection of specific periods during the year, seasonal averaging to reduce the impact of seasonal water shortage, etc.).

To describe the current status of water availability and water quality in the Mesopotamian plain, several data sources were collected and combined to allow the development of a salt load model for the Tigris and Euphrates Rivers' systems. This resulted not only in the identification of data gaps (and thus recommendations for a better monitoring system for regional salinity management), but also in the observation that spatial changes in the salt load through the Euphrates and Tigris are minimal, and that lower water flows are related to higher salinity concentrations. From the salt load analysis, it was found that the management of (Tigris) flood water through Lake Tharthar in the northern part of the Mesopotamian plain added an important volume of salt to the Euphrates and Tigris Rivers. Lake Tharthar has a high salt concentration, and because of its large surface area, loses an important amount of fresh water through evaporation. Recommendations on improved management of flood waters have been made.

Historical agricultural production data were analyzed for several winter and summer crops to determine the current state of agriculture from a historical perspective. The analysis shows that large fluctuations between years occur based on socio-political conditions (Iran-Iraq war, international sanctions, and availability of fertilizer) and water availability. For the winter cereals, an increasing trend from 2001 to 2010 can be found in the total area under irrigation (from 1.0 to 1.3 million ha). A simultaneous decline in irrigated summer crops over that period was observed (from 1.2 to 0.8 million ha).

The current state of soil salinity, groundwater levels, and water salinity was described for selected project sites using measurements obtained through field monitoring activities. Historical data sets were collected to identify changes over time. In all areas, the soil salinity of the irrigation projects appeared to be increasing.

During the analysis of historical data, a previous reclamation project in the Dijilah project was shown to have had a major positive impact on agricultural production.
The project area included in the current analysis covers Phase 1 of a reclamation process, where drainage infrastructure was improved during the 1990s. Because of the outbreak of a war in the funding country the former Yugoslavia, the surrounding areas (Phase 2) were not reclaimed. Current observations show that there is no viable agriculture in the non-reclaimed areas, while the reclaimed areas, with lower levels of soil salinity, show acceptable levels of agricultural production.

An inventory of currently available crop varieties and genotypes was made for cereals, selected forages, and halophytes. Cereal yields were compared at trial sites with varying salinity levels. Most surprising was that wheat appeared to have higher yields than barley, suggesting that wheat was more salt tolerant than barley. This is against conventional wisdom and appeared more related to the late planting of the barley than to soil salinity levels. This trial does show the importance of good agronomic practices and the effect on yield that planting dates can have. The trials also showed that a wheat genotype, coded as G5, produced 50% more yield than the local varieties and appeared to outperform the local varieties on all other indicators (based on a single season's comparison). Local barley genotypes appeared to be highly competitive with the introduced ones.

For the summer forages, local genotypes of pearl millet and sorghum appeared competitive with introduced ones in the first summer. Introduced varieties of guar and sesbania appeared to be able to produce relatively high yields (up to 14.8 t/ha for guar) under medium soil salinity conditions (10-20 dS/m).

For halophytic perennial grasses grown under highly saline conditions, the local variety appeared to out-compete the introduced ones. Trials continue to evaluate the fodder quality aspects of these grasses for animal consumption.

7.2 Phase 2: Identification of solutions

The second synthesis report of the project identifies a set of key findings and uses a framework of scale and salinity level solutions.

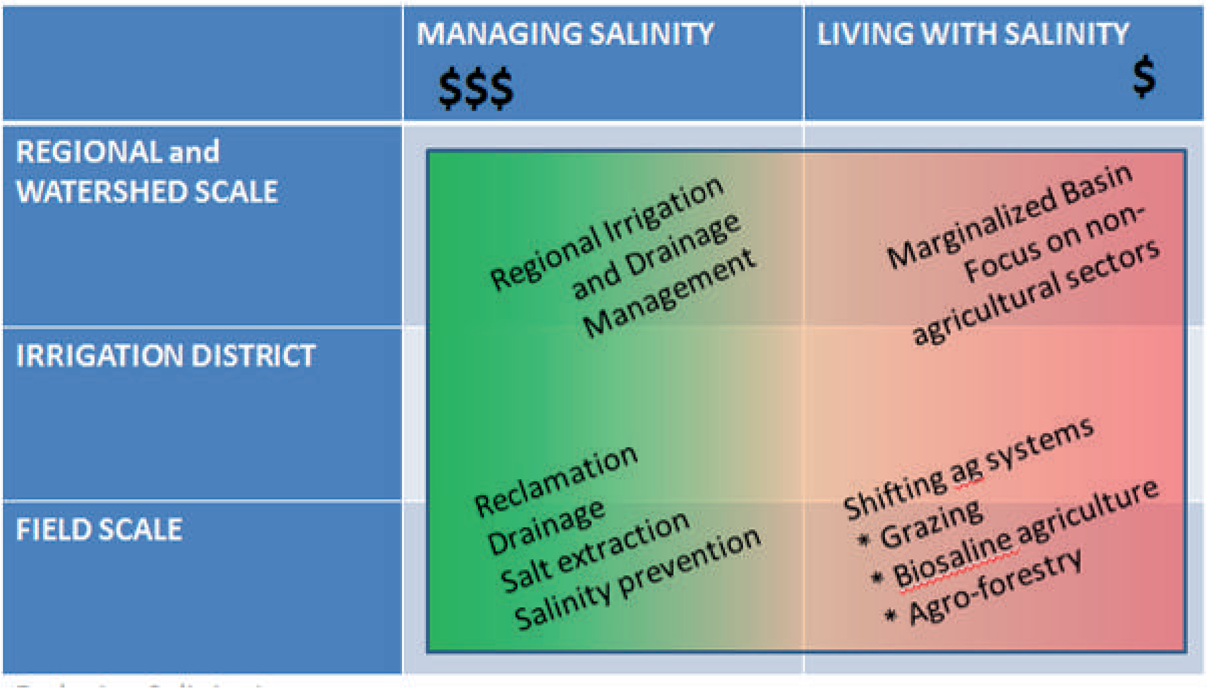

Figure 1. Salinity management options

Salinity will need to be managed at different scales; most irrigation-based systems can be divided into field, irrigation command, and regional levels (figure 1). Different stakeholders are involved at each scale, while those that benefit most can overlap all scales.
This finding results in the need for identification of stakeholders at different levels and the need to bring these stakeholders together to define the shared objectives of salinity management within a region or basin.

A national irrigated land capability understanding should guide decisions on reclamation and rehabilitation to ensure the efficient use of Iraq's land and water resources. To achieve this understanding, it is suggested to develop land and crop suitability maps based on soil, water, land drainage, water table depth, groundwater quality, and the other agro-hydrological conditions prevailing in different areas. This will be followed by the development or selection of suitable farming systems for different areas based on water availability and climate conditions.

The process of developing a salinity management framework, based on sound data, and including the identified stakeholders at multiple scales, requires an iterative process (plan–act–review–plan). Adoption of continuous improvement will require the development of objectives and goals at the national level that integrate the management of water and land across key institutions.

A standard solution to field-based salinity problems under saline groundwater conditions is to match water requirements to crop use and groundwater depth. More location- and condition-specific calculations of irrigation requirements (in-season approach), and the transfer of this information into management approaches, would lead to better water use efficiency, and eventually a decline of shallow groundwater levels. This would need to be translated into a comprehensive on-farm water management program including training and extension for farmers on the precise irrigation requirements of different crops under the conditions of the existing salinity and water table depth.

There is an urgent need to invest in rehabilitating and modernizing irrigation infrastructure. However, it is recognized that this is a hugely expensive undertaking. As such, carefully prepared business cases will be needed for each set of modernization investments. Irrigation delivery and drainage infrastructure needs to be modernized at the irrigation command level and integrated into a broader regional framework.

Surfacewater salinity must be controlled by tackling the major sources of saline water inflows to rivers within Iraq, including the increase in salinity resulting from reductions in flow. This will be best achieved by the development and implementation of a salinity management framework for the entire systems of the Tigris and Euphrates Rivers. Options that can be adopted are varied and include major engineered structures and infrastructure, such as water treatment plants. The objectives should be to maximize the volume of good quality water and minimize the volume of saline water, separate good quality water from saline water, and reduce evaporative losses in the system. The largest advantage that the lower Tigris and Euphrates system has over the Murray-Darling Basin is that a main outlet drain exists in the Mesopotamian plain. The optimization and enforcement of the use of the drainage system would reduce the pressure of saline supply water in the southern part of the Mesopotamian plain.

Salinity in Iraq is a complicated and ongoing issue and short-term projects (of two to three years duration) will not solve the problems in the long term. Authorities should explore approaches that establish a National Program for Salinity Management in Iraq, similar to those existing in other national agricultural programs. This would centralize the coordination of efforts and ensure high-level integration between the water, agricultural, and environmental sectors of government.

In areas where salt-affected soils exist and drainage waters are generated on a large scale, production systems based on salt-tolerant plant species are likely to be an important aspect of future agricultural systems. However, the use of saline water in Iraq, to a large extent, is still confined to the growing of salt-resistant grasses for fodder, bushes, and trees. The growth of salt-tolerant forage species for ruminant production offers the only opportunity to use land and water resources that are too saline for conventional crops and forages.

7.3 Phase 3: Investment options

The last phase advises the Government of Iraq and the international donor community on the best areas for investment to improve agricultural production under the threat of salinization. The four main areas of investment are identified as 'enabling actions', 'land and production systems', 'water systems', and 'knowledge systems'. Suggested investments are categorized using a system of investment size and implementation time window.

The first investment option is to make land use decisions using land and crop suitability maps. These maps should be part of a system that can respond to the dynamics of water, land, and agricultural systems. Thus the most likely mechanism is to develop an interactive GIS-based system that is accessible by all stakeholders involved in a salinity management framework. It is estimated that for this activity less than a year would elapse before results would be seen and a relatively low level of investment would be needed (less than USD 1 million).

A second investment option is to use the output of the resource capability system and evaluate the 'best' type of farming systems. The key to this process is that adjustments are made to infrastructure investments (like sub-surface drainage and irrigation delivery infrastructure) in farming systems and infrastructure investments are avoided in areas where potential agricultural production is low. Investments in field-based agriculture in the region of the Shatt Al Arab do not appear to give the best value for the money. The investment to be made would be relatively low, while the time period of implementation would be short to medium term (1–5 year).

A third investment option is to establish a National Program for Salinity Management in Iraq together with a salinity management framework (which itself includes a method to decide on investment priority). This national program would be the vehicle for and champion of a national salinity management framework. This investment suggestion falls under the development of an enabling environment, and would require a medium level of investment (USD 1–10 million), with a 1–5 year implementation window.

A standard approach is to enhance irrigation water application methods to improve their efficiency. This is an investment option in the water systems group. It would require establishing the optimal water application rates for different crops by generating reliable information on the irrigation requirements in areas with different agro-climatic conditions. This system would be more dynamic than the current standard tables. Note that an improved irrigation scheduling system would need an investment in the irrigation hardware and operation to allow demand driven irrigation applications as opposed to supply driven ones. While the improved water demand system would be a low level investment with a short time window, the improvement of the irrigation and drainage hardware and operational guidelines would be a high-level investment (more than USD 10 million) with a long time window (more than 5 year).

In combination with an improved operational system at the irrigation district level, improved operation and management of the two river systems with their many off-takes, reservoirs, and water transfers would make it possible to reduce the salt load carried in with the supply water. This system includes an optimized use of the current and improved drainage system to prevent drainage water being mixed with river supply water. This investment option has a long time window and large investment is needed.

An improved and strengthened extension service, including attention to salinity management options at the field level, is identified as a strong need to ensure improved conditions in salinity-affected areas in the Mesopotamian plain. This activity is designed to improve the knowledge system. Short-term investments with low investment amounts could have a large impact on improving agricultural production, while larger investments and longer-term support would ensure more stability and higher quality of the extension service. As part of this improvement of extension services, standard educational packages should be developed and implemented at the extension service level. The use of farm schools is also promoted in this approach.

8 Impacts

Several components in the project developed new methods, provided new analyses, or came up with new results that contributed to scientific knowledge. This resulted in the preparation of several technical reports and journal and conference articles (listed in Section 10.2). The project generated an increased knowledge of and interest in the development of a salinity management framework approach at the level of the Mesopotamian plain. Further support activities through the Ministry of Water Resources, sponsored by the Italian government, are building upon the analyses conducted in the project. The CGIAR research program (CRP) on Water, Land, and Ecosystems has selected the Tigris-Euphrates basin for further research and development activities building upon the current project results. Interest in and further development of remote sensing techniques to evaluate Iraq's agricultural production and the effects of soil salinity have been developed by the Iraq government and universities. Field applications to improve water and land management in the salinity-affected areas have been adopted in the strategy to improve agriculture in Iraq through the Harmonized Support for Agricultural Development (HSAD) project funded by USAID.

8.1 Scientific impacts – now and in 5 years

The largest impact on science was the interaction between researchers and specialists from the international community with the researchers and specialists from the Iraqi community. This interaction resulted in strong communication on the themes of

- Remote sensing
- Salinity measurements, analysis, and interpretation
- Soil-water-plant-atmosphere modeling and analysis of the models from point source to irrigation district scale
- Inventory and analysis of farmers' indigenous knowledge and methods to combat salinity
- Use of halophytic plants on salinized lands to adapt to salinity and link to small ruminant production using salinized soil resources
- Methods and analysis of socioeconomic reviews in salt-affected farming communities
- Analysis of past and current agricultural policies related to salinity management through water and land regulations for agricultural production.

This interaction was achieved in the project through regular project and thematic meetings, as well as in training sessions. As listed in Section 10.2, several more publications are planned based on the results of the project. Currently, several groups of scientists are continuing their cooperation without funding through the project. This work focuses in particular on the topics of salinity management framework processes, halophyte research, remote sensing techniques, and soil reclamation.

Future scientific impact is partially crystal ball prediction. However, that the CRP on Water, Land, and Ecosystems has selected the Tigris-Euphrates as one of the eight focus regions for the program is promising. The inclusion of this area in the research program creates a long-term cooperation framework to continue research on basin-scale water, land, and ecosystem management. The CRP method focuses on research for development, thus providing many opportunities to build upon the results of the project. CRP programs are awarded in three-year cycles, with expected life-times of 9–15 year, thus providing long-term opportunities. ICARDA, IWMI, and the FAO are partners in the CRP on Water, Land, and Ecosystems and have started initiatives to continue their coordinated research and development activities in the Mesopotamian plain.

8.2 Capacity impacts – now and in five years

The capacity impact was mainly achieved through regular meetings and training activities (see table 10.3). The capacity impact is larger than just the development of individuals directly involved in the project, however. Although the main counterparts in the project had scientific backgrounds, several training activities were conducted in Iraq for practitioners in their fields. For example, socioeconomic enumerators were trained in techniques for conducting surveys and field technicians were taught how to use laser leveling equipment. Capacity has been improved at the level of the ministries. Bureaucrats have been shown how to analyze data and combine disciplinary analyses (soil based, water based, and socioeconomically based) at the regional scale. The final presentation of the project results to the Government of Iraq at the ministerial and parliamentary level (November 2013 in Baghdad) has been the ultimate effort to impact capacity at the policy level. The involvement of the local managers of the four areas that were covered by the Iraq salinity management project ensured that middle-level management remained informed of the project processes and results. Farmers' field days and demonstration sites targeted the capacity of farmers to improve land and water management to reduce salinity impact.

Increased national and international funding for capacity development will increase the long-term impact of capacity developed during the project. Although a 'training the trainers' approach was taken for several of the international training sessions (Section 10.3), this will only have an effect when the opportunities for follow-up exist. Through the involvement of the Ministry of Higher Education, some of the universities in Iraq will have the potential to continue the capacity development of future students. The Japanese International Cooperation Agency (JICA) has contacted ICARDA for follow-up on land drainage and land reclamation courses based on the knowledge obtained through the project.

The selection of the Tigris-Euphrates for the CRP Water, Land, and Ecosystems provides opportunities to remain involved in supporting the developed capacity and continuing capacity development on the theme of regional water, salt, and land management. Farm-based interventions and capacity support and development were covered through the USAID funded HSAD project.

It must be noted that the project has provided opportunities to individuals in Iraq involved in the project. The most notable may be the inclusion of one of the project partners into the office of the Iraq Minister of Agriculture.

8.3 Community impacts – now and in five years

The project was developed with the overarching aim of developing baseline data and information for central and southern Iraq to provide a robust framework for the development of long-term sustainable salinity management strategies. The impact on communities was indicated as a derivative of the long-term sustainable salinity management strategies that would be developed. Through field-based activities, there has been involvement with farmers in the four selected regions and techniques and technologies were introduced to the area through demonstrations.

To obtain a longer-term community impact, as was envisioned at the start of the project, several constraints needed to be addressed. Given the current security issues in Iraq, local extension services from the MoA are restricted in their activities. Capacity levels in the extension service have been identified by the MoA as an issue and one of the proposed actions in the plan was to develop a higher diploma course in extension (MoA 2012). Improving land and water resources are listed in the MoA planning documents as well. These include working on reclaiming saline land through an independent ministry or institution that will oversee the reclamation efforts, and the development of desalination technology in agricultural systems using renewable energy (MoA 2012). Implementation of these plans and, thus, the impact on the community needs a national budget commitment, or international financial support.

The final synthesis report of the project includes the investment options needed to continue the development of a long-term sustainable salinity management strategy. Proposed investment in building a better knowledge extension system may focus on two main areas – the delivery system and the information that is delivered. The Government of Iraq may refine its extension services to educate farmers on the technical and management aspects of appropriate farming systems. In order to improve management at different levels, it is important to increase the efficiency of extension systems and increase farmer participation through robust extension delivery. Some suggestions for delivery mechanisms are bodies such as Water Users' Associations and farmers' field schools. A comprehensive on-farm water management program should be launched to educate farmers on the precise irrigation requirements of different crops under the conditions of existing salinity and watertable depth. This information needs to be extended through the networks established by the tasks just mentioned. It is also important to ensure that the information being extended is the latest available and has been developed within the broader national salinity management framework.

8.4 Communication and dissemination activities

Communication and dissemination activities have been integral parts of the project. The communication activities focused both on internal project communication as well as external communication. The internal communication involved several ministries, as well as groups of international support institutes. Communication covered the issues of science, policy, and project processes. The scientific communication has resulted in the publication of 24 technical reports and three syntheses reports. Additional communication of scientific results has been through scientific conferences and journal papers. Flyers and posters have been developed to provide summary descriptions and results for the English and Arabic speaking research and development communities.

The communication with policy makers has been conducted, with the partners from the ministries in Iraq, with the Deputy Minister of Technical Affairs, MoA, being the main contact. The Minister of Agriculture has been kept informed of project progress through the Deputy Minister, as well as through the forum conducted in Baghdad in November 2013. One representative on the advisory committee to the Prime Minister of Iraq has also been involved in frequent updates on the results of the project, as well as having involvement in the final forum. Several external representatives of the Ministry of Water Resources were invited to remain involved in the process throughout the project and be informed of the project results. To inform the international community, several embassies and international organizations in Amman were visited, while the World Bank and United Nations organizations were approached by email.

Iraqi media was involved when Her Excellency the Ambassador of Australia to Iraq visited some of the project sites, accompanied by the ACIAR project manager. This visit was a highlight in the communication efforts in Iraq. The main results and observations on water and salt balances, the extent of soil salinity, and salinity management activities in Iraq will be included in a salinity-themed wiki currently under construction at ICARDA. The wiki will provide a central location for knowledge and examples of salinity management in the world, and includes country-based assessments as well as descriptions of field-based interventions.

9 Conclusions and recommendations

The technical project conclusions have been presented in the synthesis reports and summarized in Section 7 of this report. The conclusions and recommendations in this section, therefore, present the key findings.

9.1 Conclusions

- Virtually no areas are left unaffected by soil salinity and large amounts of agricultural land is lost to salinity each year. Irrigation efficiency is very low, mainly a result of degraded irrigation and drainage infrastructure. Farmers of saline soils are using only 30% of their land for cropping and are achieving only 50% of the expected yields leading to a loss of approximately, USD 300 million per year to salinity
- Salinity in Iraq is a complicated and ongoing issue and short-term projects for two to three years will not solve the problem in the long term. No comprehensive study has been undertaken to assess the extent of irrigation-induced salinity. The monitoring network to record spatial and temporal changes and characterize the salt-affected soils in the different parts of the country is almost non-existent
- Irrigation delivery and drainage infrastructure needs to be modernized at the irrigation command level and integrated into a broader regional framework. The water allocation requirements for different crops should be revised so that the amount of water applied by farmers is based on crop needs, not infrastructure capacity
- Our data indicates that the salinity of water entering Iraq appears to have been stable since the 1980s. The increases in river salinity occur within Iraq; and the lower reaches of the Euphrates River – and most probably the Tigris River – are derived predominantly from irrigation drainage and saline groundwater. This being the case, it provides excellent opportunities for the Government of Iraq to invest in measures that will halt and even reverse the salinity trends in these rivers.

9.2 Recommendations

- Achieving change at the individual farm level alone is unlikely to result in much change in this regional scale problem. Investment in rehabilitation of the irrigation and drainage infrastructure is urgently required. However, these works, especially drainage works, should consider the downstream effects on water quality
- It is important that the approach to managing salinity in the rivers is done in coordination with investments in drainage infrastructure for irrigated areas. These actions to control soil and river water salinity need to be taken soon and as part of a comprehensive framework that prioritizes the measures that will deliver the greatest benefit for least cost
- Rapid classification of land capability, with parallel testing of new plants, will allow government agencies to develop timely management recommendations for farmers. Where halophytic forages are the only option, transfer of knowledge in regards to livestock feeding will be required
- To improve farm productivity under saline agriculture, it will be necessary to create mechanisms for direct farmer participation in the development, evaluation, extension, and monitoring of technologies, and highlight livelihood-enhancing and employment-generating opportunities for farm families. Such an approach needs to include a clear understanding of and planning for changes in the mix of farm enterprises associated with irrigated areas and saline lands
- The evolution of systems from mostly crop to mixed crop and forage production may be positive for farmers. Many farmers in the irrigated zone already have some livestock. Livestock production can provide significant new income for the very poor, so the development of systems of adaptation that focus on the integration of crop and livestock systems will have major benefits for disadvantaged people
- Coordination of actions within a National Salinity Management Framework for Iraq is required. A coordinated and concerted approach to salinity management across the three scales (farm, scheme, and region) is recommended.

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4	Wu, W., A.S. Mhaimeed, A. Platanov, W.M. Al-Shafie, A.H. Abbas, H.H. Al-Musawi, A.J. Khalaf, K.A. Saliem, R. Soppe, and F. Ziadat. 2013. Multi-temporal salinity mapping in the pilot sites and Mesopotamian region.
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10.3 Training activities conducted

During the project, 13 international training courses were conducted, training a total of 88 participants. In Iraq, eight national training courses were conducted for a total of 76 participants.

International training courses conducted

1	20–28 March 2011, Aleppo, Syria. Dr. W. Wu, Dr. F. Ziadat, Dr. E. De-Pauw, and Dr. M. Qadir, ICARDA. Training course on using GIS, field-scale spectral instrument AccuPAR, and salinity measurement techniques. (6 participants).
2	29–31 March 2011, Aleppo, Syria. Dr. F. Ziadat, Dr. W. Wu, Dr. E. De-Pauw, ICARDA. Training workshop on data review and field sampling design for salinity mapping. (6 participants).
3	19–20 June 2011, Amman, Jordan. Dr. R. Soppe, CSIRO. Training course on remote sensing in irrigated agriculture. (6 participants).
4	21–23 June 2011, Amman, Jordan. Dr. R. Soppe, Dr. E. Christen, and Dr. W. Quayle, CSIRO. Training course on water and salt balances, and water quality at basin scale. (6 participants).
5	24 June 2011, Amman, Jordan. Mr. B. Brown, ACIAR. Training course on monitoring and evaluation framework of the Iraq Salinity Project. (4 participants).
6	25–26 September 2011, Amman, Jordan. Dr. J. Hornbuckle and Dr. R. Soppe, CSIRO. Training course on field salinity sampling and use of EM-38. (11 participants).
7	27–28 September 2011, Amman, Jordan. Dr. R. Soppe and Mr. D. Smith, CSIRO. Training course on weather data collection and management. (3 participants).
8	13–17 November 2011, Aleppo, Syria. Dr. W. Wu and Ms. L. Atassi, ICARDA. Training course on the use of GPS and GIS tools for data management. (2 participants).
9	20–24 November 2011, Aleppo, Syria. Dr. W. Wu, ICARDA. Training course on remote sensing processing and salinity mapping. (5 participants).

10	4–6 December 2011, Amman, Jordan. Dr. A. Qureshi and Mr. W. Ahmad, IWMI. Training course on the use of SWAP model. (2 participants).
11	26–30 August 2012, Cairo. Dr. A.S. Qureshi, IWMI. Scientific visits of the senior staff of the salinity project to a reclamation project in Egypt. (14 participants).
12	7–11 May 2013, Mushagar, Jordan. Laser-guided land leveling training course. (10 participants).
13	4–17 May 2013, Australia. Dr. D. Lavery and W.R. Evans, SKM. ICARDA-Iraq study tour in the Murray-Darling Basin, Australia. (15 participants).

National training conducted

1	15–17 November 2011. Baghdad, Iraq. Training on data collection from Al-Dijilah project. (4 participants).
2	29 November–1 December 2011. Baghdad, Iraq. Training on data collection from Al-Mussaieb and Abu Al-Khaseeb. (4 participants)
3	April 2012. Baghdad, Iraq. Training on surveys and data collection at the farm level. (8 participants).
4	27–31 May 2012. Erbil, Iraq. Sampling and interviewing methodologies, use of statistical packages for descriptive and statistical analysis, and impact of salinity, agricultural policies. (16 participants).
5	30 September–4 October 2012. Erbil, Iraq. Assessing soil-water balance and salinity – use of time domain reflectometry (TDR) sensors. Installation and operation of equipment for salinity project. (10 participants).
6	28 November–8 December 2012. Iraq. On site follow-up training on measurement equipment and improved irrigation systems in Nassiriah, Dijilah, and Abu Floos. (10 participants).
7	4–8 February 2013. Erbil, Iraq. Training course on the use of GIS tools and remote sensing. (12 participants).
8	9–13 June 2013, Erbil, Iraq. Training course on socioeconomic and policy analysis of salinity problems in Iraq and their impacts on livelihoods. 12 participants