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Iraq Salinity Assessment   Report 3: Investment Options

Managing Salinity in Iraq's Agriculture

Investment Options for Government Agencies and Development Partners

Proposal: National framework for salinity management

ICARDA
Science for Better Livelihoods in Dry Areas

The University of Western Australia

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Iraq Salinity Assessment

The Iraq Salinity Assessment is the result of a three-year research project on soil salinity in Central and Southern Iraq - by the Government of Iraq, Ministries of Agriculture, Water Resources, Higher Education, Environment, and Science and Technology, and an international research team led by ICARDA 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 International Center for Biosaline Agriculture (ICBA), Dubai, United Arab Emirates. This research is funded by the Australian Centre for International Agricultural Research (ACIAR), AusAID and the Italian Government.

Key Words

soil salinity in Iraq, salinity in agriculture, land and water management, Irrigation systems rehabilitation, dryland agriculture, improving agricultural productivity, dryland farming systems, development policies; arid zones, Iraq, Agricultural Research in the Dry Areas, ICARDA, Australian Centre for International Agricultural Research, ACIAR, Government of Iraq.

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About This Report

This report is the third and last in a series of publications that provide an overview of the Iraq Salinity Assessment. This report documents an initial set of investment options identified during the course of the project. It has been compiled from project contributions from a number of authors across all of its seven technical components.

The Iraq Salinity Assessment synthesizes the results of the Iraq Salinity Project, a research partnership between five Iraqi ministries and national agencies and an international team of researchers. International partners in the project are the International Center for Agricultural Research in the Dry Areas (Lebanon), the lead institution, the Commonwealth Scientific and Industrial Research Organisation (Australia), University of Western Australia, International Water Management Institute (Sri Lanka), and the International Center for Biosaline Agriculture (UAE). The institutions of the Government of Iraq involved in the project include the Ministry of Agriculture, Ministry of Science and Technology, Ministry of Water Resources, Ministry of Higher Education, and the Ministry of Environment.

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

The assessment benefits from Australia's experience in dealing with similar, less severe, salinity problems in its agricultural sector. The salinity situation and agro-hydrological problems faced by Iraq are similar to those faced in Australia's Murray-Darling River basin. Australia has been tackling its salinity problem in a systematic way since the 1980s and today salinity is being controlled and reversed in many areas.

The solutions and implementations presented in this report are a synthesis of a body of research – 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.

Iraq Salinity Assessment - Three Reports:
- Report 1: Overview and scope of the problem.
- 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
- Report 3: Investment options to support a long-term strategy of soil and water salinity management in Iraq (this report).

Iraq Salinity Research - Multi-disciplinary, Multi-scale:
- A multi-scale focus, from the farm to irrigation project to the whole of the Mesopotamian plain
- Mapping of soil salinity and river salinity in the basins of the Tigris and Euphrates Rivers
- 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 farming in Iraq. This includes forage crops that can bring increased income to communities that are living in areas with degraded soils
- Investigation of the socioeconomic impacts of soil salinity on farmers and national agricultural production.

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Executive Summary

Executive Summary

Introduction
This report presents the key investment options arising from the 2009 study assessing the impacts of salinity on agriculture in central and southern Iraq. Building on the first synthesis report, which reviewed the current salinity situation, and the second, which suggested solutions to the problem, this report discusses how investment could be most effectively targeted.

Main findings
The project reports across three scales. At the regional scale of the Mesopotamian Plain, all areas showed reduced productivity as a consequence of soil salinity; this was more pronounced in the southern areas. The saline soils have resulted from land management practices, irrigation water management, poorly functioning drainage systems, and socioeconomic aspects affecting investments.

Water removed from the Tigris and Euphrates river systems for irrigation projects reduces the overall volume of water and results in higher salt concentrations downstream. This restricts access to irrigation water and exacerbates the problem of soil salinity in the south. Salt return from irrigation should be managed to maintain acceptable levels.

However, subsurface drainage systems reduced soil salinity and increased productivity. Additionally, some wetlands have been partially restored.

At the irrigation project scale, low maintenance, lack of oversight, and failure to follow original plans has negatively affected the success of the projects. Access to irrigation is inequitable and the flow is unreliable. Drainage systems are not well integrated, which, together with excess water application, results in the shallow groundwater contributing to the salinity problem. Both irrigation and drainage should be managed synergistically.

At the field scale, two pilot area studies showed that excess irrigation resulted in lower flows downstream and raised the water table, carrying salts back to the root zone and impairing growth.

Inherited smallholdings and tenure systems restrict the adoption of sustainable irrigation practices as they are expensive to implement and there is no incentive for farmers to invest in land they do not own.

Solutions
A coordinated and concerted approach to salinity management is required across the three scales. Prevention, reclamation, and adaptation are needed within a salinity management framework that provides a political and regulatory context for coordinating stakeholders' objectives. The framework should balance income distribution, poverty alleviation, agricultural production, and regional development.

Where to invest
With limited funds, investment needs to be carefully targeted. Four areas are key:

- Land and production systems – assessing the capability and suitability of land for production and matching farming systems to this capability
- Enabling actions – providing a focal point for stakeholders by establishing a National Program for Salinity Measures to coordinate management and education approaches
- Water – establishing optimal irrigation rates for different crops under relevant agro-climatic conditions and selectively rehabilitating suitable land. Tackling surface water salinity by addressing inflows and reductions in flow
- Knowledge extension – building on the existing extension program to improve and better target the information to farmers, with added support from water users' associations.

Although listed individually, coordinated action, especially between the water, agricultural, and environmental sectors of government, offers a potentially better outcome.

Investment should take three forms: irrigation efficiency improvements, infrastructure rehabilitation, and control of the salinity of surface waters. For this, reliable information on crops and agro-climatic conditions is essential. Interventions can be scaled according to the funds available, although major investment in large-scale infrastructure is needed.

1 Introduction

In 2009, a study was initiated to assess the impact of salinity on agriculture and identify the key areas for investment to reduce the affects in central and southern Iraq. The study was conducted by the Ministry of Agriculture (MoA) in Iraq, with the support of the Ministry of Water Resources (MoWR), Ministry of Higher Education (MoHE), Ministry of Science and Technology (MoST), and the Ministry of Environment (MoE). An international consortium, led by the International Center for Agricultural Research in the Dry Areas (ICARDA) and comprising the Commonwealth Scientific and Industrial Research Organisation (CSIRO, Australia), the University of Western Australia (UWA), the International Water Management Institute (IWMI), and the International Center for Biosaline Agriculture (ICBA), supported a study team of more than 50 participants.

The study used a spatially integrated approach, thus including an assessment of the issues, potential interventions, and impacts on field, irrigation command, and regional watershed levels.

The objectives of the study were to:

- 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. This approach led to quantification of the salt and water fluxes and the areas affected by salinity
- Determine appropriate strategic approaches to manage salinity that suited local environmental and socioeconomic conditions
- Assess key productivity limitations to and opportunities for wheat-based irrigated agricultural systems
- Develop investment options for ongoing salinity management in Iraq.

The study also included several components assessing and providing solutions at the regional, irrigation command, and field levels (Box 1). A technical assessment of the current salinity situation in central and southern Iraq was presented in the study's first synthesis report (Christen and Saliem, 2012). Solutions to the problems that were identified were presented and discussed in the study's second synthesis report (Evans et al, 2013).

It is important to note that issues related to the trans-boundary volumes and the quality of the river water were excluded from the study. The study sought to provide options and solutions that could be used in Iraq without being dependent on the interests of others. The work has shown that actions can be taken solely within Iraq that can start the process of ameliorating the problems associated with agricultural development and the water shortage crisis.

At the regional scale:
- Quantify the spatial distribution of soil salinity based on information available on salinization at the field and basin levels and identify its causes in central and southern Iraq
- Describe the qualitative and quantitative trends in river and drainage water for central and southern Iraq.

At the irrigation district scale:
- Quantify and describe the relationship between groundwater levels, groundwater salinity, and irrigation activity
- Assess the current state of irrigation and drainage infrastructure.

At the farm scale:
- Demonstrate best practices for different salt-tolerant crops, crop varieties, and fodders
- Develop methodologies to improve soil, agronomic, irrigation water, and drainage management for salinity control

All scales:
- Identify socioeconomic and policy constraints to the effective use and remediation of saline land and water resources in central and southern Iraq at the basin, irrigation district, and farm scales.

Box 1. Objectives of the Iraq Salinity Project.

2 Main findings of the project

The assessment

Regional scale

An assessment of the current salinity conditions in central and southern Iraq focused on both soil salinity and the salt flow through the Mesopotamian plain by the rivers, canals, and drains.

The main finding related to the flow of water and salt through the Euphrates and Tigris River systems was that both rivers are managed to deliver water to the main irrigation projects. Downstream of the main diversion structures to these irrigation systems, the salt concentration of the water in both rivers increases considerably. It is important to note that the mass of salt, the quantity flowing through the river, does not change considerably, in fact it decreases. The increase of the concentration of salts is mainly related to a lower volume of water in the river to dilute the salt flow.

Although there is a large increase in salt concentration below the irrigation projects, the salt concentration in the irrigation water delivered is within acceptable levels if the drainage system is functional. However, management should ensure that the concentration is as low as possible to manage salt levels in the soils within the irrigation projects. There are many opportunities to manage the flow of salt back into the river systems. For instance, one finding of the study showed that the use of Tharthar Lake as a reservoir to store flood water, mainly from the Tigris, and redistributing it during drier times in the year, can add large quantities of salts back into the rivers.

An assessment of the soil salinity in the Mesopotamian plain indicates that soil salinity problems have a larger impact on agriculture in the southern part of the plain than in the northern part. In all irrigated areas, reduction of agricultural production was apparent, independent of location. This reduction is a result of both the lower availability of water and an increase in soil salinity. The increase in soil salinity is logically related to less water being available to wash the salts through the soils into drainage systems. It is also a result of the very high levels of the water table, which promote salinization during periods of fallow as a consequence of the high evaporation rates in the region.

A regional soil salinity survey found that areas with recently installed subsurface drainage systems showed a large increase in agricultural production and a large decrease in soil salinity. Non-reclaimed areas showed an accumulation of salts, mainly through the transport of salts from shallow saline groundwater to the productive part of the soil. This remote sensing based survey also showed that more than 75% of the Mesopotamian plain is affected by saline soils, resulting from land management practices, irrigation water management, poorly functioning drainage systems, and socioeconomic aspects affecting investments.

The regional salinity assessment found that the restoration of the wetlands and marshes in the central and southern part of the Mesopotamian plain is resulting in recovery of some previously drained areas. However, the salinity of the water in the wetlands and marshes was higher than it used to be before they were drained, as some of the water that was used to restore the area was sourced from agricultural drainage water.

Irrigation project scale

Work within the study assessed the infrastructure and irrigation practices within irrigation projects. It was found that in four selected irrigation projects, the existing infrastructure deviated from the original designs. The distribution of irrigation water was affected as a result because of low maintenance levels, a lack of oversight, and 'improvements' that some users had made to the system. Missing regulators and malfunctioning pumping stations have resulted in a lower reliability of water delivery, both in timing and volume. These problems result in lower control of the water and make efficient water distribution difficult. A lack of allocation mechanisms also results in access to water not being equitable across the length of the main delivery canals, The drainage system (from local field and collector drains to the open main drains in the studied areas) was not functioning as designed as a result of the lack of regular maintenance and clogging. This has restricted the outflow of the saline drainage water from the fields and irrigation projects. A lack of flow of drainage water results in the accumulation of salts within an irrigation project, thus lowering agricultural production. The main drainage network was also not well integrated to manage the flow of salt away from the river system; many farmers are still using drainage water to supplement their water supplies.

Large areas of the Mesopotamian plain were found to have shallow groundwater levels. Shallow groundwater in irrigated areas is commonly a result of the application of excess water combined with a lack of sufficient drainage. Shallow groundwater allows salts to move into the upper part of the soil where they affect plant growth. Modeling has shown that these shallow water table levels can be managed by reducing the water applied during the growing season. This reduction in water has the effect of lowering the water table, and results in increased crop yield. Even further gains will be made when the drainage systems are restored to their design capacities and water levels fall even further. An important conclusion is that water application rates and drainage system design are both crucial aspects of ensuring optimum crop productivity.

Deep groundwater is a term that usually describes regional sandy or gravelly geological layers where water is stored in large pores. In arid and semi-arid areas, this water has usually accumulated over long periods of time. The water may flow slowly through these porous media and commonly it is recharged at very slow rates. Deep groundwater may be a source of water in arid areas, but it can be depleted when extracted at high rates. Rivers, like the Euphrates and Tigris, can be recharging (leaking into) the groundwater, or groundwater can be discharging (feeding) the river simultaneously at different stretches of the river, depending on the relative heights of the water table and the river stage. Discharge of saline regional groundwater to the river can be of concern when considering the salinity of river water.

Shallow groundwater is a term commonly used in irrigated areas for water that is within 5 m of the soil surface. This water is commonly the result of excess irrigation water and is often associated with waterlogging and salinity concerns. Where shallow groundwater levels are within reach of the root zone of plants (usually in the soil layer) salt can migrate upwards into the soil profile where the plant roots are actively using water. Thus contributes to an increase in the amount of salts in the root zone. In most systems the shallow groundwater and the regional deep groundwater are interconnected and influence the behavior of each other. Where regional deep groundwater occurs beneath flat floodplains in arid areas, it is usually saline. Shallow water tables resulting from irrigation, also tend to promote increased salinity where levels are within 2 m of the ground surface, thus compounding the problem.

Where irrigated areas have shallow water levels in underlying groundwater systems, these can produce mounds, that is, local areas where the water level is higher than the surrounding areas. As most irrigation is associated with river systems, having mounded water levels in close proximity to river channels can cause groundwater to flow from the irrigation area back to the river, thus transporting salt and influencing the river's salinity levels.

Management of all of these factors can be a complex undertaking.

Box 2. What is groundwater?

Field scale

An assessment of theoretically optimal water use at two pilot irrigation areas showed that the current practices of irrigation resulted in higher volumes of water being applied than are necessary for plant growth and the leaching of salts. Excess water application has several effects, all detrimental to agricultural production. Excess use of water reduces the availability of water to users downstream. Excess use of water combined with limited drainage systems also results in rising groundwater levels. When groundwater rises close to the root zone of a crop, more water from the groundwater will move towards the roots of the crops due to the effects of evaporation. Since the groundwater in the Mesopotamian plain is saline as a result of centuries of salt accumulation, these salts rise back into the root zone and crops cannot achieve their optimal production. Even if excess water is applied in combination with a well-functioning drainage system, water is wasted. The objective of leaching water is to use a minimum amount of water and remove a maximum amount of salts from the root zone. Careful management of the applied water goes hand in hand with careful management of the drainage water. This results in a sustainable irrigation practice.

> Plants extract water and nutrients from the soil through their roots. The depth of the roots depends on the type of crop that is grown. The depth of the soil that plants use for their water and nutrient sources is called the root zone. The objective of 'leaching' is to manage the salt levels in the active root zone and remove salts from the area through natural or manmade drainage systems. Usually, in irrigated areas with salinity concerns, the soils are loam or clay, which are limited in their natural drainage rates. Artificial drainage is needed to move the leached salts out of the field. These artificial drains can consist of open drains (dug channels to remove water) or subsurface 'tile' drains, perforated pipe installed in the soil to drain excess water and salts away from the field. Artificial open and subsurface drains can also be used to control the level of shallow groundwater. Care should be taken with the installation of artificial drainage since it can also mobilize salts from lower depths in the groundwater. Excess salt mobilization will create a larger than expected salt mass to be handled through the surface drainage systems. Eventually, the salt that is transported away from the irrigated field has to be disposed of; an integrated salinity management framework is usually required.

Box 3. How leaching works

In Iraq, two separate cropping seasons can be identified in the irrigated areas; a winter and a summer season. In addition, perennial forages (e.g. alfalfa) are grown in some areas. The amount of irrigation water available for irrigation projects is constant throughout the year. The amount supplied to the cultivated areas in winter far exceeds the plants' needs. The amount provided in summer needs to be higher because crop water use is greater in the summer. Winter crops are mainly wheat and barley, while there are a wide variety of summer crops. Barley is commonly considered a more salt-tolerant crop than wheat, and an increase in soil salinity often results in a shift from wheat to barley. It has been found that wheat is an important crop for human consumption, while barley is mainly grown as a fodder. Thus, the consequences of salinity have a fundamental impact on the use of the crops grown. The study found that the grazing of livestock is an important aspect of agriculture in central and southern Iraq.

Land tenure was identified as an important socioeconomic aspect in salinity control and agricultural development. Land holdings are often divided into small, uneconomical areas as a result of inheritance (Ministry of Planning, 2010). Additionally, a large portion of the irrigated land is tenured land rather than freehold, which is a disincentive for farmers to invest in salinity amelioration.

The study also found that the salinity of both the available irrigation water and the soil increases towards the southern parts of the Mesopotamian plain, reaching a maximum near Basra. Salt-tolerant agriculture integrated with livestock activities will be important in these areas. Understanding the spatial dimension of where individual farming systems can be implemented is an important outcome.

Proposed solutions

The study has culminated in the identification of several proposed solutions and interventions. An overall conclusion is that to be able to respond to the continuing salinization in the Mesopotamian plain, activities related to prevention, reclamation, and adaptation should be conducted within a salinity management framework. A salinity management framework provides the political and regulatory setting that allow the activities to be coordinated and present a common face of government. These settings also harmonize the objectives of the multiple stakeholders involved; for example, the balance between equitable income distribution, poverty alleviation, agricultural production targets and regional development.

Some solutions that appear useful may actually only shift the salinity problems to other areas. An example is the installation of tile drainage in an irrigation project in the upper part of the river catchment. If saline drainage water is collected by these new drains and released to the river, it will actually increase both the concentration of the salts in the river as well as the total salt mass that flows through the river. Users downstream – urban, environmental, or agricultural – will thus be negatively affected by the solutions for upstream beneficiaries.

Another example is the selection of lands to be reclaimed. Both the reclamation process, as well as the increased agricultural productivity after initial reclamation will require more water than before. An increase in consumptive water use (water that is evaporated and transpired, and thus leaves the river system) will reduce water consumption potential downstream in the river basin. This is especially important in river basins where the total available volume of water is committed, as is the case in the Tigris-Euphrates basin.

Selection of lands to be reclaimed from the salinization process, as well as the selection of lands for saline-tolerant plant production or grazing, affects the national targets set by the food self-sufficiency, poverty alleviation, and economic growth models within the country. These targets partially guide the decisions on where to reclaim and where to adapt to salt, but are in turn guided by the technical limitations for reclamation and adaptation as well. A salinity management framework, and the process to develop this framework, clarifies these interactions and makes technical and political decisions affecting salinity more transparent.

Box 4. Why is coordination of salinity management needed?

3 Where to invest to implement the solutions

There is a broad range of investment options that are required to ensure the sustainable management of the irrigated areas of central and southern Iraq. This work has identified a subset of those and proposes that they be implemented within the near future; being taken up by the Government of Iraq, and international donor agencies. The list provided below is by no means exhaustive and further investment options could have been supplied from this project. We acknowledge that investments from other assessments and analyses of the problem are just as important and relevant. The following list represents what we believe to be the key investments and they represent the quickest way to generate a return on investment in salinity management in the irrigated areas of the Mesopotamian plain.

The investment options have been partitioned into four main areas:
- Land and production systems
- Knowledge extension
- Water
- Enabling actions.

Each has been developed to be as self-contained as possible, but we also acknowledge that there are dependencies between the four areas. It is important to note that coordinated actions are required to achieve the final benefit and we believe that all investment options to manage salinity should be implemented to obtain the maximum benefit. A brief description of each of the four areas is provided.

What is the return to the nation from particular investments in salinity management and irrigation refurbishment and can a greater return be gained elsewhere for the same input? This is a difficult question that is not easily answered. However, it is a necessary question in the case of Iraq where the task is large and the current funds are limited. Investment in enabling actions is required to allow this question to be answered and to permit government to provide a clear focus for salinity management, where the various responsibilities across government can be channeled to assert a single point of action. 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. The authorities should explore an approach that establishes a National Program for Salinity Management in Iraq, similar to existing national agricultural programs. This would centralize the coordination of efforts and ensure high level integration between the water, agricultural, and environmental sectors of government. All investment in Iraq's irrigated lands across all three scales must be done within a robust investment framework where the benefits can be assessed relative to the costs.

One unpalatable truth is that not all land is capable of being irrigated the same way and hence the land needs to be classified in terms of its capabilities. Most investment should to be focused on land of high capability from a national good point of view. Some land will have such low capability that investment in these areas should be targeted at saline agricultural options as the most viable solution. Investment in land and production systems will need to focus on the development of an agreed view of the capability of the lands of the Mesopotamian plain and match the farming systems to local capabilities. In this way, production can be maximized, with flow-on benefits for both the nation and the rural population. This process will allow both management of salinity and adaptation to the problem.

Investment in the water systems will take three forms – irrigation efficiency improvements, infrastructure rehabilitation, and control of the salinity of surface waters. Despite the shortage of water, there is a general tendency towards over-irrigation by Iraqi farmers. As a result, irrigation efficiencies are very low. Work has shown that by matching water requirements to crop use and groundwater depth, productivity can be increased and the water used more efficiently (water is saved for use elsewhere). This provides a win-win situation for all involved. It will be critical to invest in establishing the optimal water application by generating reliable information on the irrigation requirements for different crops in areas with different agro-climatic conditions. This information, once agreed, can then be provided to irrigators via a knowledge extension network (see a later investment option).

There is an urgent need to invest in rehabilitating and modernizing the irrigation infrastructure. Irrigation delivery and drainage infrastructure needs to be modernized at the irrigation command level and integrated into a broader regional framework. Clear, appropriately resourced roles and responsibilities for government and farmers should be agreed. Furthermore, there is a need to increase the capacities and capabilities of the managers of irrigation commands. This will be a hugely costly exercise, but it is critical. We acknowledge that there are a range of programs already underway by the MoWR, but additional investment is required and is appropriate. However, this investment must be clearly expended within a coordinated strategic framework. Investment can be made at a variety of scales based on the amount available to be invested. At the local scale, simple schemes of replacing or rehabilitating field and collector drains can be easily instituted. Similarly, small infrastructure refurbishment schemes, where pump installations are upgraded, are also possible. Investment in this manner can be scaled; that is, the more funds that are available, the larger the number of sites, or the greater the area that can be treated. Major investment in the main delivery canals and associated facilities or in the main drainage network is also required.

Surface water salinity must be controlled by tackling the major sources of saline water inflows to rivers within Iraq. Also the increase in salinity resulting from reductions in flow needs to be addressed. Options that can be adopted are varied. Interventions on the supply side include major engineered structures and infrastructure, such as water treatment. Improving the efficiency of the water resources infrastructure and infrastructure operating guidelines for the simultaneous management of water and salt load are required. (These options need to be applied at multiple scales throughout the Mesopotamian plain.) Since the objective of the intervention is to maximize the volume of good quality water and minimize the volume of saline water, the primary goal is to separate the two and reduce evaporative losses from the fresh water system (e.g. pressurized irrigation systems).

Direct salt reduction interventions focus on the removal of salt influxes into the water supply system. This could be achieved by using the main drain in a more efficient manner at lower cost, or by installing a groundwater-pumping network to intercept return saline flows to the Tigris and Euphrates Rivers at a higher cost and more operation and maintenance expense. In the Mesopotamian plain, the lower reaches of the Tigris and Euphrates Rivers appear suitable for salt interception pumping systems. However, the investment and benefits of these interventions must be carefully evaluated.

Investment in building a better knowledge extension system will focus on two main areas; the delivery system and the information that is delivered. The Government of Iraq should develop 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 the extension systems and increase farmer participation through robust extension delivery. Some suggestions are that this can be achieved through bodies such as water users' associations (WAUs), farmers' field schools and farmer advisory groups (FAGs). 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 the existing salinity and water table depth. This information can 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.

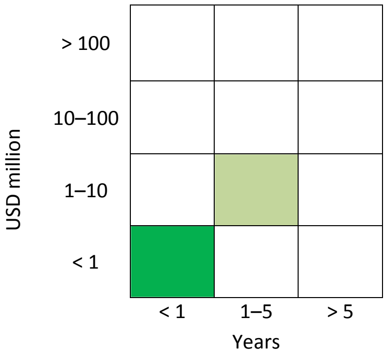
Coordinated action is critical.

Investment actions

The following pages outline a range of investment options. Each has been organized in a synoptic form to allow easy access to the ideas and concepts. Each is summarized within the context of the level of investment required, the potential return on that investment (both directly and indirectly), a description of the problem and the solution, and the likely constraints that will apply. Finally, each is summarized in the form of a level of investment versus the time required to complete the activity, so that funders can choose an entry point suitable to their resources.

3.1 Land and production systems

3.1.1 Capability/suitability



Estimated required budget
Short-term result (less than 1 year).
Less than USD1 million (total) to construct a dynamic land capability information system.

Improve the quality of the input data (1–5 year process).
Monitor the networks (USD1–10 million total cost).

Direct benefits
Beneficiaries: decision makers (using system to make decisions).
Benefits: USD0.

Indirect benefits
Beneficiaries: national agricultural production (farmers and national good).
Benefits: if implemented with farming systems investment activity, then the expected increase in gross margin is 25% (more than USD100 million).

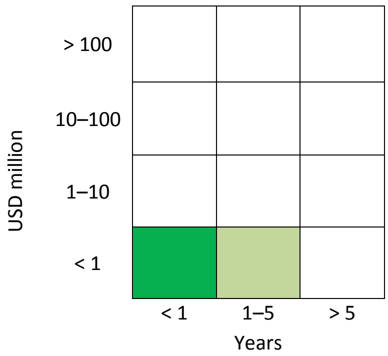
Problem description
Agricultural production on degraded lands is lower than on highly suitable land. Farming systems should adapt to the capability of a particular location, incorporating land, water, drainage infrastructure, water table depth, and water quality. Some parts of the Mesopotamian plain are not suitable for mainstream irrigated agriculture.

Solution
Knowledge of land capability will allow for the planning of matching farming systems and production expectations with the available natural resources. This will lead to greater efficiency of resource use. This maximizes production under available conditions.

Method of implementation
Make land use decisions using land and crop suitability maps.

Potential constraints
Good quality data at an appropriate scale.
Farmers unwilling to adjust to farming systems that are optimal for the physical conditions.
Getting institutional buy-in (MoWR, Ministry of Planning (MoP), and MoA need to agree that this activity will happen and that they will own the result).

3.1.2 Farming systems



Estimated required budget
Short-term result (less than 1 year).
Less than USD1 million (total) to identify farming systems.

Implementation (5–10 year process).
Less than USD1 million (total) to get the planned system operating.
Linked to extension activities, i.e. demonstration farms and farmers' field schools, water user associations (WUAs) and FAGs.

Direct benefits
Beneficiaries: national agricultural production (farmers and national good).
Benefits: if implemented with capability and suitability mapping activity then the expected increase in gross margin is 25% (more than USD100 million).

Indirect benefits
Not applicable as all benefits will accrue directly.

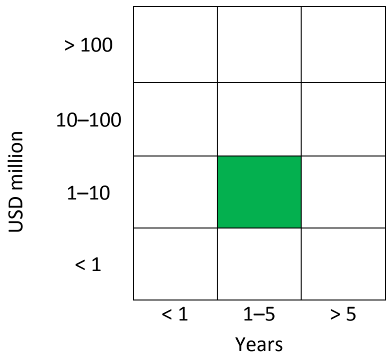
Problem description
Agricultural production on degraded lands is lower than on highly suitable land. Farming systems should adapt to the capability of a location, incorporating land, water, drainage infrastructure, water table depth and water quality. Some parts of the Mesopotamian plain are not suitable for mainstream agriculture.

Solution
Selecting farming systems to match land capability. Adjust infrastructure investments (like subsurface drainage and irrigation delivery infrastructure) to farming systems and avoid infrastructure investments in areas where potential agricultural production is low.

Method of implementation
Identify the range of farming systems for multiple land suitability classes (range of crops and forages and their salt tolerance, livestock, and water requirements). The selection of the farming system must be based on adoptability and profitability. Implement through local planning instruments like land and water management plans or water volume licenses and through national planning processes.

Potential constraints
Farmers are unwilling to adjust to farming systems which are optimal for the physical conditions.
Getting institutional buy-in (MoWR, MoP and MoA need to agree that this activity will happen and that they will own the result).

3.2 Enabling actions



Estimated required budget
Short-term result (1–5 year): USD1-10 million.
Implementation: 1–5 year process.

Direct benefits
None.

Indirect benefits
Beneficiaries: an enabling environment is needed to implement all other activities on salinity management.
Benefits: cannot be calculated, but are expected to be substantial as benefit accumulated from all the activities that were enabled.

Problem description
A lack of shared objectives on salinity management between policy makers, operators, and implementers. There is no focal point that owns the objective to reduce the impact of salinity on agriculture.

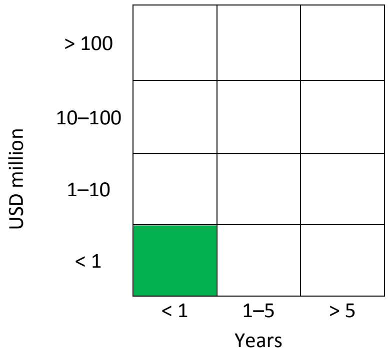
Solution
The authorities should explore an approach that establishes a National Program for Salinity Management in Iraq, including a Salinity Management Framework (which itself includes a method to decide on investment priority). Understand the policy and legislative environment and manage impediments.

Method of implementation
Development of institutions: create/use national water council or subcommittees (operating like the Tennessee Valley Authority or Murray-Darling Basin Commission) to develop an institutional response via the National Salinity Management Strategy. Develop shared objectives between policy makers and ministries through workshops/processes. Invest in setting up the group and setting up the development of the strategy.

Potential constraints
Institutions are unwilling to be part of the process and there is a lack of ownership at the highest levels of government.

3.3 Water

3.3.1 Irrigation efficiency



Estimated required budget
Short-term result (less than 1 year).
Less than USD1 million (total) to identify farming systems.

Implementation (5–10 year process).
Less than USD1 million (total) for getting the planned system operating.
Linked to extension activities, i.e. demonstration farms and farmers' field schools and WUAs.

Direct benefits
Beneficiaries: national agricultural production (farmers and national good).
Benefits: if implemented with farming systems then the expected increase in gross margin is 25% (more than USD100 million).

Indirect benefits
Not applicable as all benefits will accrue directly.

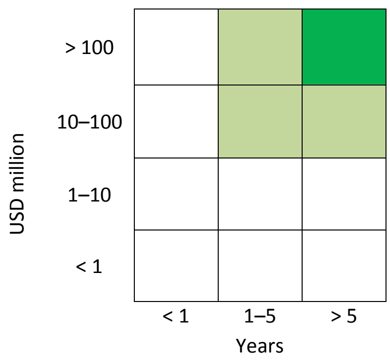
Problem description
Agricultural production is lower than its potential because of the inefficient use of irrigation water, usually through over watering. Over watering leads to high water tables that, in turn, leads to waterlogging and salinization of the root zone. Increased amounts of drainage water are required to be disposed of in those areas through functioning drainage systems.

Solution
Establish the optimal water application rates for different crops by generating reliable information on the irrigation requirements in areas with different agro-climatic conditions and transfer this information to the field.

Potential clients
Donors, Government of Iraq.

Method of implementation
Several established methods already exist to establish optimal application rates. A national system for irrigated agriculture, combining weather stations, cropping information, and soil types can provide guidance for better water applications. This needs to be linked to strengthened farm extension services.

3.3.2 Irrigation rehabilitation



Estimated required budget
Medium- to long-term result (1 to more than 5 years).
More than USD10 million (total) to identify and rehabilitate irrigation command areas (or subsets); the level of investment is scalable.

Direct benefits
Beneficiaries: national agricultural production (farmers and national good).
Benefits: if implemented with farming systems then the expected increase in gross margin is 25% (more than USD100 million).
Based on study conclusions, modifying farming systems results in an increased income of 50% of the gross margin.

Indirect benefits
Not applicable as all benefits will accrue directly.

Problem description
Potential agricultural production on degraded lands is lower than on highly suitable land. The main issue is the underperforming drainage systems. Most field drains are clogged and not operating, most off farm drainage lacks infrastructure to operate efficiently.

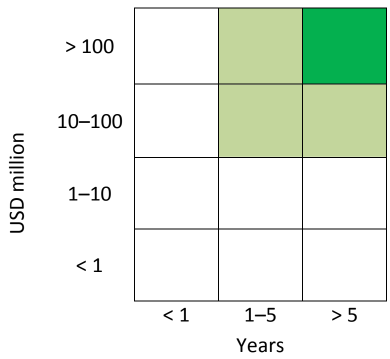
Solution
Selectively rehabilitate irrigation areas/command areas/districts or sub-areas depending on the level of investment available.

Potential clients
Donors, Government of Iraq.

Method of implementation
Identify those areas most in need of drainage infrastructure rehabilitation and design drainage systems that reflect the needs of current and future operations. Implement drainage rehabilitation through on-the-ground engineering works.

Potential constraints
Obtaining institutional buy-in (MoWR, MoP and MoA need to agree that this activity will happen and that they will own the result) and coordinating with current rehabilitation efforts. Major issue related to ownership of ongoing operation and maintenance tasks.

3.3.3 Surface water salinity control



Estimated required budget
Medium- to long-term result (1 to more than 5 years).
More than USD10 million (total) to implement salinity control projects.
Note that the investment is scalable in that small projects can be undertaken as part of the complete package.

Direct benefits
Beneficiaries: national agricultural production (farmers and national good).
Benefits: production benefits from increased water availability and system becomes more sustainable in the longer term.

Indirect benefits
As water salinity is managed, more water of irrigation quality will be available, hence, benefits extend to increased water availability and overall increased production.

Problem description
Surface water becomes more saline as it passes through the water management infrastructure within Iraq. This causes water to become too saline for use towards the end of the regulated parts of the river system.

Solution
Construct structures and schemes to control saline inflows to the rivers. Change operational rules for different parts of the river or for structures to optimize salt management.

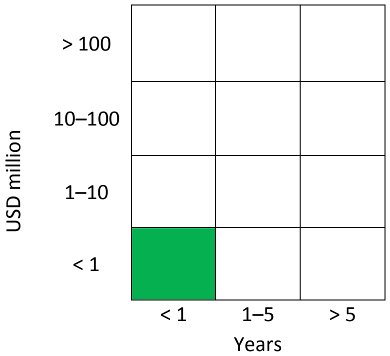
Potential clients
Donors, Government of Iraq.

Method of implementation
Identify projects that will control salinity in addition to the regulated parts of the river system, including different operational approaches for regulating structures and storage, salt interception projects, and major drainage canal diversion projects.

Potential constraints:
Development of a National Salinity Management Framework as a coordinating mechanism is required.
Obtain institutional buy-in (MoWR, MoP, and MoA need to agree that this activity will happen and that they will own the result).

3.4 Knowledge extension

3.4.1 Building extension system



Estimated required budget
Ongoing program to pay salaries, the incidental costs of the assessment study, and for training material development.

Direct benefits
None.

Indirect benefits
Beneficiaries: an effective extension system is required to ensure that there is maximum participatory involvement by the farming community.
Benefits: cannot be calculated, but are expected to be substantial as benefits accumulate from all activities that were enabled.

Problem description
Agricultural extension services in Iraq are fragmented and under-resourced. Extension services do not include salinity management options.

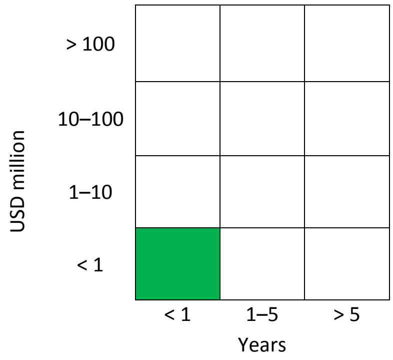
Solution
The MoA should develop its extension services to educate farmers on the technical and management aspects of these farming systems. In order to improve management at different levels, it is important to increase the efficiency of the extension systems and increase farmer participation through robust extension delivery. Establish WAUs.

Potential clients
Government of Iraq.

Method of implementation
Assess the needs.
Hire people.
Develop a program for training the trainers

Potential constraints
The MoA does not implement the approach.

3.4.2 Extending the knowledge



Estimated required budget
Ongoing program to pay salaries, the incidental costs of assessment study, and training material development.

Direct benefits
None.

Indirect benefits
Beneficiaries: reliable information is required about which farming systems works for each agro-climatic zone within the Mesopotamian plain.
Benefits: cannot be calculated, but are expected to be substantial as benefits accumulate from all activities that were enabled.

Problem description
There is currently a great deal of information available for farmers, but not all of it has been validated as suitable. Investment is required to develop a knowledge bank of information related to suitable farming systems.

Solution
Develop packages of information for use in the extension system. The packages should describe the most appropriate types of farming systems for specific locations. Ensure that this information is properly translated to a level that allows farmers to understand and adopt it.

Potential clients
Donors, Government of Iraq.

Method of implementation
Develop extension materials for use by the extension service.
Use WUAs as a recipients of information; use community leaders/tribal leaders as recipients of information.

Potential constraints
Ineffective extension network or communication model.

4 Constraints to investment, and how we propose to overcome them

There will be many constraints as to how these investments are made and to their success. These include the lack of integration between the major natural resource management institutions in Iraq (the three primary ministries) and a lack of coordination between the international donor community (a multitude of small investments that divert efforts from a broader national goal). The most important aspect of the suggested investment options is a clear role for a National Salinity Management Plan. This should provide both a key focus for investment opportunities and a mechanism for deciding where the best outcome in the national good can be achieved; that is, improve the efficiency of how that money is invested.

Developing a National Salinity Management Plan for Iraq will be difficult. At the moment, the two key ministries are not coordinating their actions to manage the salinity problem and the current institutional inertia will need to be overcome. One solution to achieving this is to develop a high level technical committee at the sub-ministerial level that implements a National Salinity Management Plan, perhaps under the aegis of the MoP. Such an approach should have a number of major elements. These would include agreeing on national goals for the outcomes desired from the natural resources of the Mesopotamian plain, be they related to water, soil, or the environment. The approach should also include a program that efficiently matches the operation of the river system to the water requirements of irrigated agriculture. Additionally, an integrated national drainage strategy and an investment framework that allows transparent decisions to be made about where funds are invested are required. This approach will also need strong compliance monitoring at all levels of government to ensure that such activities are not in vain.

5 Where to from here?

The Iraq Salinity Project has finished, but the salinity problem in central and southern Iraq still continues. On-the-ground action on a substantial scale is required and that will only come through the coordinated efforts of the Government of Iraq and the international donor community. Several ideas have been outlined in this paper that encourage progress along a coordinated pathway. Not all activities are outlined in detail and such detail will need to be completed before investment occurs – that is the task of the investment group and its related stakeholders. Many projects will need to be designed with the level of available funding in mind, and that is one reason why this report has not been prescriptive about the detail and the actual funds required. The best outcome will be to acknowledge that each investment action is positive and all should be welcomed within a coordinated program.

The proponents of the ideas reported here can provide further information if that is desired, but equally, the ideas can be developed by other parties and implemented accordingly.

However, to re-iterate, 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 is the outcome desired by this project.

6 References

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