

Assessment of the Current Status of Irrigation Activity and Drainage Infrastructure in Iraq

Reporters

Shawkat Saib Jameel

Hassan Abbas & Asad Qureshi

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

This research is funded by the Australian Centre for International Agricultural Research (ACIAR), AusAID and the Italian Government.

This technical report series captures and documents the work in progress of the Iraq Salinity Project, in its six research themes, working at the regional, farm and irrigation system scales. Technical reports feed into the *Iraq Salinity Assessment*, a synthesis and solutions to solving the problem: Situation Analysis (Report 1); Approaches and Solutions (Report 2) and Investment Options (Report3).

This report was written and compiled by Shawkat Saib Jameel, Senior Irrigation and Drainage Engineer, Office of Planning and Follow-up, Ministry of Agriculture-Baghdad, Iraq and Hassan Abbas and Asad Qureshi Senior Water Management Experts, International Water Management Institution (IWMI), Pakistan.

Key words: *central Iraq, cropping pattern, irrigation, managing operation systems, drainage network, pumping stations, irrigation surface, deficiencies in the system.*

<http://icarda.org/iraq-salinity-project/teaser>

Contents

SUMMARY	4
Background and context.....	5
STUDY SITES.....	5
RESEARCH STRATEGY	6
Cropping pattern and irrigation density	7
Management & operation of irrigation systems	8
Irrigation network and maintenance	8
Drainage network and pumping stations.....	10
Irrigation surface and water quality.....	12
Conclusions	15

SUMMARY

This technical report assesses the current state of the irrigation and drainage in the Babil and Wasit provinces in central Iraq. It describes and documents the irrigation activity and drainage infrastructure in two selected irrigation projects for this pilot study. The report also refers to the causes that led to increase salinity and land degradation in these areas.

There are many factors contributing to the degradation of these systems which threaten the sustainability of crop production. These include: insufficient pumping of drainage effluent, illegal water sharing and misleading irrigation practice. The lack of technical staff at institutions to run the existing system properly, prevent farmers' contraventions, offer proper advice on better farm management practices is urgently needed. The study also tested cropping patterns and irrigation density; assessed operation and management of the irrigation system, drainage networks, pumping stations and surface water quality.

The research team concluded that irrigation and drainage are directly responsible of increasing salinity. Furthermore, old irrigation networks, low efficiency of drainage system, limited financial allocations for rehabilitation work and lack of farmers' interest to improve farm water use are key deficiencies that need to be considered in future development projects.

Background and context

The main focus of this study is the Babil and Wasit provinces located in central Iraq. Two fundamental sites in these provinces, namely Al-Mussaib and Al-Dujaila, were selected to assess the performance of the irrigation and drainage system. Both sites represent pilot land-reclamation projects in Iraq constructed during the second half of the last century. Mussaib and Al-Dujaila provide a picture of the command area; with both open and sub-surface drainage networks exemplifying many irrigation and drainage projects that were implemented earlier, but currently subject to deterioration.

Performance assessment of irrigation and drainage activity required systematic observation, documentation, and interpretation on how these activities were managed in the past. Information on drainage and infrastructure, however, were fragmented, but were completed afterwards by a collaborative effort of the irrigation, water management and agricultural extension departments in Iraq. Social sector data were also collected through farmer interviews to develop a comprehensive database.

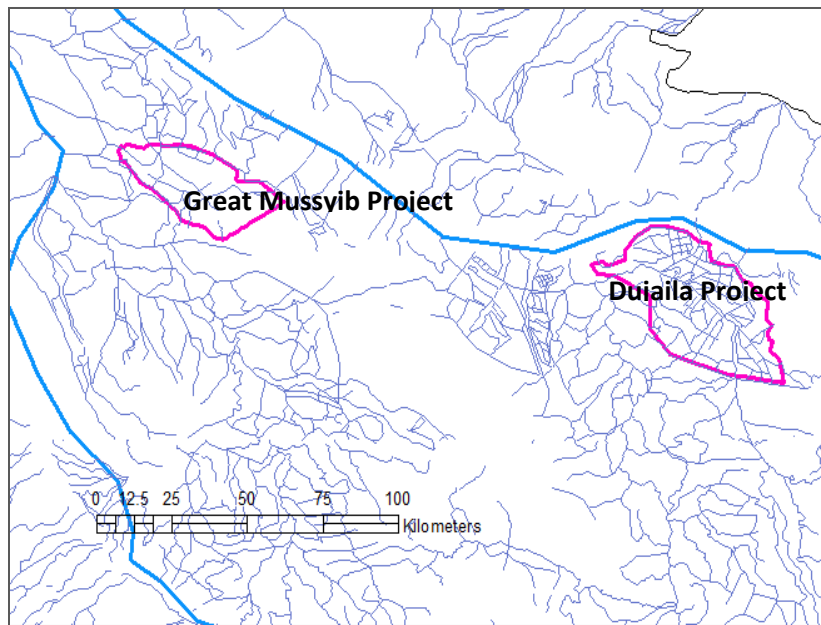


Figure 1 Selected project sites - Great Mussyib and Dujaila

Study Sites

The **Dujaila** project is located in Wassit governorate on the right bank of Tigris. It is one of the old projects with its main and branch canals constructed in 1954. Further development/reclamation works based on modern techniques took place in the period between 1973 and 1983. In 1976 Dujaila agro-industrial compound was constructed, but the reclamation works stopped later and the project suffer from subsequent deterioration.

As shown in Figure 1 Total area of the project is 396,000 donums (39,490 ha) out of which net irrigated area is 225,000 donums (22,437 ha). Within the irrigated areas there are 76,000 donums (7,579ha) of reclaimed area and 56,000 donums (5,584ha) of semi-reclaimed area. Rest of the irrigated areas is non-reclaimed.

The project is irrigated by gravity flow from the right bank of Tigris River through Al-Dujaila main canal. The canal emerges from upstream of Al-Kut barrage on Tigris River. Its total length is 57 km and designed discharge is 42 m³/s. 16 branch canals emerge from its either sides in addition to 54 small private intakes belonging to the farmers.

Reclaimed areas have concrete-lined main and branch canals, while field canals consist of sub-surface asbestos pipes feeding the field hydrants. The reclaimed area is also served with a full network of branch, collector and field drains. *Semi-reclaimed area* have unlined irrigation canals and a drainage network until the collector drains but without field drains.

The **Mussaib** project is located on the left bank of Euphrates River next to Al-Mussaib City – Babylon governorate. It was constructed between 1952 and 1956. Between 1956 and 1965, the project had been deteriorating because of the lack of maintenance, operation and rehabilitation works. The project area represents the typical environment and climate of the central region of Iraq. A project map is shown in Figure 1. The area of the project is 344,780 donum (34,381ha) with net irrigated area of 267,000 donum (26,625 acre).

The design water duty for the project is $1\text{m}^3/\text{s}/6600$ donum ($1\text{m}^3/\text{s}/645\text{ha}$). Water is supplied to the project from Euphrates river by an unlined main canal (first 500m is lined) which branches from the left bank of the river, 9.6 km north of Al-Hindya barrage. The design discharge of the main canal is $40\text{ m}^3/\text{s}$, supplying water to 13 branch canals on either side. The length of the main canal is 49.5 km. The branch canals feed the distributor canals which flow into the farms. All of these canals are unlined. Also, there are farmers' private benefit canals on the main canal. There are three cross regulators on the main canal at the distances 10, 28, 43 km from the head.

The drainage network in Mussyib consists of open field drains which flow into collector drains which in turn flow into branch and secondary drains connected to the main drains of the project. A closed field drain had been built in some parts of the project but now it is not functional.

Research Strategy

The assessment of current status of the two project areas has been done at two scales for each project (Figure 2). The first level of assessment (which covers the entire area) studies main canals, branch, cross regulators, head regulators, main drains, branch drains, secondary drains, and pumping stations. The second level of assessment studies feeder canals, farm intakes, field drains, collector drains, and open drains. This also includes irrigation and drainage water sampling on-farm practices and water-use efficiency. Figure 4 shows the existing condition of two irrigation channels in Great Mussaib and Dujaila respectively. This is an illustration of the general state of irrigation and drainage infrastructure within the two sites.



Figure 2: State of existing infrastructure at the project sites.

The detailed description of Dujaila and Great Mussyib projects' irrigation and drainage infrastructure have been discussed here with respect to cropping patterns, operation and maintenance processes, irrigation canals, drainage network, and water quality.

Cropping Pattern and Irrigation Density

In **Dujaila**, wheat and barley in winter represents the main cropping pattern in the project in addition to vegetables, corn and other crops in summer.

According to the Ministry of Agriculture in Iraq, The estimated irrigation efficiency in Dujaila for the reclaimed area (with lined canals) is 38%, for semi-reclaimed area (with unlined canals) is 28% and non-reclaimed area (with unlined canals) is 31%. The design irrigation efficiency for lined and unlined canals (with 70% surface application efficiency) is 63% and 49% respectively. Low irrigation efficiency within the project indicates a high percentage of water losses despite the scarcity of irrigation water and despite the fact that a large area of the project is covered by a concrete lined irrigation network.

Based on past five years' data, mean cultivated area of the project had been 94,102 donums (9,382 ha), against the net irrigated area of 225,000 donums (22,433 ha), resulting in the agriculture density of only 41.8 %. This is 58.2% less than the planned density of 100%.

In **Mussaib**, wheat in winter and corn in summer represent the main cropping pattern in the project area in addition to other crops like barley, alfalfa, clover, and different vegetables in winter and white maize, cotton, sunflower, sesame, chickpeas, alfalfa, clover and different vegetables in summer (Figure3).

According to data from field experiments conducted in this project by the Ministry of Agriculture within the 'national program for efficient use of water resources in Euphrates river basin 'some years ago, the average conveyance efficiency of the main, branch and distributor canals reached 63%, while the average application efficiency was 48%. As a result, the total irrigation efficiency of the project area was 30.24 %.

Management, operation and maintenance of irrigation canals with a design discharge higher than 400 l/s are the responsibility of MoWR, and are termed as "public benefit". Canals with lower design discharge are the responsibility of their beneficiaries (i.e., the farmers) and termed as "private benefit". For the drainage network, field drains and collector drains are the responsibility of the

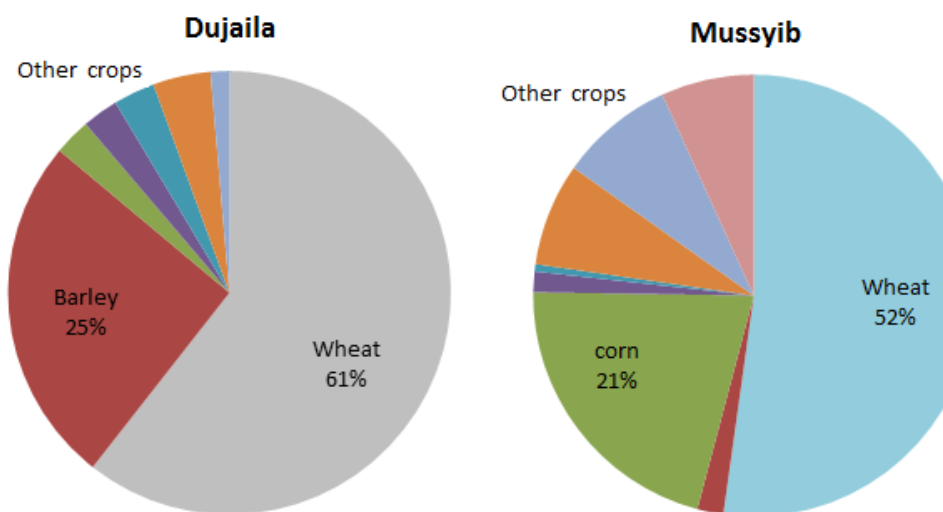


Figure 3: Wheat and barley are the major crops in Dujaila and Mussayib projects. Charts show the percentage of project area used for cultivation of various crops, based on average area cultivated between 2006 and 2010 (Data source: Ministry of Agriculture).

This irrigation efficiency is low when compared to the designed irrigation efficiency in the projects with unlined canals and surface farm irrigation methods (50%) based on conveyance efficiency of 72% and surface application efficiency of 70%. This indicates high water losses on the project. The water losses along with the absence of field drainage system raise the groundwater levels, resulting in salinity problems. The average cultivated area during the past five years is 154,000 donums (15,354 ha) out of total irrigated area of 266,898 donums (26,607 ha) giving an agriculture density of 57.7%.

Management and Operation of irrigation systems

According to the current irrigation and drainage laws in Iraq, management, operation and maintenance responsibilities in irrigation and drainage projects are divided between the project management of MoWR and the farmers themselves.

The Irrigation system of the **Dujaila** project works by ration between the main branch canals branching from Dujaila main canal by controlling the cross regulators along the main canal stream.

Irrigation system of the Mussaib project operates by ration system, the discharge from the branch canals of the project is working on two rations, by controlling the openings of the branch canals head regulators. The management of the project observes a balanced discharge between these two main rations by controlling the openings of the branch canals in an equal order to keep the amount of water almost equal in each ration.

There are three high irrigations during the winter season and other three high irrigations during the summer. These high irrigations are in accordance with main crops growing periods and water requirements for these crops during the particular season. For the purpose of setting the high irrigation times and intervals, wheat is considered as main winter crop while corn is the main summer crop. The ration system between the project's branch canals is designed to be applied during the high irrigations, while the available water in low irrigations is only for drinking and domestic use.

Irrigation Network and maintenance

The irrigation infrastructure of the **Dujaila** project varies with respect to reclaimed, semi-reclaimed and non-reclaimed areas. The project area is irrigated by gravity flow through Al-Dujaila main canal. The canal branches out from the right bank of Tigris river upstream Al-Kut barrage. It has 5 cross regulators to control water levels and maintain the ration between the branches. Total length of the canal is 57km and its design discharge is $42\text{m}^3/\text{s}$. The canal has 16 branch canals on either side. 5 branch canals serve the reclaimed area with total length of 40.8km and total discharge of $22.3\text{m}^3/\text{s}$. Another 5 branches feed the semi reclaimed area with a total length of 83km and total discharge of $12.45\text{m}^3/\text{s}$. 6 branch canals feed non-reclaimed area with a total length of 72.5km and total discharge of $11.1\text{m}^3/\text{s}$. On both sides of Dujaila main canal there are another 54 small branches belonging to the farmers (private benefit) with discharge not exceeding $0.4\text{m}^3/\text{s}$.

Mean conveyance efficiency of unlined canals in non-reclaimed and semi-reclaimed areas is 65% and 58% respectively, while that of lined canals in reclaimed area is 80%. For small unlined channels (less than 400 l/s capacity) the mean efficiency is 60%. Canals in reclaimed area are generally in good condition, but they are running below design level and there are many contraventions. The condition of canals in semi and non-reclaimed areas is classified medium or less. These canals are also running below design levels with many contraventions.

Mean efficiency of cross regulators at the main canal is estimated at 54%, while the mean efficiency of head regulators at branch canals is 60% in reclaimed area, 54% in semi-reclaimed area and 67% in non-reclaimed area. Al-Dujaila main canal and branch canal head regulator and cross regulators and the within the reclaimed area were designed to operate with an electro-mechanical computerized system, while in other parts of the project, the head regulators of the main branch canals were designed to operate on an electro-mechanical system.

The computerized operation system of the cross regulators on the Dujaila main canal are totally damaged. The computers, along with many other components of the electrical control system, were removed. Currently the regulators are being controlled electro-mechanically with a simple electric system. The average efficiency of these cross regulators is between 50-60 %. The control stations, such as the one shown in Figure6, need full rehabilitation.



Figure 4: Damaged concrete lining.

Feeders and farm intake structures in the reclaimed area have an average efficiency of 59%. At many locations the gates are lost or disabled. It operates at a medium capacity and they require maintenance and fixing. The condition of feeders in semi-reclaimed and non-reclaimed areas is under medium. These feeders are unlined and running below design levels with average conveyance efficiency of 51%. The average efficiency of head regulators at these feeders is 40%, with broken or lost gates. They require maintenance and rehabilitation.

Concrete lining in many parts of the concrete lined canals have been damaged or collapsed, as shown in Figure4. In addition, the lack of maintenance for the expansion joints with tar materials is causing seepage and water losses.

The irrigation network on all levels, public or private benefit consists of unlined canals which require continuous maintenance because of weeds, plant growth, and sediments. As a result of the continuous cleaning works using hydraulic excavators, these canals have lost their design cross sectional dimensions as well as their beds has become more compact. The channels have become many times larger than their designed dimensions causing great water losses through seepage and increasing the ground water levels.

The **Mussaib** project is irrigated by gravity from unlined main canal (except for the first 500m) which branches from the left side of Euphrates River, 9.6 km north of Al-Hindiya barrage upstream. The main canal feeding the project is 49.5 km long and has a design discharge of 40 m³/s.

The irrigation network of the project consists of the main irrigation canals (branches) sub-divided from the main canal with a total no. of 13 branch canals, and a total length of 95.1 kmⁱ.

Since the irrigation network of the project at all levels (main, branch, distributors) is composed of unlined canal, it requires continuous maintenance and cleaning works using hydraulic excavators. Consequently, these canals have lost their design cross sections and compacted soil and have become many times larger than their original design. This has increased the irrigation water losses through seepage, causing high ground water levels. Moreover, these new cross sectional dimensions have caused a decrease in irrigation water levels at the farm intakes and weirs, which have led the farmers to change and lower their farm intakes and weirs levels, and install water pumps directly on the canals, making a negative impact on the operation of distributor canals head structures. The beneficiaries from these distributaries changed these structure levels in order to pass the water to their canals because the structure level is higher than the irrigation water levels upstream.

Mussaib canal head regulator, three cross regulators on the main canal, and branch canal head regulators in the project are being maintained annually and generally in good working order, with their efficiencies between 65 and 70%. Distributor canal head regulators, however, lack maintenance being private benefit and work at 40% efficiency. Branch canal cross regulators (for maintaining levels in branch canals) have been mostly modified due to low water levels in upstream and work at 50% efficiency. Weirs, farm intakes, and tail escapes have all been abandoned due to low water levels in the canals and deepening of canals. Some weirs have been lowered and some farm intakes have been replaced by lower level pipes.

Despite maintenance works on the irrigation structures (public benefit structures), these structures are deteriorating, needing financial allocations to execute the required rehabilitation works.

Drainage Network and Pumping Stations

Reclaimed and semi-reclaimed areas in Dujaila are served with drainage networks. The reclaimed area has a complete network of main, secondary, branch, collector and field drains. The area is irrigated from branch lined canals I-1, I-2, I-3, and I-4 and unlined distributor canal no.8. In semi-reclaimed area, main, secondary, branch and collector drains exist but no field drains. Main, branch and collector drains require more cleaning. Field drains are mostly closed because no cleaning has been carried out, being the private benefit (farmer's responsibility). The average efficiency of main drains and branch drains in the semi-reclaimed area ranges between 50% and 60%, while that of collector drains is 50%. All of these drains require more cleaning. At places, there is a requirement for special cleaning equipment due to wide cross sections.

The project has 3 pumping stations; serving areas irrigated by BC 8, BC 10, and BC 13 branch canals. The pumps drain water from the main drains and discharge it to the Malih marsh.

BC 8 pumping station comprises 5 electrical pumps with $1.5\text{m}^3/\text{s}$ discharge capacity for each pump. The total discharge of the station is $7.5\text{m}^3/\text{s}$. This pumping station serves 76,000 donums (17,260 acres) of reclaimed area. The efficiency of the pumping station is 60%. Two pumps are broken, others require maintenance and the building structure requires rehabilitation.

BC 10 pumping station comprises of 3 pumps with an average designed discharge of $1\text{m}^3/\text{s}$ for each pump with a total capacity of $3\text{m}^3/\text{s}$. This pumping station serves the semi reclaimed areas for BC 9, 10 and 11. The efficiency of the pumping station is 50%. All pumps require replacement and the building structure requires rehabilitation.

BC 13 pumping station comprises of 6 diesel pumps with a total discharge capacity of $12\text{m}^3/\text{s}$. Four of these pumps were modified to work on electric power. This pump station serves the semi-reclaimed areas of BC 13 and BC 14, in addition to that it draws the drainage water of BC 10 pumping station and discharges it into the Malih Marsh. The efficiency of the pumping station is 50%. Two pumps are broken, others require maintenance and the building structure requires rehabilitation.

The drainage network of the **Mussaib** project consists of the open field drains surrounding the farm units with spacing of 330m between drains which are divided to south, north and greatⁱⁱ.

All left side drains drain by gravity into the Great and North drain, while the right side drains of the project drain into the South drain and onward discharge to the Great drain through Kesh pumping station. Kesh is one of the big drainage stations located in Kesh area within Al-Neil district, 35 km away from Babylon governorate center. The main pumping station site comprises of three stations Old Kesh station, New Kesh station and Horizontal station. There are 10 vertical pumps (5 each at Old and New Kesh) and 3 horizontal pumps at the station. The pumps' operating efficiency ranges between 70 and 80%. High efficiency of pumps may be attributed to recent rehabilitation works.

The station draws the drainage water from the right side of the project to a canal connected to the main south drain 33 km from the junction between south drain and the great drain. Operation system of the pumping stations depends on the water level in the south drain at the pumping station.

Most of the open field drains and collector drains are not cleaned and maintained as shown in Figure 8, as these are private benefit and the responsibility lies on the beneficiary farmers. Consequently these drains have low efficiency causing drainage network deficiency and ground water table increase which contribute to the salinity problem.

This area is irrigated by branch canals BC9,10,11,13, and 14. The average efficiency of main drains and branch drains in reclaimed area is 70%, while that of collector drains is 50% and of field drains is 20%. The range of drainage water quality across the main drains during summer season 2011 is between 9.2-10.7 dS/m with



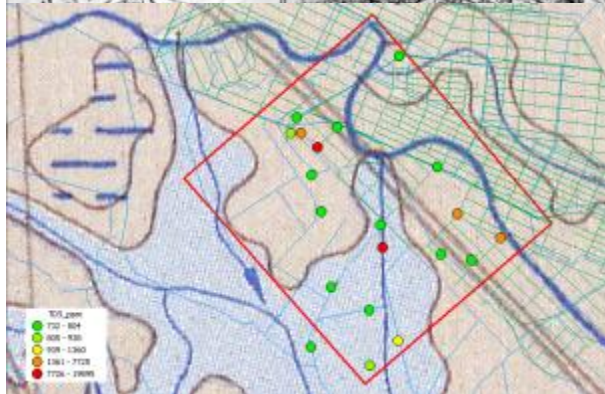
Figure 5: Wild growth in drainage channels at Mussaib

In addition to that, the distance between field drains of 330 m is too much and requires redesign of the field drains network according to the soil characteristics and conditions as well as the irrigation water quality at the current time. In some parts of the project closed field drains were built with the spacing of 70 - 100 m and depths between 2 - 2.4 m. Total length of these drains was 379 km. However, they are now misused.

The main and secondary drains are maintained by the irrigation offices with 50 % of these drains per year, implying that a particular main or secondary drain is maintained once every two years. But despite cleaning and maintenance, all the drainage structures (public benefit) are working with a capacity of 50-60 %.

Irrigation Surface Water Quality

The range of irrigation water quality across the project during summer season 2011 was between 1.11-1.32 dS/m with average 1.16 dS/m. Figure6 shows TDS and Na concentration data (surface water sampling) for Dujaila project. While there seems no particular spatial pattern of TDS concentration with respect to surface features or geology of the region, there seems strong correlation between TDS and Na concentrations, suggesting that Na is the dominant ion in irrigation water from canals in the area. Recent surface water quality data was only available for Dujaila



Surface water TDS overlay on geological map



Surface water TDS overlay on aerial photo



Surface water Na concentration overlay on aerial photo

Figure 6: TDS and Na concentration of canal water in Dujaila (Water quality data source: Field sampling by project team)

Key Deficiencies in the System

The system has the following major deficiencies which lead to land degradation, water logging, salinity and poor productivity:

Water Availability

The net amount of water available in Tigris-Euphrates basin is limited and cannot be supplemented from any adjacent watershed. Water allocation of the existing projects must be carefully reviewed/ revised based on the current availability of water in the basin.

Structural

Structural deficiencies in the system include:

- Irrigation channels which have significantly deviated from their original designs. This includes unlined canals that have lost their original levels and cross sections and the lined canals which have been damaged to a large extent.
- Regulatory structures which have been operating inefficiently are damaged and out of use, or missing altogether.
- Drainage channels in some parts have been identified as insufficient while some of the existing drains are clogged and out of action.

Planning

Comprehensive plans to combat the following issues do not exist at this stage:

- Combating climate change scenarios which might further reduce the availability of water in the basin.
- Combating land degradation and soil salinity.
- Large scale structural rehabilitation of irrigation and drainage system.
- Enforcement plans against contraventions.
- Enforcement plans for farmer's responsibilities in cleaning/maintaining field drains

Institutional

The existing institutions lack the capacity/resources to control:

- Contraventions by the farmers causing a major deficiency in the water allocation system resulting in water scarcity in many parts of the project especially the areas away from the main project head.
- Unauthorized fish farms.

There is deficiency of the following resources within the institutions:

- Shortage of technical staff to follow the operation and maintenance works.
- Shortage of enforcement staff and vehicles to detect and remove contraventions, and enforce order.
- Shortage of equipment and operators for the cleaning works of canals and drains.
- Shortage of finances for the maintenance and rehabilitation works.

There is a lack of institutional arrangements for capacity building and education of farmers in:

- Technical and financial abilities to conduct the maintenance works necessary for field and collector drains and for the rehabilitation of head regulators for the private use irrigation canals.
- Awareness in the importance of the efficient use of irrigation water, and using the surface irrigation methods in more scientific ways preventing/mitigating water logging and salinity.

CONCLUSIONS

During the process of this assessment, it became apparent that the existing status of irrigation and drainage infrastructure is directly responsible for increasing soil salinization and reduction in land and water productivity in the project areas. Based on the comprehensive assessment, we can draw the following conclusions.

- Irrigation networks are old and deteriorated to a large extent due to lack of maintenance. In addition, there are large scale farmer interventions which are further complicating the water scarcity and management problems. These include: noncompliance of the rotational system, illegal water extraction from irrigation canals, irrigating unauthorized agricultural lands and establishment of illegal fish ponds. All these factors led to serious water allocation problems causing water scarcity in many regions of the projects. On the other hand, irrigation efficiencies in the project area are very low which is causing huge field water losses. These water losses not only create water shortage for other parts of the project but also create water logging and soil salinity problems
- Low drainage system efficiency on the field and collector drains as a result of lack of cleaning and maintenance work contributes in drainage system disorder and rise in groundwater levels.
- Limited financial allocations to the maintenance and rehabilitation work are the major problems in maintaining the irrigation and drainage infrastructure. This is particularly true for the maintenance of lined irrigation canals and rehabilitation of control systems i.e. gates, regulators, drains and pumping stations.
- Lack of interest of farmers in the management of irrigation and drainage infrastructure and improvements in the on-farm water use efficiency is the major reason identified so far in soil salinity development.

Data Sources Used

- Water resources directorate in Wassit / MOWR.
- Water resources directorate in Babylon / MOWR.
- Water resources section in Dujaila/MOWR.
- Water resources section in Mussaib / MOWR.
- Agriculture directorate in Wassit / MOA.
- Agriculture directorate in Babylon / MOA.
- National program for efficient use of water resources in Euphrates river/MOA.
- Irrigation encyclopedia in Iraq / MOWR.
- Mussaib project - general view/ Study by Eng. Haider A. Mutasher and Fadhel A. kassim / MOWR.
- Interviews with irrigation officials in Dujaila and Mussaib projects
Field visits documentation.

i-Seven branch canals are on the right side of the main canal with total length of 42.5 km and total design discharge of $36.95\text{m}^3/\text{s}$, and six branch canals on the left side with total length of 52.6 km and total design discharge of $37.65\text{m}^3/\text{s}$. Also there are 9 direct distributor branches from Mussaib main canal with a total length of 27.25 km and total discharge $6.68\text{m}^3/\text{s}$. Distributors of different lengths and capacities off take from the branch canals which feed the farm units of the farmers. There are two types of distributors, first public benefit distributors (discharge more than 400 l/s) which are the responsibility of ministry of water resources, and second private benefit distributors (discharge less than 400 l/s) which are the responsibility of the farmers with reference to management and maintenance. The private distributors form a larger number of distributors in the project, with a total length of 753km, while the public distributors' total length is 168km. All the canals of the project are unlined including Mussaib main canal, and the irrigation process is by gravity on all levels.

^{iiT}The total length of field drains in the entire project is 1472 km. Field drains are connected to the collector and main collector drainsⁱⁱ. The total length of the main drains (south, north and great drain) is 69 km which are connected to 56 branch drains with a total length of 243 km. 23 branch drains (total length of 118 km) are connected to the main south drain, 3 branch drains (total length of 9.75 km) are connected to the main north drain, and 30 branch drains (total length of 115.5 km) are connected to the great drain.