Iraq Salinity Project **Technical Report 15**

Rehabilitation of irrigation and drainage infrastructure in Iraq

Reporters:

Eng. Shawkat Saib Jameel Dr. Asad Sarwar 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.

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

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

This report was written and compiled by Eng. Shawkat Saib Jameel Dr. Asad Sarwar Qureshi

With Dr Weicheng Wu (Leader), Dr Feras Ziadat (Co-Leader), Dr Eddy De Pauw-International Centre of Agriculture Research in Dry Areas (ICARDA), Richard Soppe (SCIRO) and Alexander Platonov (IWMI).

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Investment plan

for the

Rehabilitation of irrigation and drainage infrastructure in Iraq

Eng. Shawkat Saib Jameel
Dr. Asad Sarwar Qureshi

A contribution from Component D of the

Soil Salinity Management in Central and Southern Project

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Introduction

Performance assessment of irrigation and drainage infrastructure involves the systematic observation, documentation, and interpretation of the management of an irrigation and drainage system, with the objective of ensuring that the infrastructure provides the basic needs of irrigation (to meet crop water requirements and leaching of salts to maintain appropriate salt balance in the root zone) and drainage (to remove the leaching effluent from the system through a drainage network). This assessment is needed both at the larger scale (district scale) to monitor the overall performance of the system as well as at the local scale (farm scale) to evaluate the efficiency of the system in terms of sustainability of the cropping system.

Regardless of the efficiency of farm-level irrigation practices, adequate collection and disposal/reuse of drainage effluent is crucial to ensuring the sustainability of crop production systems. Considering the fragmented information on irrigation and drainage infrastructure in Iraq, there is a need to assess the current status of the infrastructure to determine key limitations influencing irrigation delivery, irrigation management, and disposal of the drainage effluent.

This study is undertaken with the collaboration of the irrigation, water management and agricultural extension departments in Iraq. The data used in this study consists of irrigation network at project and farm level (irrigation channels/outlets, current irrigation systems such as surface, furrow, drip, and sprinklers and their extent), quality of irrigation water at the farm, irrigation practices, depth of groundwater, quality of groundwater, features of drainage systems (structures, depth of drainage network, efficiency, drainage type, expected life, and drainage maintenance system), collection of drainage effluent, quality of the drainage water, disposal and/or reuse options of the drainage effluent, and cropping system.

The main focus of this study was Babil and Wasit provinces located in the central Iraq. Two major projects of these provinces namely Al-Mussiyan and Al-Dujailah were selected for assessing the existing status and performance of the irrigation and drainage infrastructure. Al-Mussiyab project is fed by the Euphrates River and Al-Dujaila project is fed by the Tigris Rivers. The main objective of this study is to review and document the current state of irrigation and drainage infrastructure in these two projects and assess the factors influencing irrigation delivery, irrigation management, and disposal of the drainage effluent. This report also aimed at highlighting the key deficiencies in the system that contributes to soil salinization and low land and water productivity. This information will finally be used to draw investment plans for the pilot scale development of irrigation and drainage infrastructure.

Figure 1 shows the location of Al-Dujaila and Al-Mussyib projects along with the pilot land-reclamation projects, which were constructed during the second half of the last century. Figure 1 also shows the projects that are non-operational or semi-operational due to deteriorated infrastructure, poor soil and water management and increased soil salinity problems which are directly or indirectly affecting land productivity in these project areas.

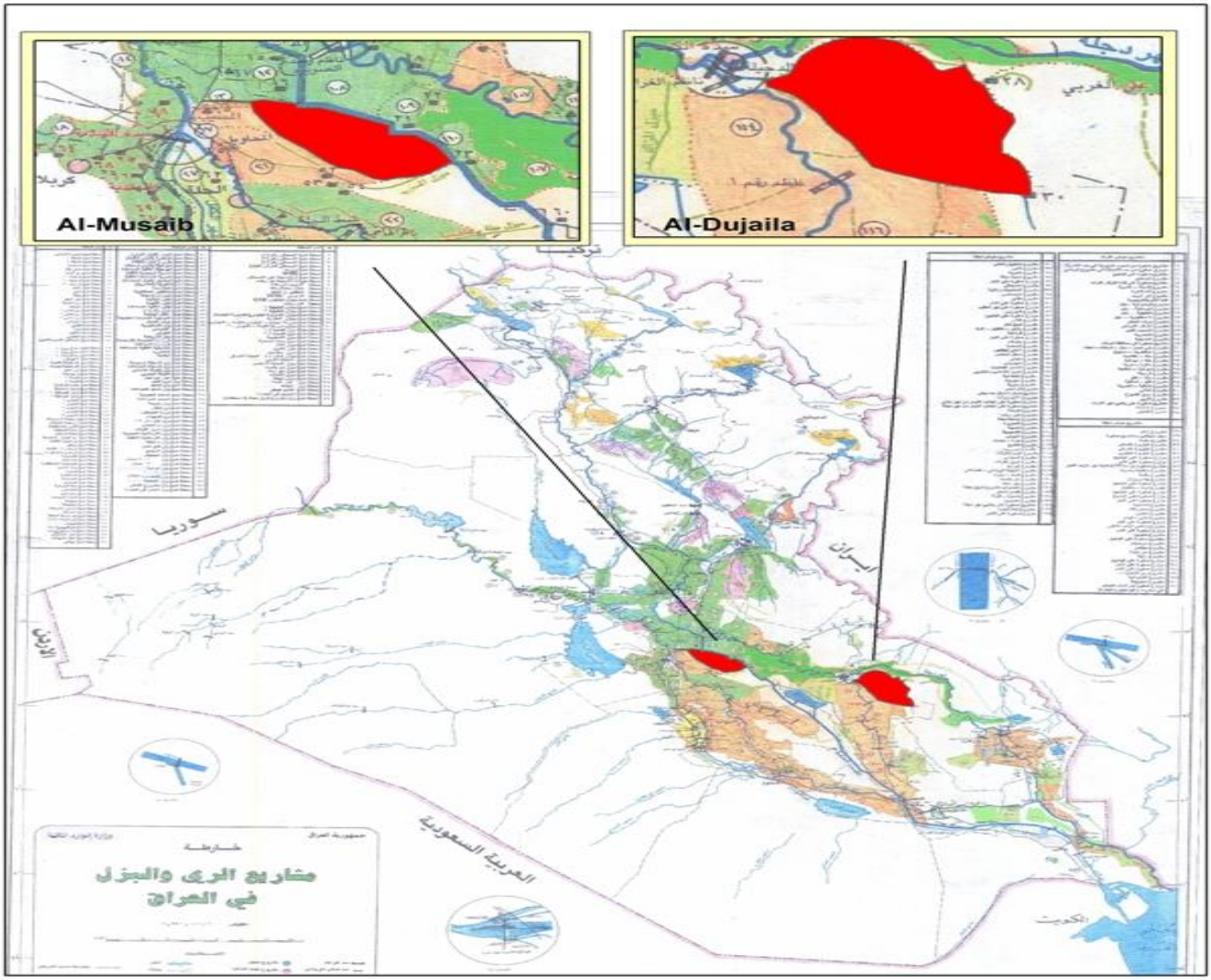


Figure 1: Location of Al-Dujailah and Al-Mussiyab project areas

Description of project areas

Al-Dujaila Irrigation Project

Dujaila project is one of the oldest irrigation projects in Iraq. The project is located in Wasit governorate on the right bank of Tigris River and left bank of Garraf River. It is bordered in the north by the Tigris River and Kut city, in west by East Garraf project, in East by Kut-Bitera project lands located on the right side of the Tigris River. The project lands extend south to border Meisan and Thi-Qar governorates.The project's management office is located 30 km from Kut City and 220 km from Baghdad city. The total area covered by this project is 396,000 donums (97,854 acres) (irrigated and non-irrigated lands), with net irrigated area of 225,000 donums (55,599 acres). About 76,000 donums (18,780 acres) are reclaimed area with full network of branch, collector and field drains. Modern network of main and branch concrete lined canals, field canals consists of sub-surface asbestos pipes feeds the field hydrants.

The construction of main drainage network started in 1954 and work continued in phases. Further development work took place during 1973-1983 in which modern techniques for reclaiming saline lands were introduced in the project area. In 1976 Dujaila agro-industrial compound was constructed. With the execution of this drainage project, soil reclamation started with visible positive impacts on agricultural production. However, maintenance work on this project could not kept pace with the time and the large scale reclamation activity stopped after 1983 due to deterioration of the project infrastructure. The project includes semi-reclaimed areas having unlined irrigation canals and a drainage network until the collector drains but without field drains. The total semi-reclaimed area is 56000 donums (13,838 acres) and the rest of the project lands are non-reclaimed.

The project lands are irrigated by gravity from the right side of Tigris river upstream Al-Kut barrage directly by Al-Dujaila main canal which off takes from Tigris river with a total length of 57 km. The designed discharge of the canal is 42 m^3/s. Sixteen branch canals emerge from its either sides in addition to 54 small private intakes belonging to the farmers. Crops cultivated in the project are wheat, barley, corn, clover, sunflower, and winter/summer vegetables. The agriculture density for the reclaimed area is 80% in winter and 20% in the summer. For semi- and non-reclaimed areas it is 50% in winter and less than 10% in summer.

Description of irrigation network

The project lands are irrigated by Al-Dujaila main canal (with a total length of 57 km and a design discharge of 42 m^3/s), which off-takes from the right side of the Tigris River upstream of Al-Kut barrage. This main canal has 16 branch canals on both sides. The irrigation infrastructure within the reclaimed area is the most developed having five branch canals with a total length of 40.8 km and total discharge of 22.3 m^3/s. There are 23 concrete lined branch canals with a total length of 72.5 km. There are 336.4 km long sub-surface asbestos pipe feeders and 5600 farm intakes (locally called as hydrants). In addition, there is also one main open unlined distributary canal with a total length of 36 km.

Five branch canals are located within the semi reclaimed area with total length of 83 km and total discharge of 12.45 m^3/s while other six canals are feeding the non-reclaimed area with a total length of 72.5 km and total discharge of 11.1 m^3/s. On both sides of Dujaila main canal, there are 54 small canals belonging to the private farmers with each having a discharge capacity of less than 400 l/s. On the main canal there are 5 cross regulators located at the distances of 16, 29, 36, 45, and 51 km from the canal head to control water levels and discharges in the branch canals (see Figure 2).

Figure 2: Irrigation network at the Al-Dujaila project area with a cross regulator at 29 km.

Al-Dujaila main canal head regulator and cross regulators (except for regulator 51) and head regulators of the branch canals within the reclaimed area are designed to operate on a computerized system in an electro-mechanical method. In other parts of the project, only head regulators of the branch canals are designed to operate on electro-mechanical method. Table 1 gives details of the canals and regulators located within the reclaimed area, semi-reclaimed area and non-reclaimed area of the Dujaila main canal.

Table 1 Structures and Canals located on Al Dujaila main canal

no.		Structure name	Location (km)	Max. Discharge (m^3/s)	Canal Name	Canal length km
1	Non-reclaimed area	Head regulator	0+00	42		
2		Cross regulator 1	16+540	37.168		
3		Cross regulator 2	29+653	28.975		
4		Cross regulator 3	36+580	17.714		
5		Cross regulator 4	45+572	14.934		
6		Cross regulator Km 51	51+022	10		
7		Head regulator B.C 1	16+570	1	B.C 1	5
8		Head regulator B.C 2	16+604	2.5	B.C 2	11
9		Head regulator B.C 3	16+514	3	B.C 3	21
10		Head regulator B.C 5	28+576	1.5	B.C 5	10.5
11		Head regulator B.C 6	28+645	1.5	B.C 6	12
12		Head regulator B.C 7	28+550	1.6	B.C 7	13
13	Semi-reclaimed area	Head regulator B.C9	42+646	2	B.C 9	16
14		Head regulator B.C 10	48+968	2.27	B.C10	12
15		Head regulator B.C 11	51+000	1.18	B.C 11	12
16		Head regulator B.C 13	57+000	3.5	B.C 13	18
17		Head regulator B.C 14	57+000	3.5	B.C 14	25
18	Reclaimed area	Head regulator B.C I-1	29+684	5.95	B.C I-1	11.58
19		Head regulator B.CI-1-6	34+842	1.545	B.C I-1-6	4.2
20		Head regulator B.C I-2	36+640	10.5	B.C I-2	13.66
21		Head regulator B.C I-3-5	41+019	0.679	B.C I-3-5	2.163
22		Head regulator B.C I-4	45+454	3.628	B.C I-4	6.397

Description of drainage network

In terms of drainage, the project area is divided into 2 regions. Fully reclaimed area of 76,000 donums (17,260 acres) consists of a complete network of main, secondary, branch, collector and field drains. The area is irrigated from branch lined canals and unlined distributary canal. Semi-reclaimed area of 56,000 donums (12,717 acres) consists of main, secondry, branch and collector drains but without field drains. Table 2 gives summary of drainage network in reclaimed and semi-reclaimed areas.

Table 2: Summary of numbers and lengths of drains on different levels in reclaimed and semi reclaimed area

Location	Main drains		Secondary drains		Collector drains		Field drains	
	No	Length (km)	No.	Length (km)	No.	Length (km)	No.	Length (km)
Reclaimed area	4	89.9	26	64.2	231	318.4	6675	2055.2
Reclaimed area	-	-	13	31.3	174	137.9	2541	1820
Semi reclaimed area	1	17	65	104.5	476	236	-	-
Semi reclaimed area	2	58	38	78.9	340	170	-	-
TOTAL	**7**	**164.9**	**142**	**278.9**	**1221**	**862.3**	**9216**	**3875.2**

Drainage pumping stations

The project has 3 pumping stations to pump drainage water from main drains and discharge it to the Malih marsh. Brief description of three umping stations is given below:

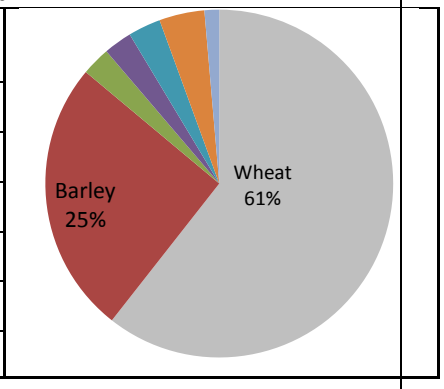
- ***BC 8 pumping station***: This pumping station is located 32 km from the project's management office and comprises of 5 electrical pumps with a design discharge capacity of 1.5 m^3/s for each pump. The total discharge of the pumping station is 7.5 m^3/s. This pumping station serves 76000 donums (17,260 acres) of reclaimed area.
- ***BC 10 pumping station***: This pumping station is 38 km from the project's management office and comprises of 3 pumps with a designed discharge of 1.0 m^3/s for each pump. The total discharge capacity of the station is 3 m^3/s. This pumping station serves the semi-reclaimed areas for BC 9, 10, and 11.
- ***BC 13 pumping station***: This pumping station is 52 km from the project's management office and comprises of 6 diesel pumps with a total discharge capacity of 12 m^3/s. Four of these pumps have been modified and now work on electric power. This pump station serves the semi-reclaimed areas of BC 13 and BC 14. In addition it throws the drainage water of BC 10 pumping station into the Malih Marsh.

Cropping pattern (winter and summer)

Wheat and barley are major winter crops whereas vegetables and corn are major summer crops. Table 3 shows the actual cultivated area under each crop within the project area for the period 2006-2010.

Table 3: Cultivated areas (donums) under each crop in Dujaila project during 2006-2010.

Year	Wheat	Barley	corn	water melon	melon	cucumber	other crops	Total
2006	51650	20000	6500	2500	2500	3500	1150	87800
2007	57200	23100	3000	4000	5000	4000	1245	97545
2008	70000	21630	2000	5250	6000	11500	3015	119395
2009	57750	33650	1105	0	0	0	700	93205
2010	48503	21525	0	635	770	800	332	72565
Average	**57020.6**	**23981**	**2521**	**2477**	**2854**	**3960**	**1288.4**	**94102**



Management, Operation, Maintenance and responsibilities

The management, operation and maintenance of all irrigation and drainage projects in Iraq are the collective responsibility of the Ministry of Water Resources (MoWR) and farmers. All the irrigation canals with a design discharge of more than 400 l/s are operated, managed and maintained by the project management unit (PMU) of the MoWR whereas beneficiaries (farmers) are responsible for the management, operation and maintenance of all irrigation canals with a designed discharge of less than 400 l/s.

For the drainage network; all the field and collector drains are the responsibility of the farmers (called as "*private benefit drains"*), while the project management office is responsible of secondary branches, main drains and pumping stations (called as "*public benefit drains*").

The irrigation water is allocated to main branch canals on rotational basis to irrigated different areas. The flow is regulated through cross regulators. Annex 1 shows an example of the monthly rotational system for the winter season of 2011-2012. It appears that two rotations are applied as explained below:

- First rotation extends for 15 days to irrigate reclaimed areas (I-2, I-3, I-4) of the main branch canals. For this purpose, cross regulator located at 45th km is closed to raise the water level at upstream side to irrigate two above mentioned canals. This rotation is further divided into two periods of 7 days and 8 days to maintain rotation between two main canals.
- Second rotation extends for 10 days to irrigate the branch canals within the semi-reclaimed areas (BC 10, 11, 13 and 14) by opening of cross regulator located at 51st km. This rotation is further divided into two periods of 4 days and 6 days to maintain rotation between the two above mentioned canals.
- As for the main branch canals within the non-reclaimed areas (BC 1, 2, 3, 5, 6, 7 and canal BC9) are concerned, a fixed amount of irrigation water is supplied by adjusting the head regulators of these canals based on the irrigation requirements of the area.
- For canal I-1 and its branches within the reclaimed area, the irrigation water is pumped at fixed amounts according to the irrigation requirements of the area during the season.

Great Mussyib Irrigation Project

This project area represents the typical environment and climate of the central region of Iraq. The project construction work started in 1952 and finished in 1956. Soon after its completion, project maintenance problems started emerging which resulted in large scale deterioration. During 1965-1980, project development started again and drainage issues were resolved (golden stage). However, after 1980s, project again went into the negligence phase and drainage problems started surfacing which ended up in low productivity and large scale land degradation.

The project lands are located on the left bank of Euphrates River next to Al-Mussyib City – Babylon governorate. In the North, the project area is bordered by the lands irrigated from Al-Iskandarya and Latifya canals whereas in the South the project is bordered by lands irrigated from Mahawel canal and Babylon canals. In the East, project extends up to the areas irrigated from Tigris River and serves the population of Mahaweel, Al-Imam and Al-Neel districts of the Babylon governorate. The total area of the project is 344780 Donums (85,197 acres) with net irrigated area of 267000 Donums (65,977 acres). Water is supplied to the project from Euphrates River by the unlined main canal (except for the first 500m which is lined). The main canal took off from left side of the Euphrates River - 9.6 km upstream of the north of Al-Hindya barrage. This canal flows to the East until it reaches the lands irrigated from Tigris River within the Wasit governorate. The canal intersects with Baghdad-Hilla main road at the 12th kilometer.

The total length of this main canal is 49.5 km with a design discharge of 40 m^3/s. There are 13 branch canals off-taking from both sides of this main canal. The branch canals feed the distributary 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 of 10, 28, 43 km from the head to control and manage the water levels to ensure the rotation between the branch canals.

The drainage network 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 (south, north and great drain after its completion). A closed field drain was also built in some parts of the project area but now it is not functional.

Project lands were divided into investment units of 66 donums (15 acre. Farmers and investors were given agricultural lands on rent in small units of 330m x 500m (41 acres) dimensions. Main crops in the project area are: wheat, barley, alfalfa, clover and vegetables in winter whereas corn, alfalfa, clover, cotton, sunflower, sesame and different vegetables in summer. The cropping intensity for the project area is 80% in winter and 20% in summer. The design water duty for the project is 1m^3/s/6600 donum (1m^3/s/1500 acre).

Description of irrigation network

This project is irrigated by unlined main canal (except for the first 500m) which off-takes from the left side of Euphrates River, 9.6 km upstream of Al-Hindiya barrage The design discharge of this main canal is 40 m^3/s, with a total length of 49.5 km. The irrigation network of this project consists of the main irrigation canals (branches) and 13 branch canals covering a total length of about 95 km. Seven branch canals are on the right side of the main canal (with a total length of 42.5 km and total design discharge of 36.95 m^3/s) and six branch canals are on the left side of the main canal (with a total length of 52.6 km and total design discharge of 37.65 m^3/s) (see Table 6 and Figure 4). In addition, there are 9 direct distributary canals from Mussyib main canal (with a total length of 27.25 km and total discharge 6.68 m^3/s). These distributary canals are of different lengths and capacities and directly feed the farm units of the farmers. There are two types of distributary canals. First public benefit distributary canals (discharge more than 400 l/s) which are maintained by the Ministry of Water Resources and second private benefit distributary canals (discharge less than 400 l/s) which are maintained and managed by farmers. The total length of private distributary canals are 753km long whereas public distributary canals are only 168km (Annex 7). This shows that farmers have greater responsibility of management and maintenance of irrigation network. All canals of the project are unlined including Mussyib main canal. Table 6 gives the description of different branch canals of the Al-Mussyib project area whereas Table 7 gives details of the types and functions of different structures installed in the Great Mussyib project:

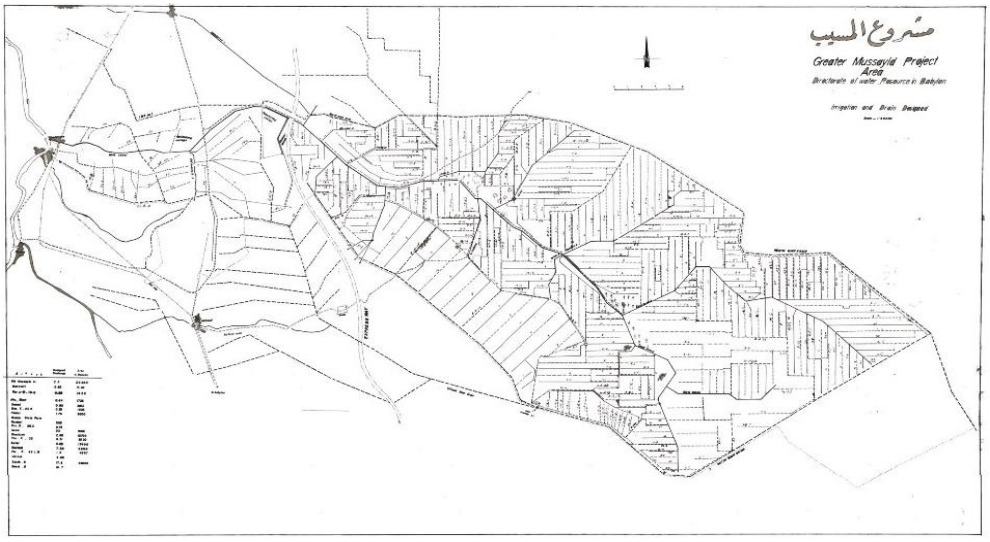


Figure 4: Map of the Al-Mussyib Project area

Table 4: Description of Mussyib branch canals.

No.	Branch name	Offtake side	Length (km)	Q (m^3/s)	No. of distributaries	Irrigated area (dounm)	Distance from Head (km)
1	Old mussyib	right	4.5	4	3	22796	10
2	Al-Mansouri	right	4.5	0.75	3	4157	19.3
3	Abu Shair	left	1.5	0.5	4	1415	22.2
4	Dulaimy	right	3.5	1.95	7	3149	23.98
5	Hamiyar	left	2.5	1.95	4	4374	24.85
6	Al-Haidari	right	4.5	2.2	5	11906	28
7	Imam	left	8	3.8	12	10000	31.99
8	Kharbana	right	5.5	4.25	7	10988	35.4
9	Akaer	left	8.7	7.1	11	14268	37
10	Rashaid	left	9.4	7.3	27	22980	43
11	Ajrish	right	5	7.8	10	19048	43.5
12	Zubaidy	left	22.5	17	51	39360	49.5
13	Hilaly	right	15	16	38	43488	49.5
sub total for right side			42.5	36.95	73	115532	
sub total for left side			52.6	37.65	109	92397	
TOTAL			95.1		182	207929	

Table 5: Types and functions of Irrigation infrastructure in the Mussyib project area

No.	Structure type	Function
1	Mussyib main canal head regulator	Control water entrance to the main canal
2	3 cross regulators on the Mussyib main canal	Control water levels in the main canal
3	Branch canals head regulators	Control water entrance to the branch canals
4	Distributary canals head regulators	Control water entrance to the distributor canals
5	Branch canals cross regulators	Control water levels in the branch canals
6	Weirs	Provide irrigation water to the farm intakes in its upstream
7	Farm intakes	A small structure to provide irrigation water to farm units
8	Tail escapes	Discharges surplus irrigation water to the drains
9	People and vehicles bridges	Provide roads to the vehicle and people

Description of drainage network

The drainage network of this project consists of open field drains surrounding the arm units with a spacing of 330m between drains. The total length of field drains in the entire project is 1472 km. In addition there are closed field drains installed in some parts of the project. The total length of closed field drains is 379 km. These drains have a spacing of 70-100 m between field drains and depth between 2-2.4 m. Most of these drains are non-functional now due to lack of maintenance. Field drains are connected to the collector and the main collector is connected to the branch drains. There are 56 branch drains in the project area with a total length of 243 km. These drains are finally discharged into the main drains of the project (north, south and great drain). Details of these drains are given below (see also Annex 8):

- 23 branch drains with total length of 118 km are connected to the main south drain.
- 3 branch drains with total length of 9.75 km are connected to the main north drain.
- 30 branch drains with total length of 115.5 km are connected to the great drain

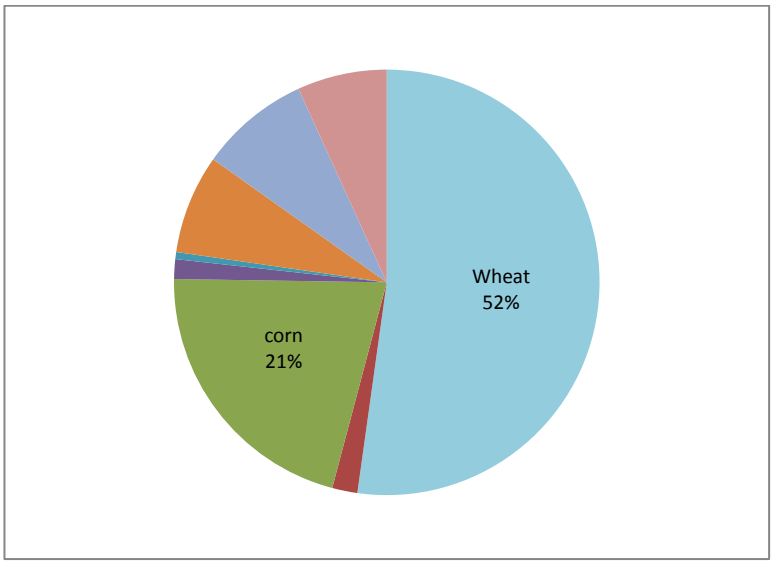
The total length of these main drains (south, north and great drain) is 69 km. On the passage of the drainage network there are many culverts, siphons and bridges. All left side drains discharge their water into the great and north drain while the right side drains are discharged into the south drain. The south drain is then discharged into the great drain through Kesh pumping station which is one of the biggest drainage stations located in Kesh area within the 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). This pumping station extract drainage water from the right side of the project and discharge it to a canal connected to the main south drain located 33 km from the junction between south drain and the great drain. Operation of the pumping stations depends on the water level in the south drain at the pumping station.

Cropping pattern (winter and summer season)

Wheat in winter and corn in summer represent the main cropping pattern in the project area. In addition barley, alfalfa, clover, and different vegetables are grown in winter whereas white maize, cotton, sunflower, sesame, chickpeas, alfalfa, clover and different vegetables are grown in summer. Designed water duty for the project is 1 m^3/s/6600 donums (1 m^3/s/1630 acres). Table 8 shows the actual cultivated area within the project from 2006 to 2010 based on the data collected from the Ministry of Agriculture.

Table 6: Cultivated areas under different crops in the Al-Musasyib project area during 2006-2010.

Year	Wheat	Barley	corn	cotton	sunflower	other crops	winter vegetables	summer vegetables	Total
2006	85063	3146	36964	1803	------	11134	9113	6242	153465
2007	84341	3000	40950	3096	2996	11993	12550	12350	171276
2008	67078	3163	29843	2864	249	12298	12944	15177	143616
2009	82564	2578	29601	2227	33	12080	15277	10358	154718
2010	83419	2871	25446	1544	32	10559	14652	8408	146931
Average	**80493**	**2951.6**	**32560.8**	**2306.8**	**827.5**	**11612.8**	**12907.2**	**10507**	**154001.2**



Management, operation and maintenance

Irrigation system of the project operates on a rotational system. Main branch canals of the project works on two rotations. The discharge between these two main rotations is controlled by adjusting regulators. Table 9 shows a monthly pattern of the rotational system. According to this table, first rotation consists consists of 4 branch canals from the right side of the project and two from the left side with a total design discharge of 36.7 m^3/s. The second rotation consists of 4 branches from the left side and three from the right with a total design discharge of 37.9 m^3/s. The rotational system is based on opening the canals for 4 continuous days and closing for 6 days except for Hilaly and Zubaidi canals for which opening and closing is for 5 days because they irrigate larger areas as compared to the other canals. The actual discharges of the main canal vary from month to month depending on the season and crops grown. Table 10 shows the average discharge in Mussyib main canal for the year 2011 allocated based on the existing agricultural plan of Babylon Governorate.

Table 7: Rotational system for the Mussyib main canal and Branches for the period (22.11.11 to 21.12.11) (*Source: Water resources office of Great Musaib Project*)

no.	Branch Name	length (Km)	Irrigated area (Donum)	Design Discharge (m^3/s)	22/11	23/11	24/11	25/11	26/11	27/11	28/11	29/11	30/11	1/12	2/12	3/12	4/12	5/12	6/12	7/12	8/12	9/12	10/12	11/12	12/12	13/12	14/12	15/12	16/12	17/12	18/12	19/12	20/12	21/12
	FIRST ROTATION																																	
1	Zubaidy	22.5	39360	17	X	X	X	X	X	O	O	O	O	O	X	X	X	X	X	O	O	O	O	O	X	X	X	X	X	O	O	O	O	O
2	Rashaid	9.4	22980	7.3	X	X	X	X	X	O	O	O	O	X	X	X	X	X	X	O	O	O	O	X	X	X	X	X	X	O	O	O	O	X
3	Kharbana	5.5	10988	4.25	X	X	X	X	X	O	O	O	O	X	X	X	X	X	X	O	O	O	O	X	X	X	X	X	X	O	O	O	O	X
4	Al-Haidari	4.5	11906	2.2	X	X	X	X	X	O	O	O	O	X	X	X	X	X	X	O	O	O	O	X	X	X	X	X	X	O	O	O	O	X
5	Dulaimy	3.5	3149	1.95	X	X	X	X	X	O	O	O	O	X	X	X	X	X	X	O	O	O	O	X	X	X	X	X	X	O	O	O	O	X
6	old mussyib	4.5	22796	4	X	X	X	X	X	O	O	O	O	X	X	X	X	X	X	O	O	O	O	X	X	X	X	X	X	O	O	O	O	X
	sub total		**111179**	**36.7**																														
	SECOND ROTATION																																	
7	Hilaly	15	43488	16	O	O	O	O	O	X	X	X	X	X	O	O	O	O	O	X	X	X	X	X	O	O	O	O	O	X	X	X	X	X
8	Ajrish	5	19048	7.8	O	O	O	O	X	X	X	X	X	X	O	O	O	O	X	X	X	X	X	X	O	O	O	O	X	X	X	X	X	X
9	Akaer	8.7	14268	7.1	O	O	O	O	X	X	X	X	X	X	O	O	O	O	X	X	X	X	X	X	O	O	O	O	X	X	X	X	X	X
10	Imam	8	10000	3.8	O	O	O	O	X	X	X	X	X	X	O	O	O	O	X	X	X	X	X	X	O	O	O	O	X	X	X	X	X	X
11	Hamiyar	2.5	4374	1.95	O	O	O	O	X	X	X	X	X	X	O	O	O	O	X	X	X	X	X	X	O	O	O	O	X	X	X	X	X	X
12	Abu Shair	1.5	1415	0.5	O	O	O	O	X	X	X	X	X	X	O	O	O	O	X	X	X	X	X	X	O	O	O	O	X	X	X	X	X	X
13	Mansouri	4.5	4157	0.75	O	O	O	O	X	X	X	X	X	X	O	O	O	O	X	X	X	X	X	X	O	O	O	O	X	X	X	X	X	X
	sub total		**96750**	**37.9**																														

x = closed, o = open

(Note: In emergency cases such as floods, main canal is closed and the rotational system is readjusted based on closed number of days)

Table 8: Average discharge (m^3/s) in Mussyib main canal for the year 2011

month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Discharge	10	6	21	23	18	20	25	25	20	18	17	16

In the project area, canals are operated on the basis of high and low irrigation demand. In the high irrigation demand period, main canal is run on full authorized discharge. In the low irrigation demand period, the discharge is limited to drinking water demands. Table 11 shows the periods of high and low irrigation demand in a year.

Table 9: High and low irrigation demand periods in a year

Season	Irrigation intensity	Period
winter	high irrigation(first planting)	1/11 to 15/12/2010
winter	low irrigation	16/12 to 31/1/2011
winter	high irrigation (second)	1/2 to 15/2 /2011
winter	low irrigation	16/2 to 14/3/2011
winter	high irrigation (last)	15/3 to 15/4/2011
winter	low irrigation	16/4 to 30/6/2011
summer	high irrigation	1/7 to 10/7/2011
summer	low irrigation	11/7 to 15/7/2011
summer	high irrigation	16/7 to 25/7/2011
summer	low irrigation	26/7 to 30/7/2011
summer	high irrigation	31/7 to 9/8/2011
summer	low irrigation	10/8 to 14/8/2011
summer	low irrigation	15/8 to 31/10/2011

Table 11 shows that there are three high irrigation periods during winter season and three in the summer. These high irrigation periods are in accordance with the water requirements of the main crops grown during these periods. For selecting high irrigation periods, wheat and corn are considered as the main winter and summer crops, respectively.

Data Collection

Data collection process faced a lot of difficulties in the beginning of the project because most of the information expected from the Ministry of Water Resources (MoWR) was not available from their responsible directorates. Moreover, the little data that was available was very old and did not represent the current status of Dujaila and Mussyib projects. The project team, therefore, had to explore new sources for information to collect data from two projects sites. The team carried out many site visits, field surveys and interviews with officials from irrigation and agricultural departments to get the needed information. Most of the collected data i.e. maps, tables and reports, were in paper form. Therefore to perform any meaningful analysis, this data and information were converted into electronic form, checked and analyzed.

Sources of data collection

- Various directorates of MoWR (Baghdad and local sites).
- Previous studies and research done related to soil salinity in Iraq, especially for the two selected projects.
- Field trips and field surveys to the Dujaila and Great Mussyib projects.
- Meetings with officials from the irrigation and agriculture offices in the projects sites.
- Water sampling for the irrigation and drainage water quality.
- Meetings and interviews with the farmers.
- Information from internet.

The data and information collected includes:

- Irrigation and drainage network design in the targeted project areas (historical and current status).
- Information on operation and maintenance of irrigation and drainage networks that includes water allocation for projects, drainage water effluent as well as the responsibilities of operation and maintenance.
- Water allocation for farmers and lands (water ration).
- Cropping pattern (winter and summer).
- Irrigation and drainage water quality.
- Irrigation and drainage network maps. Physical verification of irrigation and drainage infrastructure.
- Historical data regarding irrigation, salinity build up, cropping patterns, irrigation practices.

Evaluation of the current status of irrigation and drainage infrastructure

Dujaila Project

To assess the current state of irrigation and drainage infrastructure, assessment was performed at two levels. Level 1 investigation include evaluation of cross regulators on the Dujaila main canal, performance efficiency and working of head regulators at the main branch canals, working of drainage system including main, branch and secondary drains and pumping stations. At the second level, evaluation of feeding canals and farm intakes and field and collector drains was performed. The work also included irrigation and drainage water sampling at different locations of the project. For this purpose, areas within the reclaimed lands of the concrete lined canals I-2, I-3, and I-4, semi-reclaimed areas within BC 9 and non-reclaimed areas within BC 6 were selected (Figure 3).

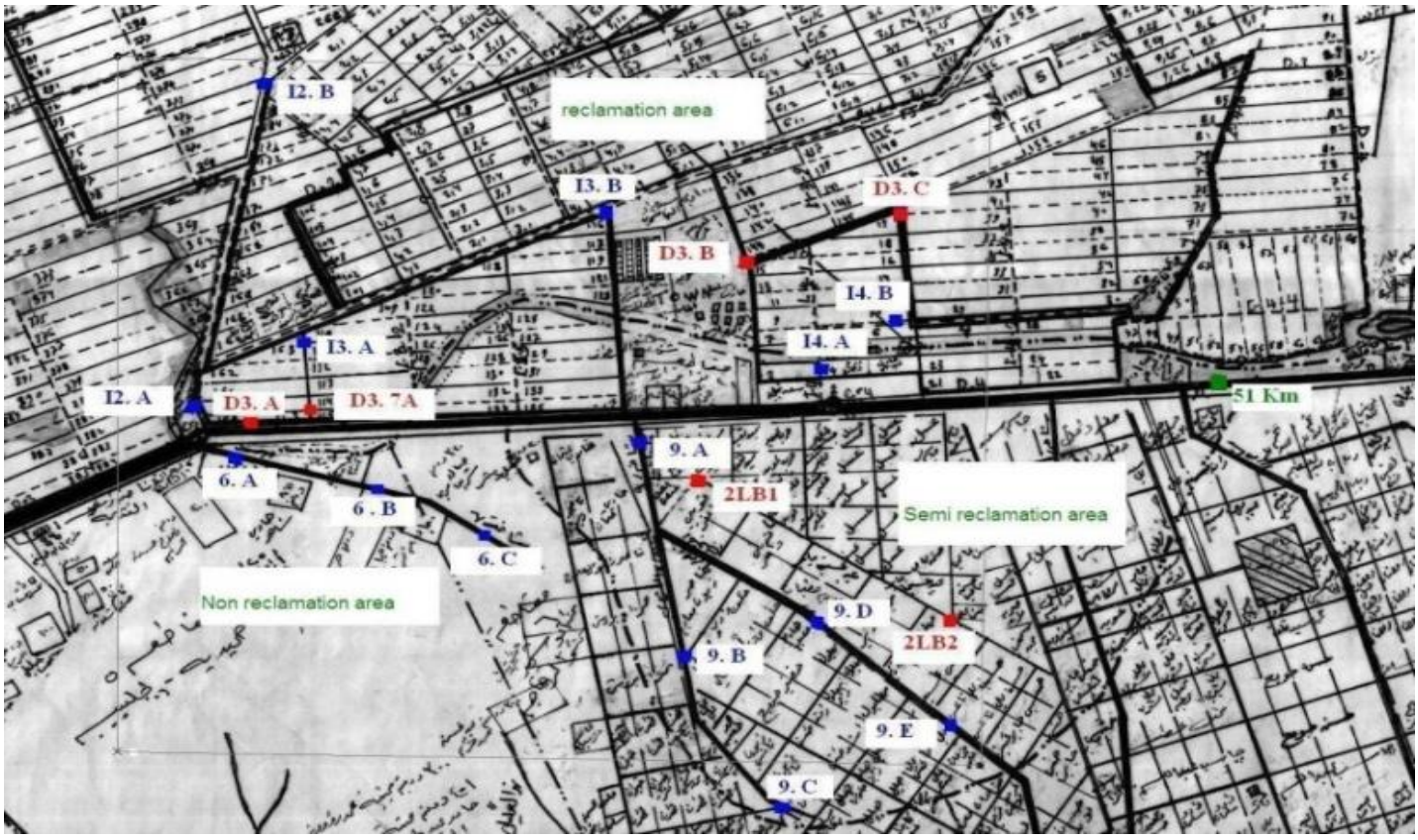


Figure 3: Areas selected for the monitoring of current status of irrigation and drainage infrastructure

Summary of results regarding the evaluation of irrigation canals and regulators is given in Table 4. Inspections during the field visit to irrigation canals have shown that in reclaimed area, most of irrigation and drainage infrastructure is in poor state and urgent maintenance and rehabilitation work is needed. The average efficiency of canal system and regulators is only 50-60 percent in reclaimed, semi-reclaimed and non-reclaimed areas of the Dujaila project. The computerized system of the cross regulators on the Dujaila main canal is totally damaged. The computers, along with many other components of the electrical control system have disappeared. Because regulators are controlled electro-mechanically with a simple electric system therefore the control set needs urgent and full rehabilitation. Concrete lining of canals have been damaged or collapsed, which is causing seepage and water losses problems. Main branch canal head regulators are operated manually/mechanically instead of electric control therefore needs continuous maintenance. The feeders and hydrants have also deteriorated at different levels.

Table 4: (a) Cross and head regulators evaluation -large scale

Regulator type	Location	No.	Efficiency range	Average efficiency	Remarks
Main head	Tigris river	1	70%	70%	Maintenance required
Cross	Dujaila main canal	5	50-60 %	54%	Maintenance and rehabilitation required
Head	Non-reclaimed areas	6	60-80 %	67%	Maintenance and rehabilitation required
Head	Semi-reclaimed areas	5	30-70 %	54%	Maintenance and rehabilitation required
Head	Reclaimed areas	5	50-70 %	60%	Maintenance and rehabilitation required

Table 4: (b) Dujaila main canal Branches evaluation – large scale

No. of canals	Location	Canal type	Length (km)	Conveyance efficiency	Average conveyance efficiency	Status	Remarks
6	Non reclaimed	unlined	72.5	60-80 %	65 %	Medium	Many contradictions in design
5	Semi-reclaimed	unlined	83	50-70 %	58 %	Average	Many contradictions in design
5	Reclaimed	lined	40.8	80 %	80 %	Medium-Good	Many contradictions in design
54 small	All of the project on both sides	unlined		50-70 %	60 %	Average	Less than 400 l/s discharge , without head regulators

Table 4: (c) Feeders and farm intakes evaluation (Reclaimed areas)

Feeders evaluated	Evaluation locations	Average gates efficiency	Remarks about gates	Length of evaluated feeders (km)	Average feeders status	No. of farm intakes				Remarks about feeders and outlets
						total	working	Not working	Not working (%)	
51	Canals I-2, I-3, I-4	59%	Disabled or lost gate	70.75	medium	962	241	721	25%	Maintenance required

Table 4: (c) Feeders and farm intakes evaluation (Semi-reclaimed areas)

Feeders evaluated	Average head regulators/ gates efficiency	Remarks about gates	Length of evaluated feeders (km)	Average feeders state	Average convey efficiency	Remarks about feeders
34	40 %	Broken or lost gates	56.90	Average	51%	Unlined canals and levels below design

Table 4: (c) Feeders and farm intakes evaluation (Non-reclaimed areas)

Feeders evaluated	Average head regulators/ gates efficiency	Remarks about gates	Total length of evaluated feeders km	Average feeders status	Average convey efficiency	Remarks about feeders
16	40 %	Lost gates	34.2	Average	51 %	Unlined canals and levels below design

In the semi-reclaimed and non-reclaimed areas, cross regulators on main canal are old and have deteriorated over time and needs extensive repair. The irrigation canals in these areas (public or private benefit) are unlined and have lost their carrying capacity due to continuous negligence. Flows in these canals are badly restricted because of weeds, plants growth, and deposition of sediments. Over the past many years, these canals were continuously cleaned using hydraulic excavators and other heavy machinery. As a result, these canals have lost their design cross sectional dimensions and these channels have become many times larger than their designed dimensions. This has resulted in huge water losses through seepage leading to increased groundwater levels.

The irrigation water quality across the project during summer of 2011 ranged between 1.1-1.3 dS/m with an average 1.2 dS/m. The evaluation of drains and drainage structures in the Dujaila project on the large spatial scale is described in annexes 5 and 6. The assessment results of drain's efficiency in the project at all levels is shown in Table 4.

Table 10: Assessment of drain's efficiency in the Dujaila project at all levels

Location	Main drains		Branch drains		Collector drains		Field drains	
	Avg. effic.	Remarks	Avg. effic.	Remarks	Avg. effic.	Remarks	Avg. effic.	Remarks
Reclaimed areas (I-1, I-2, I-3, I-4)	70%	Cleaning work being done.	70%	Cleaning work being done.	50%	Few maintenance works (private benefit)	20%	most of them are non-functional due to lack of maintenance.
Reclaimed areas BC8	70%	Cleaning work being done.	70%	Cleaning work being done.	50%	Few maintenance works (private benefit)	20%	most of them are non-functional due to lack of maintenance.
Semi reclaimed areas BC9,10,11	60 %	Cleaning work being done.	60%	Cleaning work being done.	50%	Few maintenance works (private benefit)	none	none
Semi reclaimed areas BC 13,14	50%	Requires additional cleaning work using special excavators because of its wide cross section	60%	Cleaning work being done.	50%	Few maintenance works (private benefit)	none	none

The range of drainage water quality across the main drains during summer of 2011 is between 9.2-10.7 dS/m with an average of 9.8 dS/m.

Status of drainage pumping stations

The current status of drainage pumping stations is given in Table 5.

Table 11: Project drainage pumping stations evaluation results

Pump station name	No. of pumps	Total discharge m^3/s	Efficiency (%)	Remarks
BC 8 pump station	5	7.5	60	Two pumps are broken and requires maintenance, building requires rehabilitation
BC 10 pump station	3	3	50	Requires replacement of all pumps, building requires rehabilitation
BC 13 pump station	6	12	50	Two pumps are broken and requires maintenance, building requires rehabilitation

Summary of Dujaila project area problems

The project's drainage system suffers from many problems. A summary of these problems related to the drainage network as well as pumping stations is as follows:

- Field drainage system is completely deteriorated as most of the field drains are out of order due to lack of cleaning works for a long time.
- Efficiency of the collector drains has declined in all of the reclaimed areas due to lack or absence of required maintenance work. Cleaning of collector drains is the farmers' responsibility and they have not given any importance to this task.
- Sediments, weeds growth, and clogs in some of the main and branch drainage system has choked the system.
- There is deficiency of pumping stations for drainage. Most of the existing pumping stations are out of order and needs immediate maintenance and rehabilitation work for the pumps and reconstruction of buildings.

Irrigation efficiency of the Dujaila project

The results of the field experiments to evaluate the irrigation efficiency conducted by Ministry of Agriculture in another project with same conditions some years ago were considered as a reference to estimate the irrigation efficiency in Dujaila project (irrigation efficiency = conveyance efficiency X application efficiency).

Using the surface irrigation methods at on-farm level in this project and using the conveyance efficiency from the table shown in annex 2, the project irrigation efficiency is estimated as follows:

Location	Conveyance efficiency (%)	Application efficiency (%)	Total Irrigation efficiency (%)	Design efficiency according to irrigation type and field application method
Reclaimed area	80	48	38	63% (lined canals 90%, surface irrigation 70%)
Semi reclaimed area	58	48	28	49% (unlined canals 70%, surface irrigation 70%)
Non reclaimed area	65	48	31	49% (unlined canals 70%, surface irrigation 70%)

The comparison of existing irrigation efficiency with the designed efficiency indicates a high percentage of water losses in the entire project area despite the scarcity of irrigation water and that a large area of the project is covered by concrete lined irrigation network.

The cropping intensity in the project area during 2006-2012 remained about 42 percent. The lower cropping intensity in the project area was mainly due to shortage of water from the Tigris River. Equally important problems are the lack of irrigation and drainage infrastructure leading to land deterioration problems specially the salinity problem and its negative effects on the agriculture productivity.

Assessment the current status of the project

In order to assess the current status of the project's infrastructure, the investigations were done on two main levels. The first level consists of assessing the main canal and the branch drains including branch canal's cross and head regulators. It also includes evaluation of the main branches and secondary drains and drain pumping stations.

The second level of assessment includes a spatial scale evaluation of water allocations between farmers and distributary canals and farm intake structures. In addition, on-farm irrigation methods and their efficiency, field drains and collector drains were also evaluated.

In order to carry out a detailed assessment on the second level , one of the branch canals (Akaer canal) of the main canal was selected. The distributary canals and drainage network associated with this canal was also selected to represent the entire project's lands (Figure 5). Akaer canal is one of the branches of the Mussyib main canal. It off-takes at the 37th km left side of the main canal. The total length of canal is 8.7 km with a design discharge of 7.1 m^3/s. The total command area of this canal is 14268 donums (3526 acres) out of which 17000 donums (4200 acres) are irrigated. In total 11 distributary canals off-takes from Akaer canal. Out of this, 10 are private benefit and one public benefit canal. In addition, there are other 7 secondary distributary canals.

The drainage network consists of 241 open field drains connected to 21 collector drains which are connected to two branch drains surrounding the Akaer area and discharging the drainage water into the great drain. Detailed description of irrigation and drainage network for Akaer area is shown in annex no.9.

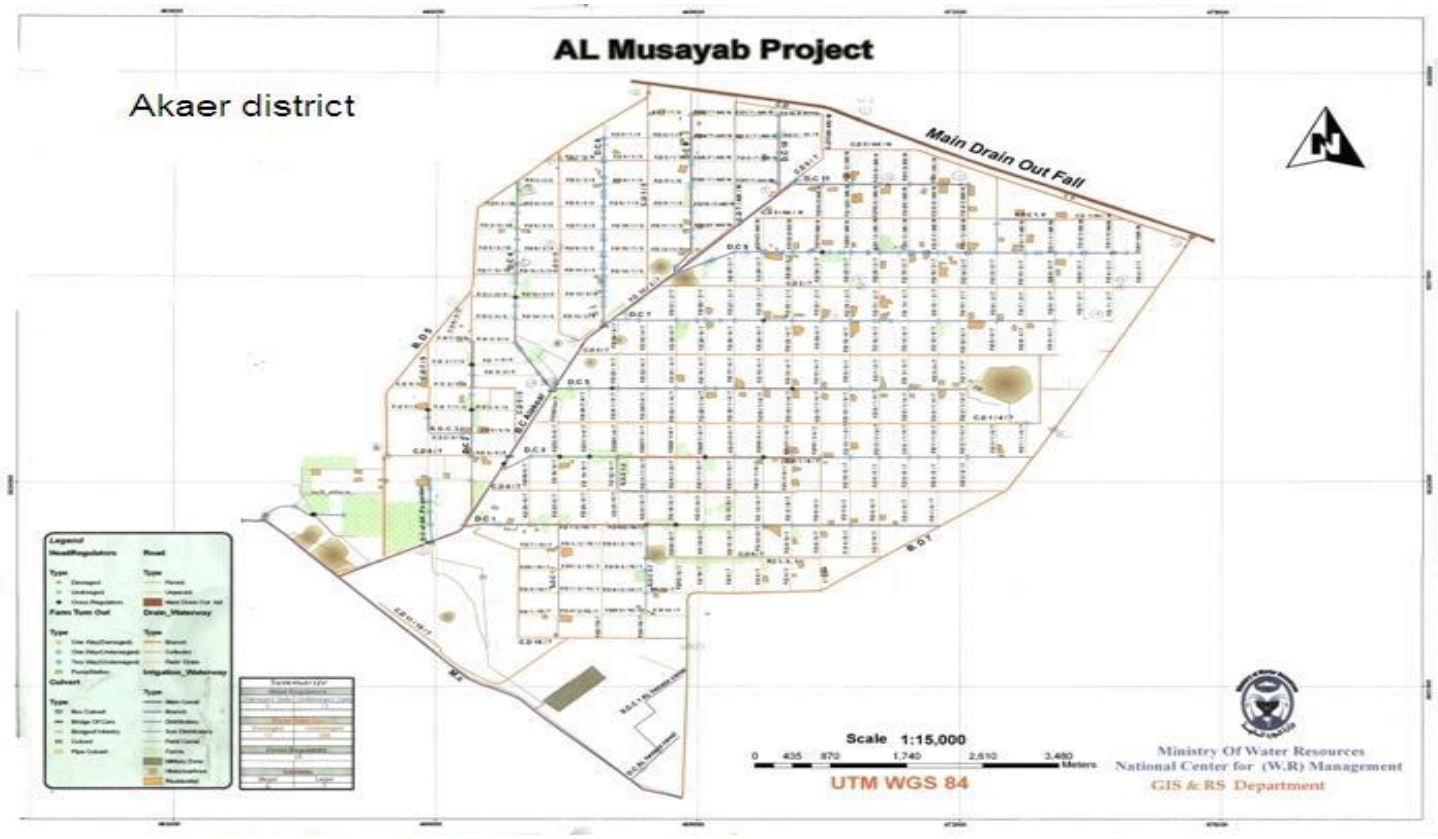


Figure 5: Map of the Al-Kaer district

Status of irrigation canals and structures

The irrigation network of the project is composed of unlined canals. These canals have lost their design cross sections and carrying capacity due to continuous negligence of maintenance. This has increased the irrigation water losses through seepage, causing high ground water levels. Moreover, these new cross sectional dimensions have caused decrease in irrigation water levels at the farm intakes and weirs. This has prompted farmers to lower their farm intakes and weir levels and install water pumps directly on the canals. 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.

Despite some maintenance on the irrigation structures (public benefit structures) every year, all of these structures and the private benefit structures are in bad shape due to age and poor maintenance. Many of them have completed their lifespan and needs intensive rehabilitation which requires additional financial allocations to execute required rehabilitation work. Table 12 shows a summary of the current status and efficiency of the existing irrigation infrastructure.

Table 12: Summary assessment for the project structures

	Structure type	Function	Efficiency	Remarks
1	Mussyib canal head regulator	Control water flow to main canal	70%	*Under annual maintenance- works good*
2	3 cross regulators on the main canal	Control water levels within the main canal	65%	*Under annual maintenance- works good*
3	Branch canals head regulators	Control water flow to the branch canals	65%	*Under annual maintenance- works good*
4	Distributor canals head regulators	Control water flow to the distributaries	40%	*Private benefit, poor maintenance* *Most of its levels were lowered*
5	Branch canals cross regulators	Control water levels in the branch canals	50%	*Modified because of the low water levels in its upstream*
6	weirs	Provide irrigation water to the farm intakes in its upstream	0%	*Useless because of the low water levels resulting from bad maintenance works* *The levels of these structures are lowered in order to provide water to the tail parts of the canal*
7	Farm intakes	Small structure to pass water to the farm units	0%	*It's been demolished by farmers because of the low water levels in its upstream and replaced by lower level pipes*
8	Tail escapes	Overflow irrigation water to the drains	0%	*Completely demolished because of the deepening of canal and the low water levels*
9	Bridges for vehicles and people	Provide roads to the vehicles and people	50%	*Needs maintenance works*

Status of drainage network

Most of the open field drains and collector drains are not cleaned and maintained because they are private property and the responsibility lies on the beneficiary farmers. Consequently these drains have low efficiency causing groundwater table to rise which contribute to the salinity problem. The distance between field drains is 330 m which is not effective in draining the water on time. Therefore it is suggested that the network of field drains should be redesigned keeping in view

soil characteristics, cropping pattern and existing irrigation water quality. The main and secondary drains are also poorly maintained by the irrigation department. Therefore, despite this maintenance, all drainage structures (public benefit) are working with efficiency between 50-60%, while the pumping stations are rehabilitated recently and are working with good efficiency (Table 13).

Table 13: Status of pump stations

No.	Pump station name	No. of pumps	Pump type	Operation	Discharge	Date of construction	Efficiency	Remarks
1	New Kesh pump station	5	vertical	electric	3.375	Seventies	80%	pumps works good
2	Old kesh pump station	5	vertical	electric	1.6	Since project beginning	70%	pumps works good
3	support horizontal kesh pump station	3	horizontal	diesel	1	Since project beginning	70%	pumps works good

Irrigation efficiency of the project area

Based on the data collected by the Ministry of Agriculture under the project 'national program for efficient use of water resources in Euphrates river basin', average conveyance efficiency of the main, branch and distributary canals is 63% while the average application efficiency is around 48%. This makes the overall average irrigation efficiency equal to 30.24%. These values are substantially lower than the generally considered irrigation efficiencies of unlined canal systems with surface irrigation methods (50%). The lower irrigation efficiency indicates high water losses in the project area. These high field losses together with non-operational field drainage system are the major reason for rising groundwater levels and increase in the soil salinity problems in the project area. The cropping intensity in the project area is about 58%. Shortage of good quality irrigation water, increasing soil salinization problems and poor maintenance of irrigation infrastructure by farmers are major reasons for low cropping intensities.

Technical and administrative problems

In addition to the infrastructure problems in Dujaila and Great Mussyib projects, there are other technical and administrative problems which contribute to the deterioration of these projects. These include:

- Illegal interventions by farmers in the water allocation process results in water shortages in many parts of the project especially in the areas located away from the main project head.
- In the areas downstream of the branch canals, farmers do not follow the rotational system and draw larger amounts of water than their actual share. In addition, they also install illegal irrigation intakes and water pumps on irrigation canals. Intentional and unintentional damage to the distributary canal head regulators (private use) has also become common. The illegally extracted water is usually used to irrigate unauthorized agricultural land and for fish ponds.

Technical and administrative obstacles facing the project management include:

- Shortage of transport to follow the operation and maintenance works and remove the farmer interventions.
- Shortage of machinery, technical staff and finances to carry out cleaning work on canals and drains. Most of the cleaning work is done by the operation and maintenance directorates of MoWR.

- Lack in technical and financial abilities of farmers to carry out needed maintenance work for field and collector drains and the rehabilitation of head regulators for the private use irrigation canals.
- Lack of farmers' awareness in the importance of the efficient use of irrigation water to avoid problems of waterlogging and soil salinization.
- Absence of water users associations. Presence of water users associations can help in organizing to carry out needed operation and maintenance work, ensure equitable water allocation and improve management of irrigation water at the farm scale.

Conclusions

During the process of this assessment, it was strongly realized that existing status of irrigation and drainage infrastructure is directly responsible for the 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 waterlogging 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 is the major reason so far as soil salinity development is concerned.

Investment Plan for the Rehabilitation of irrigation and drainage infrastructure

The review of the current state of irrigation and drainage infrastructure at both project areas has revealed that the management, operation and maintenance responsibilities of the irrigation and drainage projects are shared between the Ministry of Water Resources (MoWR) and the farmers. Very recently, the responsibility of cleaning of tertiary canals has also been given to the government as farmers were reluctant or unable to do this job. The Irrigation system at both projects works by rotation and controlled through the main/cross regulators. Regulatory structures at main and branch canals require urgent maintenance. Efficiency of regulatory structures at Dujaila is only 54-60%. Many regulators were designed to operate with an electro-mechanical computerized system but the computerized operation system of the cross regulators are totally damaged. The computers and other components of the electrical control system have been stolen. Currently the regulators are being controlled with a simple electric system.

Irrigation network

Regulator gates for feeders and farm intakes are mostly broken or lost. These structures are unlined and running below design levels with conveyance efficiencies of 50% or so. Concrete lining in many parts of the lined canals have been damaged or collapsed and their expansion joints leaking, causing seepage and water losses. The irrigation network of unlined canals on all levels requires continuous maintenance because of weeds, plants growth, and sediments. As a result of the continuous cleaning works using hydraulic excavators, these canals have lost their design cross sectional dimensions and their beds have compacted. The channels have become many times larger than their designed dimensions, producing excessive seepage and causing groundwater levels to rise. Furthermore, irrigation water levels at the farm intakes and weirs have decreased which has forced farmers to install water pumps directly on the canals to access water. Despite the maintenance works on the irrigation structures (public benefit structures) every alternate year, these structures are deteriorating, needing more financial allocations to execute the required rehabilitation works.

(a) Cross and head regulators evaluation at Dujaila -large scale

Regulator type	Location	No.	Efficiency	Avg. Efficy.	Remarks
Main head	Tigris river	1	70%	70%	Maintenance required
Cross	Dujaila main canal	5	50-60 %	54%	Maintenance and rehabilitation required
Head	Non-reclaimed areas	6	60-80 %	67%	Maintenance and rehabilitation required
Head	Semi-reclaimed areas	5	30-70 %	54%	Maintenance and rehabilitation required
Head	Reclaimed areas	5	50-70 %	60%	Maintenance and rehabilitation required

(b) Dujaila main canal Branches evaluation – large scale

No. of canals	Location	Canal type	Length (km)	Conveyance efficiency	Avg. convy. efficiency	Remarks
6	Non reclaimed	unlined	72.5	60-80 %	65 %	Many contradictions in design
5	Semi-reclaimed	unlined	83	50-70 %	58 %	Many contradictions in design

5	Reclaimed	lined	40.8	80 %	80 %	Many contradictions in design
54 small	All project on both sides	unlined		50-70 %	60 %	Less than 400 l/s discharge without head regulators

Summary assessment for the project structures in Al-Mussyib project.

Structure type	Function	Efficiency	Remarks
Mussaib canal head regulator	Control water flow to main canal	70%	*Under annual maintenance- works good*
3 cross regulators on the main canal	Control water levels within the main canal	65%	*Under annual maintenance- works good*
Branch canals head regulators	Control water flow to the branch canals	65%	*Under annual maintenance- works good*
Distributor canals head regulators	Control water flow to the distributaries	40%	*Private benefit, poor maintenance Most of its levels were lowered*
Branch canals cross regulators	Control water levels in the branch canals	50%	*Modified because of the low water levels in its upstream*
weirs	Provide irrigation water to the farm intakes in its upstream	0%	*Useless because of low water levels resulting from bad maintenance works*
Farm intakes	Small structure to pass water to the farm units	0%	*Demolished by farmers because of low water levels in upstream and replaced by low level pipes*
Tail escapes	Overflow irrigation water to the drains	0%	*Completely demolished because of the deepening of canal and the low water levels*
Bridges	Provide roads to the vehicles and people	50%	*Needs maintenance works*

Drainage network

Drainage network at both projects operates through pumps operating at efficiencies between 70-80% at Mussaib and 50-60% at Dujaila. Higher efficiency at Mussaib may be attributed to recent rehabilitation works. Main, branch and collector drains are maintained by public but require more maintenance than the current level. Field drains and collector drains, being the farmers' responsibility, are not cleaned or maintained altogether. Consequently these drains have low efficiency causing the drainage network deficiency and water table rise, contributing to the water logging and salinity. At some locations within the irrigation projects, the spacing of drainage channels seems insufficient to serve the irrigation areas.

Technical and Administrative Problems

Contraventions by farmers cause major deficiencies in water allocation system, resulting water scarcity in many parts of the project, especially in the areas away from the head reaches of canals. The farmers do not follow the ration system and draw larger amounts of water than their share, by installing irregular irrigation intakes and water pumps on all levels of irrigation canals. Other contraventions include intentional or unintentional damage to the distributary canals' head regulators (private use), irrigating areas outside the planned agricultural areas, and construction of unauthorized fish farms.

Project management faces shortage of equipment, financial allocations and technical staff to carry out maintenance and rehabilitation work at irrigation canal regulators and gates. There is a lack of awareness among the farmers regarding the importance of efficient use of irrigation water, which results in large scale waterlogging and salinity problems. Moreover, farmers lack technical and financial abilities to conduct their share of maintenance works. There is absence of water users associations which can contribute in bearing the responsibilities of operation and maintenance within specific levels.

Key Deficiencies in the System

Key deficiencies in the system which contribute to land degradation, water logging, salinity and poor productivity include water availability, structural shortcomings, planning gaps, and institutional capacities. The net amount of water available in Tigris-Euphrates basin is limited and cannot be supplemented from any adjacent watershed. The structural shortcomings relate to irrigation channels which have significantly deviated from their original designs, regulatory structures which have been operating inefficiently, are damaged and out of use, or gone missing altogether, drainage channels which have been identified as insufficient in some parts, and existing drains which have been clogged and out of action. As to the planning gaps, comprehensive plans to combat overarching issues such as climate change, land degradation, contraventions and enforcement of farmers' responsibilities do not exist. The institutions lack the capacity to enforce regulations and penalize offenders. There is severe scarcity of resources in terms of skilled manpower, equipment and funds to carry out many important functions. Capacity building and farmer's education at institutional level does not exist.

During the process of this assessment, it was assessed that existing status of irrigation and drainage infrastructure, current operations and maintenance setup, and on-farm irrigation practices are all directly responsible for increasing soil salinization and reduction in land and water productivity in the project areas. Irrigation networks are old and deteriorated to a large extent due to lack of maintenance. There are large scale farmer interventions, noncompliance of the rotational system, irrigation of unauthorized agricultural lands, and establishment of illegal fish ponds. All these factors lead to serious water allocation problems causing water scarcity in many regions of the projects. On the other hand, project areas with available water suffer from low irrigation efficiencies, causing waterlogging and soil salinity problems.

Irrigation and Drainage Infrastructure Rehabilitation Plan

In order to develop rehabilitation plan for the irrigation and drainage infrastructure for both project areas, a comprehensive process of consultation was launched. During the process, interviews were conducted with the officials from Ministries of Water Resources and Agriculture. Consultations were carried out with the staff of both projects and the farmers of the project areas. In addition, opinions of other stakeholders such as water experts, progressive farmers and officials of local governments were are also recorded.

Based on their suggestions, rehabilitation needs were divided into three phases of implementation i.e. short-term (2-3 years), medium-term (3-5 years) and long-term (5-10 years). The short-term needs are those which do not require significant financial resources and most of the work can be completed through the local project funds and with the involvement of the local farming community. However, this will be very important to get quick relief from the choking drainage conditions and manage irrigation component to control soil salinity and enhance crop productivity.

The medium-term plan would require commitment from the Central government both in terms of financial and technical support. The medium-term plan can also be implemented by mobilizing local funds and resources. Implementation of this plan will solve more than 80% of the problems of both project areas. Long-term plan is mainly to solve the regional irrigation and drainage problems which go beyond the project areas. These plans need to be implemented to ensure long-term sustainability of irrigated agriculture in Mesopotamian plain. The suggestions for all three phases are given below:

Short-Term Needs

- Clean all branch canals (public benefit) from plants and sedimentation (total length is about 150 km).

- Improve and rehabilitate weirs and roads on drains (300 km length).
- Clean private benefit drains (collector and field drains) (1000 km length).
- Rehabilitation of structures on the branch canals and drainage canals (Head regulators, cross regulators, bridges, culverts and pedestrian bridges.
- Organizing farmers into Water Users Associations (WUAs) to ensure maintenance work and equitable water distribution among all farmers.

Medium-Term Needs

- Concrete lining of public benefit canals (125 km length) including all structures on them (head, cross regulators and bridges for vehicles and pedestrians.
- Cleaning and rehabilitation of main drains (north and south main drains) to ensure standard cross sections and all the structures on them.
- Rehabilitate collector drains to make the standard design cross sections and repair all outlets and structures.
- Rehabilitate the open field drains with all of its outlets.
- Develop plans (including incentives for farmers) to introduce modern irrigation techniques such drip/sprinkler in these areas to improve water use efficiency.

Long-Term Needs

- Complete concrete lining of private benefit canals with all structures.
- Concrete lining of 5 km long Mussaib main canal.
- Land leveling of 400000 donums (100,000 ha) of the project area.
- Replacement of open field drains system by sub-surface pipe drain system.

In addition to this rehabilitation work, government should also take certain administrative and management steps to improve governance and educate farmers about their responsibilities regarding water use and operation and maintenance of irrigation and drainage systems. These may include:

- Organize farmer meetings with the Directorate of Water Resources to educate them about water allocation laws and their due share of water.
- Work with farmers to remove all unauthorized pumps and pipes especially for fish ponds
- Develop a mechanism of water pricing to control unauthorized water extraction.
- Develop water pricing mechanism on volume basis instead of area basis. It is learned that such mechanism is present however its implementation is delayed due to different reasons. MoWR should take steps in order to implement this pricing mechanism.

Annexes

Annexes attached

Sources of information:

- Water resources directorate in Wassit / MOWR.
- Water resources directorate in Babylon / MOWR.
- Water resources section in Dujaila/ MOWR.
- Water resources section in Mussyib / 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.
- Mussyib project - general view/ Study by Eng. Haider A. Mutasher and Fadhel A. kassim / MOWR
- Interviews with irrigation officials in Dujaila and Mussyib projects
- Field visits documentation.