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# ATTEMPTS TO DETERMINE SOME PERFORMANCE INDICATORS IN THE QASMIEH RAS – EL- AIN IRRIGATION SCHEME (LEBANON)

**K. Karaa[*], F. Karam[**] and N. Tarabey[***]**
[*]Litani River Authority, Dept. of Rural Development, P.O. Box 3732, Bechara El Khoury, Beirut, Lebanon; E-mail: am-rural@litani.gov.lb
[**]Lebanese Agricultural Research Institute, Dept. of Irrigation and Agro-Meteorology, P.O. Box 287, Zahlé, Lebanon; E-mail: fkaram@lari.gov.lb
[***]Lake Share Communities Union, Association of Irrigation Water Users in South Bekaa Valley, Lala, Lebanon

**SUMMARY -** The Qasmieh Ras -El- Ain (QRA) is an open channel irrigation scheme working on demand. It has been executed and operated since 1942. Nowadays QRA operates under the control of the Litani River Authority. In the post-war period, the scheme was rehabilitated and achieved in 1999. This paper aims at analyzing some performance indicators in the scheme, dealing with both technical and management sides. The technical indicators include water delivery performance, whereas management indicators include financial and sustainability performances. The primary results of this study show a positive response of the technical indicators, while the response of the management indicators were not satisfactory, because of an overstaffing and a non satisfaction in the water tariff system. With the rehabilitation plan, the system was able to deliver water upon farmer's request. Actually, the rehabilitation plan had improved the water delivery performance through the addition of a new regulation system. Furthermore, the irrigation consumption module was found to decrease about 45% with the rehabilitation plan, compared with situation in the pre-rehabilitation period. Finally, the sustainability performance was increased with the rehabilitation plan from 0.71 to 0.81.

**Key words:** Qasmieh Ras -El- Ain irrigation scheme, water delivery performance, financial performance, sustainability performance.

## INTRODUCTION

Qasmieh Ras-el- Ain Scheme (QRA) is sited on south plain coastal area. Due to its soils quality and climate, it is considered a profitable project. Vegetables can be cultivated throughout the year, with bananas and citrus crops are highly profitable.

The execution of the project had started more than sixty years ago. Works were accelerated in the period 1941-1942 and the irrigation scheme has been operated since 1942. The rehabilitation of the scheme took place in the period between 1996 and 1999.

Initially, the project foresaw the allocation of 450,000 CM daily to irrigate some 5000 ha and the execution of an open channel network of primary, secondary and tertiary canals. Only the primary canal has been executed.

The management of the scheme has been assigned to several governmental bodies. After the Ministry of Public Works, the Ministry of Agriculture and the Qasmieh Ras EL Ain Office, the LRA, in 1974, took the scheme in charge.

Two main water sources supply QRA Scheme: The Litany River and the Ras-el-Ain springs (Vasques de Salamon).

At present there are some 1281 subscribers covering an area of 3220 ha.

## Location

The QRA scheme is located in the southern coastal zone of Lebanon stretching between the Awali River located north of Saida city to some 8 km south of Sour city (Figs 1 and 2). It falls between the sea level and 100 m altitude, covering a total equipped area of 4000 ha.

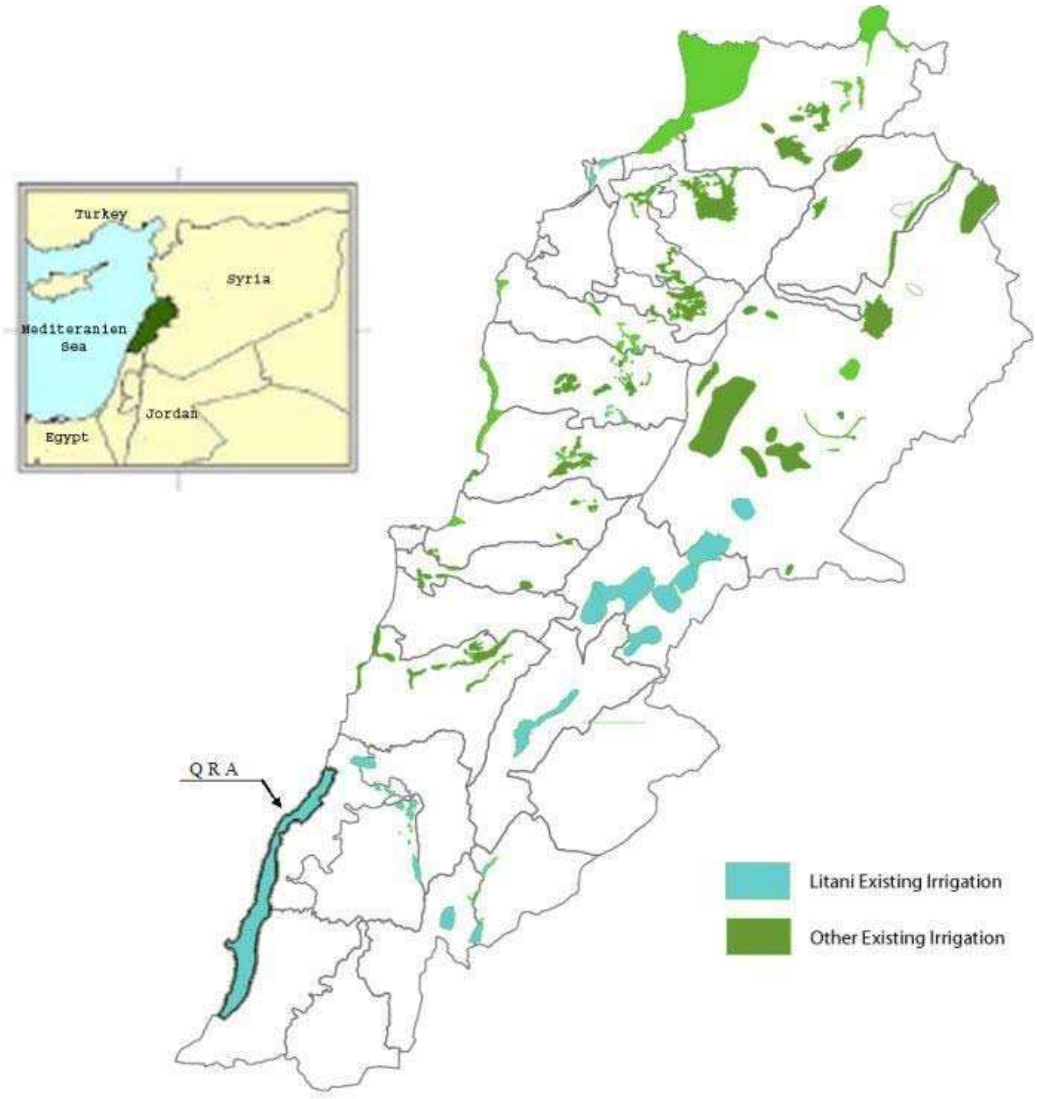


Fig. 1. Geographic location of QRA irrigation scheme (sources: MEW, 2003)

## Climatic conditions

Average annual precipitations in the QRA Scheme area amount to 660 mm. Average annual temperature and relative humidity are 20.5°C and 74%, respectively. Dry season extends from April to September, with cumulative evapotranspiration of 1057 mm measured on Class A pan.

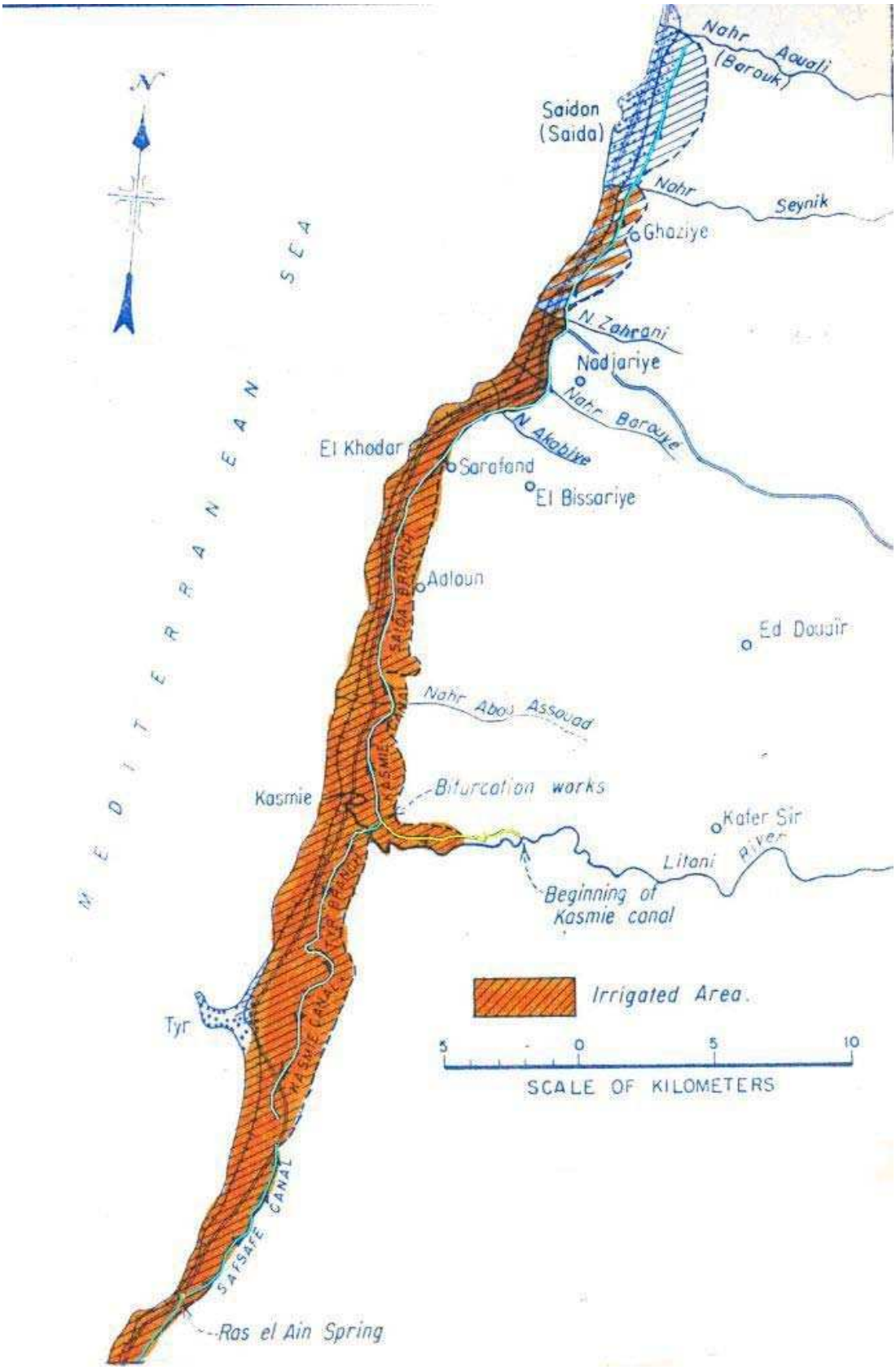


Fig. 2. The QRA irrigation scheme (source: USOM, 1955)

## PROJECT DESCRIPTION

The irrigation scheme is composed of two distinct sectors comprising a conveyor, a divider and two main canals each. Total present canals length is about 56.572 km conveying a water flow up to 5.1 CM per second. There are actually 587 secondary intakes along the main canals.

### Qasmieh Sector

This sector takes up water from Qasmieh River (which is the nomination of the Litani River in its lower part) through a small derivation dam at Zrariyeh area. The dam is built at an elevation of 30 m a.s.l.

*Main conveyor*

Main conveyor stretches parallel to the river bed at a length of 8.2 Km to reach a partition facility at the area of Djezireh. It has a flow up to 4.5 CM/sec. The cross section of this canal is trapezoidal in the first 700m then, it takes rectangular shape in the tunnels and at the end. The area irrigated by the main conveyor is very limited.

*The divider*

The end of the main canal is equipped by a divider (Partiteur) at Djezireh allowing to divide the water into two separate canals: the Saida Branch (or Qasmieh North) and the Sour Branch (or Qasmieh South).

*Saida Branch*

This canal section has a length of 28,852 Km. It stretches northward from the divider to Sainiq River. It comprises 3 tunnels and several siphons. The water elevation starts at the divider at 23.36 m at top and 21.66 m at bottom. Water flow is between 3.25 CM/sec at the beginning and 0.91 at the end of the canal. Canal slope is 0.15 m/km.

*Sour Branch*

This canal section has a length of about 8.37 Km. This section starts with a main siphon which lies across the Qasmieh river bed. The flow in this section varies between 0.91 and 1.844 CM/sec.

*Qasmieh main pumping station and dam*

During the dry season the derivation Zrariyeh dam divert the entire riverbed water flow. However, and in order to harvest the water that still flowing downstream the dam, and from the sources in the river bed before the embouchure of Litani river; a pumping station was constructed near the divider at Djazireh area at the left bank of the river. Pumping power of this station is 1.9 CM/sec divided on 5 pumps which allow good pumping management. Average annual pumped water volume is about 10 MCM. Before the rehabilitation works, a makeshift rock dam was constructed yearly with the aim to siphon water and was destructed every winter season.

### Ras El Ain Project

Water sources in this sector originate from Ras EL Ain springs located south of Sour city. Its main components are a conveyor, a divider and two main canals.

*Main Conveyor and divider*

The main conveyor is rectangular 1.6 m high by 1.45 m wide at the end of which a simple octagonal divider is set to divide water northward and southward into canals.

*Ras El Ain North*

The length of this section is 4.3 km, in which water flow is regulated at about 0.3 CM/sec.

*Ras El Ain South*

The length of this section is 7.5 km. Cross section is trapezoidal. It carries a flow up to 1 CM/s. this section has two siphons.

The project of QRA is equipped with series of security discharge devices, as well as with access roads. Secondary canals were not executed form the beginning. By and by, farmers have constructed their own secondary canals often following plot cadastral boundaries. The management of QRA project stops therefore at the level of secondary intakes.

## SITUATION BEFORE REHABILITATION

The initial design conceived a limited number of secondary intakes on main canals. However, as the execution of secondary and tertiary canals was delayed, farmers started from 1948 to make their own intakes at uncontrolled way.

In the case of Qasmieh sector, which had 80 intakes by design, the number of intakes and openings reached, before the rehabilitation, about 500. This situation has led to a considerable head drop especially at the end of the canals. As a final consequence, water turns by canal sections was adopted reaching up to 21 days at the tail end of the canals.

Water consumption in QRA scheme was, before rehabilitation, estimated at 63 M.C.M, as distributed in Table 1. Based on these data, and knowing that the estimated irrigated area was about 2800 ha, the water consumption of QRA scheme was about 22,500 CM/ha/year.

Table 1: Water consumption in QRA scheme before rehabilitation (source: LRA, 1990)

| Water source | Water volume (MCM) | (%) |
|---|---|---|
| Qaraoun dam | 36 | 57 |
| Litany River bed | 13 | 20 |
| Djazzireh pumping station | 10 | 16 |
| Ras El Ain springs | 4 | 7 |
| Total | 63 | 100 |

## SITUATION AFTER THE REHABILITATION

Rehabilitation works concerned the damaged parts of the canal and the pumping station. Furthermore, new constructions were added to the initial scheme. A movable dam substituted the temporary rock dam. In order to maintain a constant water flow level in the canals, a new compensating reservoir of 1500 CM was constructed, as well as series of downstream flow regulators. Both sides of the canal were raised by 20 to 40 cm. Moreover, the number of traditional water intakes was reduced and replaced by a new type, with a constant discharge (module à masque). Consequently, the water distribution has become according to farmers request.

After the rehabilitation the water consumption fell to 40 MCM/year; water needs from Qaraaoun dam became limited to 13.5 MCM/year instead of 36 MCM/year.

Based on this data, and knowing that the irrigated area has become 3220, the water consumption is estimated actually at 12,492 $m^3$/ha/year

**Water saving policy**

At its inception, the QRA scheme was an open channel system. Recently, in view of a better water management and a water saving policy, the LRA has started to promote using pressurized irrigation techniques at on-farm level. Reduction in water tariffs up to 33% for farmers using trickle and sprinkler irrigation was put under effect starting from 2001. Total irrigated area by modern techniques reached in 2002 about 333 ha which represent 10.3% from total irrigated area. The saved amount of Water was 4000 CM/ha/year which is a reduction of 30.8 % regarding to surface irrigation.

**Cropping pattern**

The general cropping pattern in QRA scheme in year 1999 is summarized in Table 2. After rehabilitation, in 1999, the Litani River Authority (LRA) estimated the scheme Gross Added Product at 33 Million USD.

Table 2: Cropping Pattern in QRA scheme (source: LRA, 1999)

| | Banana | Citrus | Vegetables | Total |
|---|---|---|---|---|
| Hectare | 1755 | 1255 | 210 | 3220 |
| Percent | 54.50 | 38.98 | 6.52 | 100 |

**PERFORMANCE INDICATORS**

In the Qasmieh Ras El Ain Irrigation scheme, several parameters were retained as performance indicators. These performance indicators can be applied within the limited time, money, and available information resources. Among these indicators, water delivery performance, financial performance and sustainability performance (Nelson, 2002). Additional details of the performance indicators are found in appendix 1.

**Water Delivery Performance**

*Water saving due to rehabilitation (WSR)*

Water saving due to rehabilitation (WSR) is the percentage of water saving consumption/ha/year. This indicator is about 44.48 % between the pre and post rehabilitation period (1996 and 1999). In the pre-rehabilitation period, water consumption was estimated at 22500 m3/ha/year. Due the improvement of the irrigation infrastructures that have been introduced to the project with the rehabilitation work, water consumption was decreased to 12492 CM/ha/year. Furthermore, in the post rehabilitation period, the volume of water withdrawn from Qaraaoun dam had decreased from 36 MCM per year to 13.5 MCM per year, making consequently the QRA irrigation scheme less dependent on Qaraaoun Dam; this enables more water allocation to future irrigation projects in South Bekaa and South Lebanon. In addition, due to power generation, a gain in water profitability was achieved, because water in Qaraaoun dam is used for power generation.

*Tail-end Supply Ratio (TSR)*

Tail-end Supply Ratio (TSR) is the number of days that sufficient water reached the end of the canal system, divided by the total number of days. It indicates whether adequate water is reaching the farmers at the end of the canal system. The TSR increased from 3/13 in the pre-rehabilitation period to 1 in the post-rehabilitation period. This is due to a changing in the water delivery system from a rotation mode where water turn at the tail-end was 3 days every 13 days, while with the rehabilitation plan, TSR became equal to 1 because the system was able to deliver water upon farmer's request. Actually, the rehabilitation plan had improved the water delivery performance through the addition of a new regulation system. This led to maintain the same water level along the canal, and by consequence, to ensure certain equity in water delivery among all the beneficiaries.

*Area Uniformity (AU)*

This parameter divide the worst supplied area on the canal system by the average supply, in terms of water depth (volume/irrigated area) supplied. Thus, an AU equal to one is perfect. Values below one indicate the relative shortage suffered by the worst area. In QRA case it is to notice that the water depth depends on the type of crops because the allocated water quantity is related to crop type. However, within the same type of crop, AU is equal to 1, since the irrigation system benefits from a regulatory mechanism, which is based on an equitable delivery system. Actually, due to the use of module à masque along the main canal, which permit an abstraction of an equal water discharge to all end-users, the Litany River Authority attributes fixed irrigation duration for each farmer upon the cultivated area and type of crop, in such a way the farmers benefit from an equitable water depth per type of crop.

*Delivery Timeliness Ratio (DTR)*

Delivery Timeliness Ratio is the number of orders where water was delivered within the target time of the requested date, divided by the total number of orders. Ideally, this ratio would equal to one. Possible reasons for the latter could be poor reservoir management, or failure by the water master to anticipate demand. It could also be caused by poor maintenance or management of the diversion dam, pump stations, or canals. After the rehabilitation of the project, this parameter is equal to 0.94 that can be considered as a good value.

For the previous indicators the high indices are due to availability of water taken at demand from Qaraaoun Lac. This situation will be changed after the execution of all irrigation projects that will have Qaraaoun as their principal water source (36000 ha in south Lebanon and 22500 ha in South Bekaa).

*Water Delivery Flexibility Index (WDF)*

Water Delivery Flexibility Index is a qualitative Index, which equals the sum of a frequency rating + a flow rate rating + a duration rating. Every rating is quoted from 1 to 5 as follow:

*Frequency rating:*
1 - Always a fixed rotation
2 - Fixed rotation with trading, or limited frequency, or fixed rotation during peak season only.
3 - 24 hours or more advance notice required before delivery is made
4 - Less than 24 hours advance notice required before delivery
5 - Farmer does not need to notify district before delivery

*Flow rate rating:*
1 - Same flow rate must always be delivered
2 - Several flow rates are allowed during the season
3 - A different flow rate is available each irrigation, with up to 2 changes per irrigation allowed.

4 - Flow rate can be changed any time, provided advance notice is given to the district.
5 - Flow rates can be different and changed by the farmer without giving advance notice to the district.

*Duration rating:*
1 – Management assigns a fixed duration of irrigation.
2 - Management assigns a fixed duration, but allows some flexibility.
3 - Farmers must select duration with a 24 hour increment
4 - Farmers can choose any duration, but must give notice before changing
5 - Farmers can have any duration, with no advance notice required before changing

The index can vary from 3 to 15, with 15 the most flexible rating possible. Table 3 summarizes the WDF of the pre and the post rehabilitation period.

Table 3. Water delivery flexibility in the QRA irrigation scheme

| | Frequency rating | Flow rate rating | Duration rating | Water Delivery Flexibility |
|---|---|---|---|---|
| Before Rehabilitation | 1 | 1 | 2 | 4 |
| After Rehabilitation | 3 | 1 | 2 | 6 |

From the previous table, it can be noticed an improvement in the system flexibility after rehabilitation. This improvement is mainly due to the improvement of the frequency rating: Actually, the water delivery system was changed from rotation mode before rehabilitation, to on farmers request after rehabilitation.

**Financial Performance**

*Fee Collection Performance (FCP)*

Fee Collection Performance is defined at the annual collected irrigation fees, divided by the total assessed annual fees. This indicates the effectiveness of the collection program, but it can also be affected by the economic condition of the irrigators and the degree to which the irrigators feel the system is worth supporting. After the assignment management to LRA, this indicator is varying from 0.80 to 0.92; in 2002 FCP was around 0.89 indicating a high performance.

*Maintenance Budget Ratio (MBR)*

Maintenance Budget Ratio is the annual maintenance expenditures, divided by the total operation and maintenance (O&M) expenditures. Between 1998 and 2002 the MBR was decreased from 0.12 to 0.02 due to rehabilitation.

*Personnel Cost Ratio (PCR)*

Personnel Cost Ratio is the annual expenditures on personnel divided by the total expenditures. Optimum values of PCR are in the range of 50-60%. For QRA case the PCR was close to 0.86 indicating most of the expenditure is attributed to the personnel cost.

*Manpower Numbers Ratio (MNR)*

Manpower Numbers Ratio is the number of staff (full-time equivalent) divided by the total irrigated area. The optimum value for this indicator may vary widely among different regions of the world, because of differences in labor productivity and irrigation intensity (Index varying from 1 in USA to 20 in Nigeria). In QRA scheme, MNR = 15.32 person/1000ha that is considered as high index. The two previous indicators show an over staffing.

*Financial Self Sufficiency (FSS)*

Financial Self Sufficiency is the annual revenue from water user fees and other local income, divided by total annual expenditures. For self-sufficiency, this indicator should be near one. FSS is actually a measure of the *present* state of financial self sufficiency. A value less than one do not mean that the system cannot *become* self sufficient; the system may just be taking advantage of subsidy opportunities. FSS also does not indicate whether total expenditures are at the appropriate level. In QRA case the FSS is equal to 0.85 indicating that the project is unable to cover all the expenditure from fee collection. An additional effort is needed to reach self sufficiency: Slight increase in water tarification, better use and distribution of the human resources and better performance in fees collection.

*Cost per unit Area (CPA)*

Cost per unit Area is the total annual expenditures divided by total irrigated area. In year 2002, Cost per unit Area was 694,037 L.L./ha or 462 USD/ha.

**Sustainability Performance**

*Sustainability of Irrigated Area (SIA)*

Is the current irrigated area divided by the initial designed irrigated area (Bos, 1997). A trend towards reduced area generally indicates that the system is not sustainable (for water supply, environmental, or economic reasons). If area has increased significantly from the designed area, it may indicate that the water supply is now distributed over too much land, or the delivery capacity is being exceeded. For QRA, before rehabilitation SIA was equal to 0.7 and was increased to 0.81 after rehabilitation. This improvement indicates amelioration in the system sustainability due to rehabilitation works that improved the system performances.

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**Appendix 1 - Summary of the Performance Indicators for Irrigation Water Delivery Systems**

*Water Deliveries performance*

1. Water saving due to rehabilitation WSR = $(C_{Pre-} C_{Post})/C_{Pre}$

$C_{Post}$ is the water consumption/ha/year after rehabilitation

$C_{Pre}$ is water consumption/ha/year before rehabilitation

2. Tail-end Supply Ratio TSR = $N_S / N_T$

   $N_S$ is the number of days that sufficient water reached the end of the canal system.

   $N_T$ is the total number of days the canal system was delivering water.

3. Area Uniformity AU = $D_W/D_{AVE}$

$D_W$ is the water depth (volume/irrigated area) for the worst supplied area in the system.
$D_{AVE}$ is the average water depth supplied to the whole system during the same time period.

4. Delivery Timeliness Ratio DTR = $N_t/N_T$
$N_t$ is the number of orders where water was delivered within the target time.
$N_T$ is the total number of orders (from the individual water order records).

5. Water Delivery Flexibility Index WDF = Frequency rating + Flow rate rating + Duration rating,
Frequency rating
1 - Always a fixed rotation
2 - Fixed rotation with trading, or limited frequency, or fixed rotation during peak season only.
3 - 24 hours or more advance notice required before delivery is made
4 - Less than 24 hours advance notice required before delivery
5 - Farmer does not need to notify district before delivery
Flow rate rating
1 - Same flow rate must always be delivered
2 - Several flow rates are allowed during the season
3 - A different flow rate is available each irrigation, with up to 2 changes per irrigation allowed.
4 - Flow rate can be changed any time, provided advance notice is given to the district.
5 - Flow rates can be different and changed by the farmer without giving advance notice to the district.

Duration rating
1 - Management assigns a fixed duration of irrigation.
2 - District assigns a fixed duration, but allows some flexibility.
3 - Farmers must select a duration with a 24 hour increment
4 - Farmers can choose any duration, but must give notice before changing
5 - Farmers can have any duration, with no advance notice required before changing

*Financial performance*

6. Fee Collection Performance FCP = $F_C/F_A$
$F_C$ is the annual amount of water charges collected.
$F_A$ is the annual amount of water charges assessed.

Maintenance Budget Ratio MBR = $E_M/E_{O\&M}$
$E_M$ is the average annual expenditures for maintenance.
$E_{O\&M}$ is average annual expenditures for both operations and maintenance.

Personnel Cost Ratio PCR = $E_P/E_T$
$E_P$ is annual expenditures on personnel (wages, fringe benefits, training, etc.).
$E_T$ is total annual expenditures.

Manpower Numbers Ratio MNR = $N_S/A_T$
$N_S$ is number of staff (full-time equivalent)
$A_T$ is total irrigated area

Financial Self Sufficiency FSS = $I_F/E_T$
$I_F$ is income from water user fees and other locally generated income (not including subsidies).
$E_T$ is total annual expenditures.

7. Cost per unit Area CPA = $E_T/A_T$
$E_T$ is total annual expenditures.
$A_T$ is total irrigated area

*Sustainability performance*

Sustainability of Irrigated Area SIA = $A_C/A_I$
$A_C$ is current total irrigated area.
$A_I$ is total irrigated area when system development was completed.